Large Animal Surgery - Supplemental Notes

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Horse doctor giving medicine to a horse, German, 18th century;https://wellcomecollection.org/works/wb4aqmdf

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Introduction

Half of what you'll learn in [medical] school will be shown to be either wrong or out of date within five years of graduation; the trouble is that nobody can tell you which half, so the important thing to learn is how to learn on your own." –David L Sackett

Being a competent veterinarian isn't easy. You are licensed to handle many different species and issues, some of the latter won't even exist during the time you are in veterinary school. Some conditions and situations you will only encounter after graduation. You may switch career paths and see species you never intended to see. Many times the answers aren't in the book or the book is outdated. Dr. Google provides many "answers", not all of which are helpful. Hopefully this resource will give you a starting place to understand the common conditions encountered by veterinarians working on large animal species and the exercises will help you expand your capabilities for sorting through the myriad "answers" out there. Your wonderful brains can help you put them together. It just needs practice.

This resource is not intended to read cover to cover. When you have a question, check the table of contents on the right of each page and head to that section! Save the cover to cover reading for something more fun.

Comments and/or suggestions? Please fill out this survey! You can also annotate (add links, comments, suggestions, questions, etc) this book using the hypothes.is app and this link

Finding Resources

One of the biggest challenges in the digital age is sorting out answers you can find online. Over time, each of us develops our "go to" resources for things at two levels:

- basic information for new or unfamiliar topics
- advanced, detailed or updated information for more familiar topics

These are rarely the same.

For starter explanations, try these:

- Wikipedia– useful for physiology, unknown terms and other more general knowledge questions
- Vetfolio – has been free for students; great summaries of topics and conditions
- Merck Veterinary Manual online- good for pathogenesis and presentation; not as good for therapies
- Vet Clinics of North America Equine, Food Animal, and Exotics– see the search function at the top. Does require a subscription. Available through many University libraries. Peer-reviewed summaries of SA topics; NOT always peer-reviewed for LA topics but extensive reference lists.
- VIN – abstracts are posted in related feeds. Free for students and contains a variety of other resources (3D anatomy, drug calculators, financial aid info). The help from the boards is variable; sometimes excellent, sometimes dangerous.
- Specialty sites with info for animal owners (many are free for students): ACVS.org, ACVIM.org, AAEP.org, AASRP.org, AABP.org, AASV.org, sites with .gov or .edu
    - ACVS is probably the weakest of the bunch.
- Plumb's Veterinary Drug Handbook and app (lots of versions out there in different formats and prices)
- SCOVE Edu+ – online source of online resources

For more detailed explanations or comparison of therapies, diagnostic tools etc:

- Google scholar– look for the ones with a pdf. You can sort by year, type of article etc using the left hand bar
- Veterinary medical library Pub Med and other databases; video how to for UMN system; or go visit the librarian in person
- UMN library search– For articles and books. Great for specific articles you are trying to access or specific topics, particularly if not likely to be in pubmed.
- Ivis – international veterinary information service – is a great place to find specific meeting proceedings

- Extreme googling
- Surgery textbooks- great for how to perform surgery and the perioperative care required
- Revisit sites above

Unless it is fiction or for fun, don't read every word.

- Textbooks – read the chapter summary and/or skim the headings; then read the applicable sections.
- Journal articles – start with the abstract and/or introduction, follow with the last paragraph, finish with any middle bits that are useful
- Online materials – start with Ctrl-F if you have a specific question; otherwise go with the section headings and introductory sections as above.

Why we care:

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Field Surgery

This section is designed as an overview for those with limited to no exposure to ambulatory practice.

Equine ambulatory practice

The majority of horses are treated on the farm by a veterinarian. This means the vet brings supplies with them and that animals are basically treated on an outpatient basis. A few will be treated in a local “haul-in” clinic (taken to a clinic by the owner). Even fewer will be trailered to a referral center.

Horse facilities range from paddock only (potentially without running water or electricity) to heated barns with living quarters for humans included. Work areas may be pastures/lots, stalls, arenas, front yards or other open spaces. Other horses are often in or near the space (and are quite frequently talkative while you are trying to sedate or anesthetize their buddy.) Some barns may not have the wiring to support high powered radiograph machines. Internet access is typically spotty. Clients (and their friends and relations) are often in attendance.

This leads to a quite different environment than a small animal practice in which pets are typically removed from the client’s view for simple procedures such as blood and urine collection, not to mention surgery. While a few small animal vets do house calls, many use a mobile truck that can be the site of procedures and can get animals out of the home and the owner’s arms. The closest model in the SA world is probably in home visits for euthanasia.

Most barns are equipped with halters, lead ropes, and basic bandaging supplies. The veterinarian is expected to bring the rest of the necessary equipment and drugs to the farm in the practice vehicle. The vehicle is often a truck with an insert that holds bottles and equipment. The insert generally has a small refrigerated compartment and a lock box for controlled drugs. Alternatives include various SUVs or large cars with similar inserts. Regardless, space is limited, particularly since large patients need larger volumes of drugs, fluids, and bigger supplies in general. Equipment such as ultrasounds and radiograph units may also be shared among trucks and vets in the practice. Having a good history or best guess can make packing the truck most effective.

Horse owners are often involved in the calming of their horses and even the cleaning and bandaging of wounds while waiting for the veterinarian to arrive. Legally, it is best to not rely on the horse owner for handling; however, it is often necessary, particularly with emergency calls. Not all clients are able to handle the gore and excitement that can be associated with equine practice; the equine veterinarian also has to manage the safety and expectations of owners and bystanders. The lucky veterinarian brings an experienced technician or veterinary student along as an assistant..

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Veterinarians will typically visit a barn or stable twice yearly at a minimum for spring and fall shots, dental care, and other preventive medicine steps. Many barns are visited monthly for various treatments (particularly for lameness conditions). However, with horses being horses, visits tend to be fairly regular and frequent.

Farriers are often on the premises at least as frequently and often have a closer relationship with the horse owners. Lay specialists may be involved in dental care, chiropractic and massage therapy. Legislation varies by state; most states require these practitioners to work closely with a veterinarian.

Food animal ambulatory practice

Most of food animal practice ambulatory – the vet travels to the farm with supplies. Most work is done on this form of outpatient care.

Food animal practice varies widely from the backyard pets (usually goats) to large dairy farms. Facilities also vary, even among similar types of barns (eg dairy barns come in may different styles). The farm may be the primary source of income, a supplemental income, a tax write off, or a hobby.

Much of the veterinary care on a farm is performed by the farm managers/producers or their staff. Vaccinations, castrations, other youngstock processing (disbudding, dehorning, etc) and minor surgeries are often performed by farm personnel. Palpation and breeding may be performed by lay specialists. Veterinarians are used for select procedures, such as disease diagnosis, regulatory testing and surgery. Pig and poultry medicine is often focused more on necropsy than on surgery. Owners of goats and camelids are less likely to do their own procedures and will be more reliant on their veterinarian.

Handling facilities on beef farms are often minimal (a squeeze chute) with animals being unused to handling unless they are show animals. Dairy cattle are typically more used to human contact and facilities are typically more veterinarian friendly.

Dairy producers are typically comfortable handling their animals; beef producers are variably so (depends on the type of farm). Small ruminant and camelid owners vary significantly in their interest and ability to manage animal care. Many are well versed and are happy to educate their veterinarian as needed.

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Small ruminants can transported to a veterinary clinic in vans or other vehicles, making it relatively easy for owners to bring them to the veterinarian. This tends to be cheaper than having a veterinarian travel to the farm. Travel time often results in a loss of income for whomever is doing the driving (owner, veterinarian). Multiple visits in the same direction can minimize losses and make farm visits more efficient.

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Pigs, poultry and more

Production pigs and poultry do not usually receive surgery.

Pot bellied pigs are treated as pets and will usually be brought into the clinic for care. Pot-bellied pigs can be treated more like dogs than like other farm animals.

Camelids and camelid owners are managed more like horses than goats.

Deer and elk farms are managed more like beef farms (limited handling).

Large exotics are often managed at the state level and must be licensed and under the care of a veterinarian. Clients should not be requesting medical care unless they are already in partnership with you for animal care.

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General pharmacology

Basic principles, drug formulations and local blocks that cross species

Perioperative medications

This chapter is an overview of the drugs that may be needed prior to surgery. Sedatives, analgesics and potentially antibiotics are required for standing surgery. If we are going to use general anesthesia for recumbent surgery, we will add induction agents and maintenance agents, as well. See the later chapters for details on the drug types and for species specific recommendations.

Sedatives

Sedatives and calming agents are often necessary prior to procedures. Excited animals do not respond well to general anesthesia and it is important to induce sedation before attempting general anesthesia.

Sedatives also need time to work. If an animal is constantly stimulated (talked to, patted, poked), it may not sedate at all. Generally ask everyone to step back and stay calm and quiet for several minutes after administering a sedative or calming agent. Avoid pain or trauma while the sedative is working.

Most sedatives will work quickly. IV (intravenous) medications will usually take effect within 2-3 minutes while intramuscular injections take 5-10 minutes if not longer. Acepromazine is a calming agent (anti-anxiolytic agent) that can take at least 20 minutes to take effect regardless of administration route. Some animals (pigs, mean horses, needle shy animals, +/- camelids) typically need intramuscular medication. Once you have some sedation in the animal, intravenous administration may be an option.

Analgesics

Analgesics (opioids, NSAIDs) should be given prior to any pain stimulus whenever possible. Once pain starts, the nerves become upregulated and hypersensitive (“wind-up”). To prevent wind-up, we provide “preemptive analgesia” through preoperative medication. We want the analgesics on board before we cause pain. Again, iv agents will work more quickly than im or sq agents. Orally administered drugs are generally cheaper but oral medications need 1-2 hours to take effect. Plan ahead!

NSAIDs have long durations of action (12-24 hours) while narcotics may need redosing during longer procedures.

Typically, surgical inflammation will continue for at least three days. This means we need to control inflammation for three days so that healing can occur.

We should ***always*** give analgesics preoperatively. We know surgery is going to cause pain and inflammation.

Antibiotics

Antibiotics should be used only when necessary. Sometimes you don't know if it will be necessary. Preoperative antibiotics that are at high levels at the time of any "surprise" are more effective than trying to treat after the fact. This is considered prophylactic use. Prophylactic use of antibiotics is typically restricted to the preoperative +/- surgery period and does not include postoperative care. We typically give antibiotics preoperatively in most cases of abdominal, respiratory and urogenital surgery due to the risk of contamination.

Timing of drugs depends on the route. You want the peak levels to be when you are doing the stuff that might lead to contamination. This is often at least 10 minutes after you anesthetize your patient..

For prophylactic coverage (preventative), we try to have peak levels at the time of the incision. This varies by drug and route but generally

- Oral: ~ Two hours after drug is administered
- IV: ~ 15 minutes after injection/infusion
- Intramuscular (IM): ~30 minutes after injection (does depend on the drug formulation with some taking much longer)
- Subcutaneous administration – variable; avoid the subcutaneous route for preoperative medications if possible

Some antibiotics need to be re-administered during longer surgeries to maintain peak levels.

If the surgery is clean or clean-contaminated, further antibiotic therapy is generally not needed unless the animal is immunocompromised, infection would be life-threatening, or an implant is used.

Timing of drugs is critical to ensure they are most effective at the time you need them.

When we don't know what sort of surprises we will encounter, we err on the side of broad spectrum bactericidal drugs. We typically pick first line drugs, rather than those saved for cases of resistance.

If antibiotic therapy is indicated postoperatively, it is often continued for 3-14 days. One common rule is to treat three days past the resolution of clinical signs (fever, signs of inflammation, etc). In hospitalized cases, a blood count is often checked prior to discontinuing antibiotics to ensure no further signs of infection.

Sample protocols for surgical procedures

Species	Sedatives	NSAIDs#	Antibiotics
Horses	Xylazine or detomidine	Flunixin meglumine or phenylbutazone	Penicillin + gentamicin or ceftiofur
Cattle	Xylazine	Flunixin meglumine or meloxicam	Ceftiofur (lactating cattle)*, penicillin or ampicillin
Small ruminants	Detomidine	Flunixin meglumine or meloxicam	Ampicillin
Camelids	Butorphanol	Meloxicam or ketoprofen (can go im)	Ceftiofur or ampicillin
Swine	Ketamine + midazolam or dexmedetomidine	Flunixin meglumine or meloxicam	Ceftiofur or ampicillin

*In lactating cattle, ceftiofur is typically our first choice due to the limited **withholding**time required for milk.

#Narcotics are commonly added to all protocols

Resources

Perioperative analgesics

The Efficacy of Preemptive Analgesia for Acute Postoperative Pain Management: A Meta-Analysis, *Anesthesia and analgesia* 100 3 (2005): 757-73- human work but nice overview

Equine NSAIDs and analgesics chapter

Food animal NSAIDs and analgesics chapter

Perioperative antibiotics

Principles of Antimicrobial Therapy: What Should We Be Using? Vet Clin Equine 22 (2006) 279–296- good review of surgical use of antibiotics

Randomized prospective trials to study effects of reduced antibiotic usage in abdominal surgery in cows. J. Dairy Sci. 101:8217–8223. With careful attention, maybe we can pick which cases get preop antibiotics.

Equine antibiotics chapter

Food animal antibiotics chapter

Sedatives

Common sedatives include alpha-2 adrenergic agents, benzodiazepines, phenothiazines and occasionally other drug classifications by species or age group.

Alpha-2 adrenergic receptor agonists

Small animal drugs in this class included medetomidine and dexemedetomidine. While those can be used in LA species, we commonly use xylazine, detomidine and romifidine. These drugs reliably cause sedation and skeletal muscle relaxation and are often the only sedative needed. Most have a dose dependent effect (more drug = more sedation); however detomidine has a ceiling effect in horses where more drug stops causing more sedation and switches to causing longer duration sedation. Due to the alpha-1 effects that they also carry, these drugs do affect the heart and blood pressure. Hence, alpha-2 adrenergic receptor agonists cause significant decreases in cardiac output along with vasodilation and hypotension.

As each drug as a difference balance of alpha-1 and alpha-2 activities, side effects vary by drug and by species. These are notable concerns to keep in mind

- these drugs can cause first or second degree heart block – auscultate the heart before administering!
- these drugs cause pulmonary resistance and sometimes fatal pulmonary edema in sheep; don't use in sheep if it can be avoided
- cattle are very sensitive to xylazine and require only 1/10 of the equine dose; they are NOT more sensitive to detomidine
- xylazine causes uterine contractions and can lead to abortion in cattle in the third trimester; xylazine also makes Csections harder
- xylazine causes glucosuria and increased urine production; this can be bad if your patient can't urinate (urolithiasis)
- xylazine causes vomiting in pigs and is not as useful as in other species
- xylazine impairs cardiac output significantly in neonates (slows heart rate and neonates cannot adjust stroke volume); do not use in neonates

Noteworthy

Xylazine in horses causes them to shift their weight to their front legs and numbs their neurons. This means they tend to kick without thinking and can kick easily due to the weight shift. Do not use xylazine alone as a sedative for any rear end procedures in horses. When combined with butorphanol, it is safe due to a more balanced weight distribution. Detomidine is also okay to use for hindlimb procedures due to the more balanced weight distribution.

Xylazine does not cause this weight redistribution in cattle.

The alpha-2 agents can be reversed.

When combined with narcotics, the drugs are synergistic. The sedation is more profound as is the analgesia. Common combinations are xylazine +butorphanol (horses, cattle) or detomidine + butorphanol (horses).

Phenothiazine derivatives

Acepromazine is currently the main LA drug in this class. Typically administered parenterally (iv, sq or im), it leads to calming and muscle relaxation but no analgesia. It has a very prolonged onset of action but then persists for several hours. Assume it will take at least 20 minutes to take effect, regardless of route administered. If startled, the effect of the acepromazine can be overridden (animals are easily aroused).

These drugs also have anti-emetic and anti-arrhythmic effects.

The drugs are synergistic with opioids (**neuroleptanalgesia**) and the combination results in enhanced analgesia and enhanced sedation. Cattle respond well to an acepromazine + morphine combination.

Acepromazine cannot be reversed.

Side effects

- stallions can develop priapism (persistent erections) that can lead to infertility; avoid in stallions
- bulls develop penile relaxation but are not at risk of infertility unless the penis is traumatized while exposed. (The exposure is handy for penile surgery.)
- severe hypotension occurs in sick animals and neonates; avoid in sick animals
- many animals develop a temporarily lowered hematocrit due to splenic sequestration of red blood cells

Benzodiazepines

The common LA drugs in this class are diazepam and midazolam. They are generally used interchangeably with midazolam used more commonly due to the higher cost of diazepam. Zolazepam is part of the drug combination Telazol (tiletamine/zolazepam).

The benzodiazepines are calming agents as well as anticonvulsants, appetite stimulants and skeletal muscle relaxants. The calming effect works best in neonates, geriatric and sick patients. They tend to have minimal effects in healthy adults and/or can actually lead to paradoxical excitement.

These drugs are most often part of a general anesthesia protocol. As sedatives, benzodiazepines are primarily used in neonates when the alpha-2 adrenergic agonists would be too dangerous.

If diazepam is used, it is important to remember that diazepam binds to plastics and cannot be left in syringes or it will deactivate. Diazepam also tends to precipitate out when mixed with other drugs. It can be mixed with ketamine.

Diazepam should also only be given iv while midazolam can be given im.

Other drugs

In some species and age groups, butorphanol and ketamine can also be sedatives. In other species and age groups, they can lead to excitement rather than sedation. Be careful and do your research before using.

- Butorphanol and other narcotics cause excitement in horses; do not use unless the horse is sedated
    - Neonatal foals do get sedated rather than excited
- Butorphanol can cause excitement in calves but to a lesser degree; we can administer the sedative at the same time as butorphanol
- Ketamine causes excitement in horses but can cause sedation in cattle
- Camelids may or may not sedate with butorphanol. Blindfolding may help enhance the sedative effects

See the subsequent chapters for more details

- Equine sedatives
- Equine standing sedation protocols
- Food animal sedatives
- Bovine standing sedation protocols
- small ruminant sedation and anesthesia
- camelid sedation and anesthesia
- swine sedation and anesthesia
- Perioperative guidelines

Resources

Veterian key – sedatives and tranquilizers- nice cross species comparison

Analgesics

Analgesics need to be given prior to the pain stimulus to prevent hyperalgesia and wind-up phenomenon (basically when nerves become super sensitive and react even more strongly to pain). This preemptive analgesia decreases the amount of pain produced but does not prevent pain. Analgesics should also be used *after* the stimulus to control the residual pain.

The most common analgesic classes are NSAIDs (nonsteroidal anti-inflammatory agents) and narcotics.

Non-steroidal anti-inflammatory drugs

NSAIDs are aspirin like drugs that block cyclooxygenase and inhibit the production of prostaglandins and leukotrienes. Prostaglandins and leukotrienes are inflammatory mediators and many cause heat, pain, swelling, redness and loss of use. Most surgical pain is related to the release of these inflammatory mediators so NSAIDs are a good first choice for managing surgical pain. Inflammation usually increases for about 3 days postoperatively before it starts to resolve (expect more swelling and incisional **dehiscence** about day 3!)

NSAIDs typically cause muscle necrosis when given im so are administered iv, orally or topically. Ketoprofen can be given im but is not as effective as other NSAIDs.

NSAIDs have varying levels of toxicity. As they block prostaglandin release and prostaglandins do lots of things, side effects are widespread. Prostaglandins are important in most facets of physiology so NSAIDs have the potential to interfere with everything from bone healing to parturition. Most NSAIDs cause gastric irritation, ulceration and protein loss into the gastrointestinal tract. One of the earliest signs of NSAID toxicity is low total plasma protein. Other common concerns include renal damage and colitis. Neonates, geriatric animals, animals on other renally metabolized drugs, animals that are dehydrated or not drinking are at increased risk of NSAID toxicity.

Common LA NSAIDs include phenylbutazone, flunixin meglumine, meloxicam, firocoxib, and diclofenac sodium. Use of a particular NSAID varies by species.

Flunixin meglumine is the only approved NSAID for food animal species and is also used in horses. It is considered best for visceral pain but does work for musculoskeletal pain, as well. It is less toxic than phenylbutazone but more toxic than firocoxib. It is labeled for intramuscular use but should never be administered im except to pigs. Due to the muscle necrosis, it can lead to clostridial myositis. Give it iv or orally or topically, depending on the formulation.

Phenylbutazone is the most common NSAID used in horses – it is cheap and available in oral formulations. It is also the most toxic. It should not be used in food animals as it is also toxic for people.

Meloxicam is an oral NSAID used in food animals, including camelids. It is used off label so requires a veterinarian-client-patient relationship. It works even though it has to pass through the rumen or C3.

Firocoxib is an oral NSAID used in horses that are at risk of NSAID toxicity. It is the safest NSAID we have available in horses right now. This is the same ingredient as in Previcox. However, it is illegal to use Previcox in horses since there is a horse formulation.

> Most NSAIDs cannot be given intramuscularly due to the muscle irritation!

Narcotics

Narcotics are used to enhance the pain relief (especially before and during surgery) and/or when NSAIDs are not advisable. Narcotics are also needed when the pain isn't caused by inflammation.

Narcotic use in LA species is expanding. Common narcotics used include butorphanol, morphine, and buprenorphine. Use of a particular narcotic varies by species. Narcotics can cause excitement in many LA species so iv administration of narcotics alone (without a sedative) is avoided in most situations.

Narcotics are generally synergistic with alpha adrenergic agents (xylazine, detomidine) and with phenothiazines (acepromazine) resulting in improved sedation and analgesia compared to the effects from individual agents.

Narcotic side effects include drowsiness, recumbency, and Gi stasis (colic, constipation). Side effects also include muscle twitches (annoying for head surgery) and excitement if a sedative is not on board first. Almost all adult horses should be sedated prior to opioid administration. Animals also become less sensitive to the effects of narcotics over time due to downregulation of receptors.

Narcotics can be reversed by naloxone.

Butorphanol is a common additive to equine sedation protocols. Morphine is a cheaper and longer acting opioid that is used in place of butorphanol in cattle and is often used for pain control even when sedation isn't needed. Acepromazine is combined with either butorphanol or morphine (**neuroleptanalgesia**) to create standing sedation protocols in cattle, particularly for Csections. Buprenorphine is another narcotic that is used to manage postoperative pain in goats.

More information:

- Equine analgesics and NSAIDs
- Food animal analgesics and NSAIDs
- Perioperative guidelines

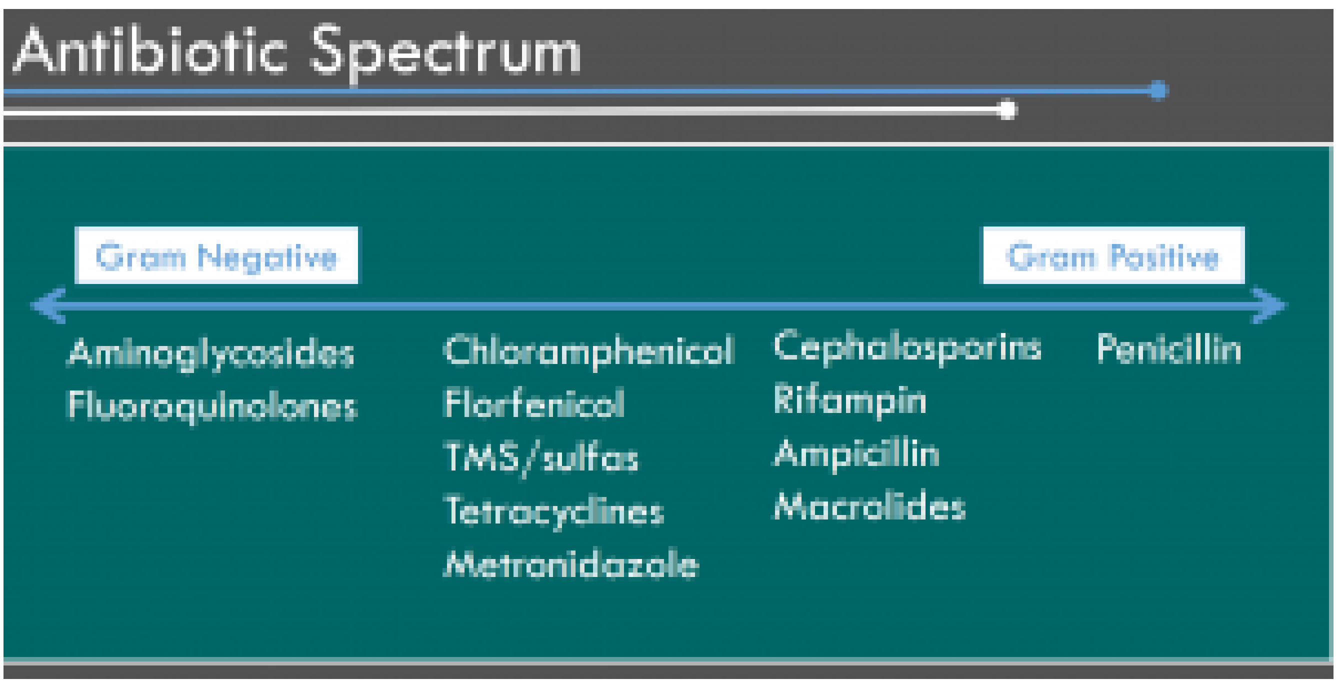
- small ruminant analgesics, sedation and anesthesia
- camelid analgesics, sedation and anesthesia
- swine analgesics, sedation and anesthesia

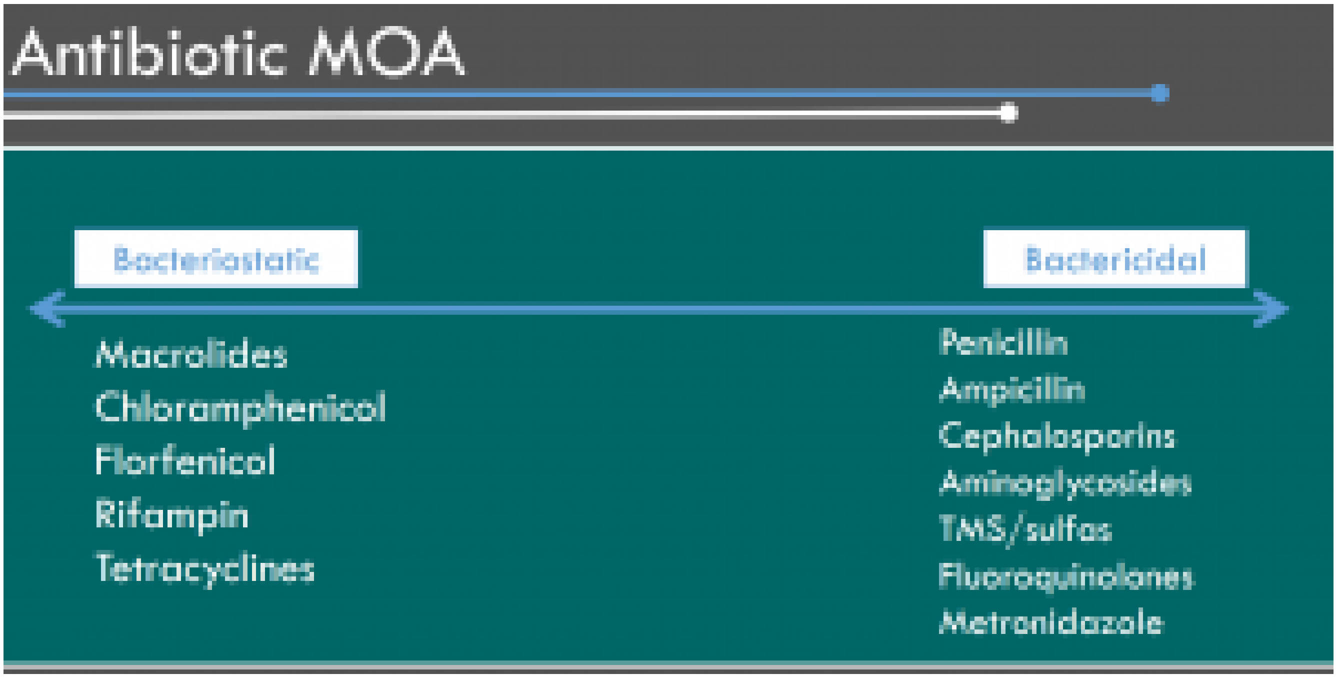
Antibiotics

Ideally, we choose antibiotics based on the level of need – the type of organism, the level of importance (static vs cidal drugs), and known resistance patterns. Often, we have to include route of administration so that clients (and veterinarians) don't get hurt when administering longer term therapy. We also have to remember that many oral drugs will not make it past the rumen or C3 to be absorbed by the patient.

Also ideally, we have a set of guidelines that helps us decide when to pull out the "big guns" and the "big guns" still work because we don't use them unless necessary. The drugs we can use vary by species and we try to avoid using the "big guns" for prophylactic (preoperative, just in case) administration.

Antimicrobial overview (Dr. Alex Bianco)





Drug	**IV***	**IM/ SQ***	**PO***	**Anaerobes**	**Good penetration**
Penicillin	x	x		x	
Ampicillin	x	x			
Cephalosporins	EQ/ SRC	x			
Aminoglycosides	x	x			
Fluoroquinolones	EQ	FA	EQ		
Macrolides		FA	FA/ foals		
TMS/sulfas			x		
Chloramphenical/ Florfenicol		FA	EQ	x	x
Rifampin			EQ		x
Tetracyclines	x	FA			
Metronidazole	foals ($)		EQ	xx	

*US formulations

Prophylactic drug choices tend to be more consistent as prophylactic use is designed to prevent contamination rather than treat an infection. Bacteriocidal drugs are preferred. Managing skin flora is a common concern so drugs that tackle gram positive organisms are typically included. If the surgery will involve the GI tract, gram negative organisms should be on the list. Anaerobic organisms are included when the foot, colon or rumen is involved.

Horses tend to get Excede (a long acting ceftiofur) for castrations and similar superficial procedures. For more involved procedures, they are given gentamicin (for gram negatives) plus penicillin or cephalosporin (for gram positives). Penicillin is also useful for anaerobic organism management. Trimethoprim sulfa is a bacteriostatic drug combination that can be used as a prophylactic antibiotic if needed but it does need to be administered a few hours prior to surgery. It is more commonly used for therapy – it can be given orally and is relatively broad spectrum.

Noteworthy

Gentamicin is strongly discouraged in food animal species due to the prolonged duration in the kidneys (meat **withholding**). Gentamicin can stay in the kidneys for 18 months.

Small ruminants and camelids will often get a cephalosporin (more broad spectrum) or ampicillin. Pigs will often also get these drugs as they are approved in swine and can be given im.

Beef cattle are treated like small ruminants and camelids and get a penicillin, ampicillin or cephalosporin. For dairy cattle, we often start with ceftiofur even though it is more expensive because it doesn't add much antibiotic to the milk and the milk can be safely fed to others. Penicillins and similar drugs are leaked into the milk meaning the milk cannot be sold for human consumption.

See the species specific guidelines and timing recommendations

- Equine antibiotics
- Food animal antibiotics
- Perioperative guidelines

Local anesthesia

We use local blocks very commonly in large animal species. Often bovine standing surgery can be performed without sedation and just with local anesthesia. Epidurals are also relatively easy in dairy cattle and can help with many perineal procedures. More and more horse surgery is being done standing with sedation and local blocks.

Drugs

Lidocaine – Lidocaine is the predominant local anesthetic agent used. Species sensitivity varies with small ruminants and camelids much more sensitive than cattle. Horses are relatively insensitive. The following guidelines are useful to consider as high end doses. Calculate how much you can give and then decide if you need to dilute the drug. Diluted drug still works but has a shorter duration. Hint: 2% lidocaine is 20mg/ml.

Species	Max dose
Cats	2 mg/kg
Sheep and goats	4-5 mg/kg
Camelids	4-5 mg/kg +
Horses	8 mg/kg
Cattle	8 mg/kg +
Swine	8 mg/kg

Mepivicaine lasts longer than lidocaine and can be used for longer procedures if needed. Mepivicaine is commonly used in equine procedures. Bupivicaine can be more tissue toxic and is typically isn't used except for therapeutic long term blocks (laminitis treatment).

Types of blocks

Nerve blocks: If we know where the nerve is, we can just put local anesthetic near the nerve. Eg dehorning blocks, paravertebral blocks, lameness blocks

Line blocks: Local anesthetic is injected in the line of the planned incision. This does deform the tissue planes but is the easiest to perform; no guessing required.

Field blocks: The nerves to a region are blocked using specific types of line blocks. An L block is used in the flank to block the regional paravertebral nerves.

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Ring blocks: A specific type of field block. The entire limb is encircled with subcutaneous local anesthetic to reach any and all nerves

Regional iv blocks: A tourniquet is placed on the limb and local anesthetic injected into a vessel below the tourniquet. The local anesthetic is diluted to the level that it pushes out of the vasculature and into the tissues (typically 20 cc +). This is mock up in a calf using a butterfly catheter (you are supposed to hold the wings up to help direct it).

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Rather than threading the vein, go straight in at the “squishy” part – level of the dewclaws, center of the limb. The vessel is very superficial

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2471#oembed-3

Sterile block: for “top ups” – eg it didn’t work and now you are scrubbed in and sterile (and have to block her again)

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2471#oembed-4

Epidural

The most common epidural agent in food animals is again lidocaine. We typically use 2-8 mg/kg BW, or 5 cc as starting amount in a standard size dairy cow. Lidocaine epidurals can cause ataxia and even recumbency. Lidocaine can be combined with xylazine for longer duration effects with less risk of recumbency; the combination is more common in horses than in cattle. In cattle, detomidine leaves the epidural space quickly so more resembles intramuscular detomidine than epidural detomidine. Ketamine and morphine are other options for epidurals.

Lidocaine/xylazine combo – lidocaine 0.22mg/kg + xylazine 0.05 mg/kg, saline added to total volume of 5.7ml

Combination lasts about 300 minutes vs 80 minutes for lidocaine alone

Epidurals are typically performed in the sacrococcygeal space (the most movable space when the tail is pumped up and down). In dairy cattle, a 1.5″ 18 ga needle is inserted in that space at a 45^{o} angle so that the hub is angled toward the tail. A drop of lidocaine is put in the needle hub and should be sucked down into the needle when the epidural space is reached. This is known as the hanging drop technique. It works well in most dairy cattle but isn't as useful in obese animals.

If the needle is positioned so the bevel is up, the drug will diffuse further forward. If the bevel is pointed down, this will tend to keep the drug in the caudal region.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2471#oembed-5

The needle is this video is way longer than it needs to be but it shows a great hanging drop technique

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2471#oembed-6

Flank anesthesia

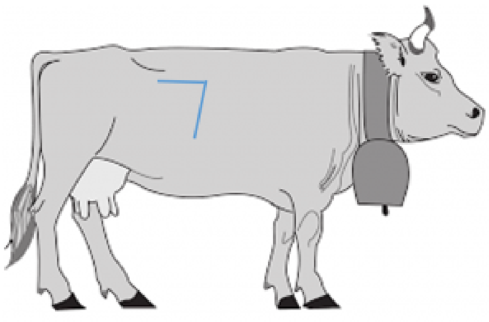
Flank surgery is common in cattle and requires good local block. Options include a line block (at the incision site), an inverted L and paravertebral blocks.

Line block

A line block is an injection of subcutaneous lidocaine along the site of the incision. Relatively straightforward, it is often used when nothing else is working. The block can be easier on the animal if a longer needle is used and is inserted through the site of the last injection. This minimizes the number of pokes in unblocked skin. For flank incisions, it is important to also place lidocaine deeper in the muscle layers.

The main disadvantage of a line block is distortion of the surgery field.

Inverted L block



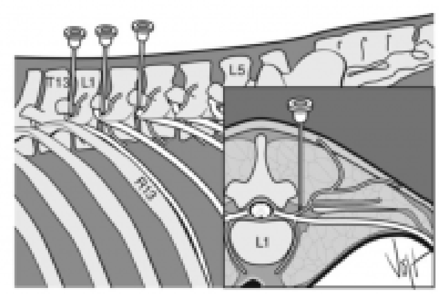
This block is similar to the line block but is used to block the nerves as they come down the flank and avoids lidocaine directly in the surgery field. The lidocaine is injected in two long lines – one just behind the last rib and one below the transverse processes of the vertebrae. The injection must be deep enough to get the deeper nerves and typically does not block the peritoneum.

Proximal paravertebral block

For this block, the spinal nerves T13, L1 and L2 are blocked as directly as possible as they exit the spinal cord. This creates a more

effective block. When the block is working, the cow will bend toward the opposite side as muscles are relaxed. The flank will also be warmer due to related vasodilation.

At each site, ~20 ml of lidocaine is injected. Needles are inserted above the transverse processes T13, L1 and L2 and walked off the dorsal margin of each bone. A long needle is used to block the nerve branches both above and below the fascia.



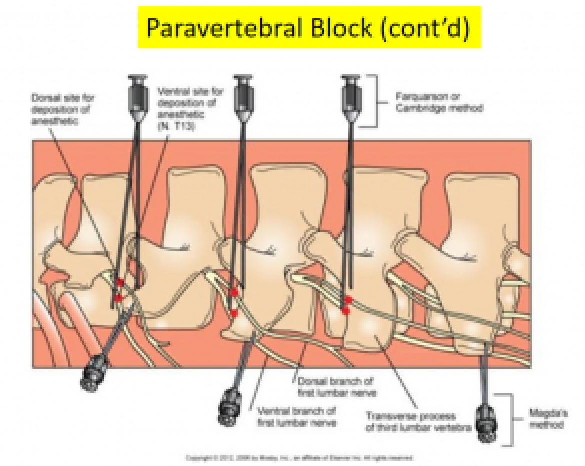
from Veteriankey

This block can be challenging in very large beef breeds due to difficulty palpating landmarks.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2471#oembed-7

Distal paravertebral block

This block is also aimed at spinal nerves T13, L1 and L2 but is coming at them from a more distal position. As the nerves traverse caudally, the injection sites are at the tips of L1, L2 and L4. At each site, 10-20 ml of lidocaine is injected.



from https://slideplayer.com/slide/7545976/

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2471#oembed-8*

Maxillary nerve block for tooth extraction

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2471#oembed-9*

Resources

Ocular blocks chapter

Perineal blocks chapter

Local, Regional, and Spinal Anesthesia in Ruminants, 2016 VCNA- lots of blocks with good diagrams

Local blocks, Kathy Whitman, Great Plains Education Center (ppt will download)

Comparison of lidocaine, xylazine, and lidocaine-xylazine for caudal epidural analgesia in cattle. Vet Anaes Analg 2002

Epidural analgesia in cattle, buffalo and camels, 2016 Vet World

Local anesthesia/analgesia – OSU – all species

A narrative review of caudal epidural anaesthesia and analgesia in horses. Part 1: Safety and efficacy of epidural drugs. 2022 EVE.

A narrative review of caudal epidural anaesthesia and analgesia in horses. Part 2: Clinical indications and techniques. 2022 EVE

Anesthesia induction agents

Induction agents are used to move from standing sedation to recumbency. The most common LA induction agents are ketamine, telazol, and guaifenesin (GG). Propofol is used occasionally in camelids or small ruminants. Masking with isoflurane can be used to induce anesthesia (and is used with pigs) but is higher risk to the environment and to people in the environment.

Ketamine

Schedule III

Ketamine is a **dissociative anesthetic agent** used to induce recumbency after sedation when given at higher doses.

It is commonly combined with other drugs (xylazine, diazepam or midazolam, guafenesin) to prolong the anesthetic duration and to enhance relaxation.

Ketamine is a relatively safe drug with minimal cardiovascular or respiratory depressant effects. “It is hard to kill with ketamine.” Horses must be well sedated before ketamine is given; otherwise life gets a bit too eventful due to the excitement phase of anesthesia. Unlike in horses, there is minimal excitement phase in ruminants. Both the sedative and induction agents can be combined in the same syringe (eg ketamine/diazepam or xylazine/ketamine) and given at the same time.

Telazol

Schedule III

Telazol is a combination of tiletamine (dissociative agent like ketamine) and zolazepam (benzodiazepine like diazepam). It lasts longer than ketamine/diazepam but is more expensive.

The drug needs to be reconstituted prior to use and then has a limited shelf life.
It can be administered intramuscularly (can be handy at times).

Guaifenesin (GG)

Guaifenesin is a muscle relaxant that helps counteract the rigidity associated with ketamine. GG must be compounded and can be explosive if done incorrectly.

It can be used for induction (0.5-2 ml/kg) but has a slightly delayed effect so overdosing is a risk. However, the gradual induction minimizes the apnea risk.

GG is combined with xylazine and ketamine to form “triple drip” or with just ketamine to form “double drip” (see maintenance protocols). The combinations are used more commonly than is GG alone.

Side effects : Very irritating perivascularly. Use a catheter. Overdoses of GG can lead to increased muscle tone, making the animal appear too light vs too deep.

****

See the next chapter for species specific links

Anesthesia maintenance agents

Maintenance of anesthesia is commonly performed using one or more these protocols

- repeat injections of the sedative and induction agents
    - typically this uses 1/2 doses as needed
    - some agents (benzodiazepines) have a long half life and do not need redosing
- constant rate infusions (CRI)
    - common combinations include triple drips and double drips
    - just about any induction agent or combination of agents can be made into a CRI infusion
- intubation and inhalant anesthesia
    - intubation often requires a deeper plane of anesthesia
    - this can be risky in LA species, particularly if effective ventilation is not possible
    - if procedures will last more than 60 minutes, intubation and inhalant anesthesia is strongly recommended

See species specific information

- equine general anesthesia
- food animal general anesthesia
- small ruminant sedation and anesthesia
- camelid sedation and anesthesia
- swine sedation and anesthesia

Drug Dosing, Concentrations and Recipes

Dosing for general anesthesia or even for standing sedation is tricky. There are species variations, diseases that impact drugs and drugs that impact diseases, change with age, etc. Not to mention resources all come with ranges. So how do you know where to start? The following are my approaches to different situations. You will develop your own over time!

In general, if I can find the same dose in two separate references, I feel pretty comfortable. I will search Veterinary Clinics of North America or do a google search with edu added to the requirements (see extreme googling). I may also search by someone's name (eg Hubbell for anesthesia stuff).

Antibiotics

Generally I use the higher end of the range for oral antibiotics, figuring some will end up on me or on the floor, not in the animal. For IV, IM or SQ antibiotics, I go higher with the very safe drugs, lower with the unsafe ones. Neonates usually need more drug due to the higher volume of body water. Sick animals may need less frequent administration due to less effective metabolism of the drug. Most drugs are metabolized by the liver or kidneys and excreted by the kidney. If those organs are impaired, the drug will stay around longer. Drugs metabolized by the liver may also impact other drugs through the cytochrome P450 system. Those need to be researched more thoroughly.

Sedatives

I tend to go light on sedatives until I have more information on how the animal will respond. Clients may be able to tell you if the horse is a 'lightweight" or "sucks down drugs". Assume ruminants are light weights. Overdosing can make your patient very sleepy. If you are trying for a standing sedation, you really don't want them super sleepy. It is frustrating to spend all your time trying to get them to stop swaying or to perform your standing procedure with the animal on the ground.

Anesthetic agents

There is nothing worse than an animal that will not hit the right plane of anesthesia but keeps waking up. This is more likely if you underdose the sedative and induction agents. For these, I go in the upper half of the range. If the animal is healthy, I go higher in the range than if they are sick. Intact males get the high end; testosterone really seems to interfere with the effect of the drugs (no neurons?). It is much easier to maintain a surgical plane of anesthesia if you get there on the first try. If there is a large range (ketamine), it is usually a safe drug. Remember many animals are sensitive to xylazine.

Standard drug concentrations

Drugs	Concentration	Bottle Size
Acepromazine	10mg/ml	50ml
Butorphanol	10mg/ml	10ml
Detomidine	10mg/ml	50ml
Ketamine	100mg/ml	10ml/bt
Lidocaine	20mg/ml (2%)	250ml
Midazolam (or Diazepam)	5mg/ml	10ml
Penicillin-G (Procaine)	300,000 IU/ml	250ml
Sterile Diluent (for Telazol)		
Telazol	100mg/ml	5ml
Xylazine (Equine version)	100 mg/ml	100ml
Xylazine (SA or ruminant version)	20mg/ml	20ml
Morphine	10mg/ml	1ml vials

Midazolam drip recipe: 5ml (25 mg) midazolam + 20 ml (2 g) ketamine +5 ml (100 mg) 20mg/ml xylazine in 1 liter bag fluids.

Xylazine/ketamine drip recipe: 50 mg xylazine and 1.0 to 1.5 g ketamine added to 1 L electrolyte solution

Double drip -Ketamine (1mg/ml or 1g/L) is added to 5% Guaifenesin

Muscle relaxation should be satisfactory if an adequate dose of xylazine is used at induction, or it can be improved by administering 25 to 50 mg of midazolam or diazepam intravenously as a bolus or by increasing the infusion rate of xylazine and ketamine. Approximately 2-4 ml/100# BW /hour.

See the following chapters for species specific doses and protocols.

Pharmacology terms

Dr. Alex Bianco

Use this section as a resource for interpreting articles and advanced materials.

Definitions

Pharmacokinetics =What the body does to the drug. E.g. Metabolism, elimination
Pharmacodynamics =What the drug does to the body. E.g. Desired effects + adverse effects (AE)
Dosage =Amount of drug administered per unit body weight. Mg/kg, mg/lb, IU/kg
Dose =The amount of drug the animal receives. Total mg/tablets/mL
Initial concentration (C_0)= [Drug] at first time point after administration (t=0)
Maximum concentration (C_{max}) = The highest [drug] obtained after a single dose of drug
Concentration at steady state (C_{ss}) =Applies to repeated drug administration or CRI; the [drug] where drug administration and clearance equilibrate
CRI -constant rate infusion (an iv drip)
Terminal half life ($t_{1/2}$) = The amount of time it takes to decrease the plasma [drug] by 50%

$t_{1/2}$ = (0.693 *Vd)/Cl = 0.693/k where k = the elimination rate constant (slope of the elimination curve)

Clearance (Cl) = Rate at which drugs are eliminated from the body (urine or feces). Cl is inversely proportional to half-life

$$Cl = (0.693 * Vd)/(t_{1/2})$$

Volume of distribution (Vd) =Amount of drug in body relative to plasma volume

↑Vd_{ss}= more drug NOT IN plasma
↓Vd_{ss}= more drug IN plasma

$Vd = (Dose\ (mg))/C_0$ Can only calculate from iv parameters

Time to maximum concentration (t_{max}) = How long it takes before reaching C_{max}. Depends on rate of absorption vs. clearance

tmax always = 0 when given IV : highest drug concentration is immediately after administration

Bioavailability (F%) =Percentage of drug administered that is ultimately absorbed in to bloodstream.

Calculated by comparing to same dose given IV (100% bioavailable). Measured by comparing area under the curve using trapezoidal rule (fancy math)

Routes of administration

IV administration

$C_0 = C_{max}$

C_{max} after IV dosing will ALWAYS be higher than other route of administration

A drug given IV will always have a shorter withdrawal time than when given by other routes

Other routes

Once drug enters blood, it should behave as with IV dosing

Rate of absorption (k_a) = the time it takes to reach the blood

Bioavailability is never 100%. Drug is simultaneously being cleared/absorbed

PO is generally a lower peak (C_{max}) and a longer elimination

Some drug is never absorbed when given po.

Parameters of interest

Time dependent antibiotics – we care about time above MIC

Concentration dependent antibiotics – we care about C_{max}: MIC ratio and AUC: MIC ratio

Other resources

Pharmacology chapter, Dairy Production Medicine ebook

Swine drugs, Dr. Z's antibiotic ebook

Practice: Adjusting drug frequency and doses for neonates

Level C. What happens if you have a neonate? Neonates are mostly water (much more so than adults) and often don't have normal drug elimination due to immature kidneys.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=122#h5p-16

RESOURCES

These videos help explain why neonates need different dosing protocols. The powerpoints referred to are in the regulatory section but I think you can follow these without viewing those first.

One or more interactive elements has been excluded from this version of the text. You can view them online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=122#oembed-1

One or more interactive elements has been excluded from this version of the text. You can view them online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=122#oembed-2

Neonatal Adjustments. November 2003, Veterinary Clinics of North America Food Animal Practice 19(3):551-6, v

Note: the same principles apply for liver dysfunction and in neonates of other species:

Effect of age on the pharmacokinetics of a single daily dose of gentamicin sulfate in healthy foals .
Intravenous administration of gentamicin at a dose of 12 mg/kg bwt q. 36 h would be required in foals less than 2 weeks of age. In foals 2 weeks of age or older, a lower dose of 6.6 mg/kg bwt given q. 24 h was predicted to be adequate.

Equine Drugs

Equine drugs are simpler than food animal drugs due to the current lack of market for equine meat. This section discusses specific equine NSAIDs, analgesics, antibiotics and anesthetic agents.

Equine NSAIDs and Analgesics

Remember, analgesics need to be given prior to the pain to prevent windup and hyperalgesia.

We don't do preoperative medications well in most field surgeries (including castrations). Often we give our perioperative antibiotics after the procedure and we offer NSAIDs as a client option. If we give NSAIDs, it is often after recovery. *And this makes no sense other than tradition.*

- Giving antibiotics preoperatively means they are on board to fight any contaminants. Giving them afterwards means the little buggers have had time to gain a foothold and even multiply.
- Giving clients the option of NSAIDs means costs drives the discussion. Every horse deserves pain relief.
- Giving NSAIDs after the procedure is NOT cost effective. Your drugs are less useful due to windup and you have to give more to get to the same effect.
- If cost is a concern, a preoperative dose is the most cost effective!

NSAIDs

NSAIDs are the most commonly used analgesic in horses. The most common non-steroidal agents used in horses are phenylbutazone ("Bute"), flunixin meglumine ("banamine"), and firocoxib (Equioxx), in that order. All three have similar side effects but to various degrees.

Phenylbutazone

"Bute" is the cheapest NSAID and is available in oral (tablet, powder, paste) and iv formulations. It is very irritating so should never be given intramuscularly. IV injections should be given carefully to avoid perivascular administration.

Standard doses for 1000# horses are 2-4 grams per day. The high end of the range (4 grams per day) should be given for as few days as possible. Phenylbutazone is generally used for musculoskeletal issues.

Bute does come in smaller sizes and can be compounded with flavoring. It has excellent bioavailability. Higher doses increase duration rather than increasing analgesia.

Phenylbutazone is the least safe in terms of side effects. It should be avoided in neonates as well as in animals with renal or GI disease. Bute should ideally be minimized or avoided in pregnant mares. However, many performance mares are retired as broodmares due to musculoskeletal issues and have chronic pain. Many are on bute for the chronic pain. This can lead to birth defects and foals with bute toxicity.

Flunixin meglumine

Flunixin or “Banamine” is more expensive than “Bute” but is considered safer. It is generally used for gastrointestinal or other visceral pain. It comes in oral (paste) or iv formulations. While labeled for intramuscular use, it should never be given intramuscularly as it creates a significant risk of clostridial myositis.

Bioavailability is good at 80%. Higher doses increase duration vs increasing analgesia.

Banamine is commonly used for pain relief in colics. Avoid overdosing or “stacking” NSAIDs (using bute + banamine). Doubled up NSAIDS increase the likelihood of renal damage. Maintaining hydration is essential to minimize renal damage.

Firocoxib

Firocoxib or “Equiox” (LA version of Previcox) is much safer and the most expensive. It is used for long term therapy in horses that don’t tolerate phenylbutazone. Use of the small animal version is common but illegal.

A 3x initial dose is often used to more rapidly increase serum levels (FWIW).

Diclofenac sodium

Diclofenac or “Surpass” is a topical NSAID (cream) that is applied to inflamed areas. Side effects are minimized by restricting the dose to the affected site (minimal systemic absorption). It has been used rectally for postoperative pain.

General notes for NSAIDs

Increasing dose leads to increased duration of action rather than increased efficacy. Two grams once a day has similar activity to one gram twice a day, and may be easier for owners to administer.

Blood levels are mostly irrelevant. NSAID levels at the site of action are necessary to determine appropriate dosing. *Many articles publish blood levels!* Be cognizant of their purpose in measuring blood levels. Many times blood levels are needed for regulatory purposes (e.g. did the horse show or perform while on NSAIDs?). This is not the same as effectiveness of the drug. And the discussion portion of the article often confuses the two.

Most common side effects are gastrointestinal (stomach ulcers, oral ulcers, right dorsal colitis) and urinary (kidney failure, hemorrhagic cystitis). ***Lowered TPP (part of the PCV/TPP) is an early warning sign.*** Other symptoms include poor appetite and isosthenuric urine (due to renal damage).

Prostaglandins are important in most facets of physiology so NSAIDs have the potential to interfere with everything from bone healing to parturition.

Narcotics

Narcotics and other non-NSAID drugs are used when additional pain relief is needed or when the pain isn't caused by inflammation.

Butorphanol

Schedule IV

Butorphanol is a narcotic analgesic. It acts as a narcotic but can reverse other narcotics (partial agonist-antagonist). It is commonly used in combination with sedatives such as xylazine or detomidine.

Typically, 0.5 -1 ml is given iv or 2 ml im (10 mg/ml). It is absorbed orally, as well.

More effective than morphine, it starts working in ~ 15 minutes and can last up to 4 hours.

Butorphanol is excitatory in healthy adult horses so **should not be given alone**. An excited horse can be a very dangerous horse. Butorphanol is more of a sedative in neonates and it tends to not cause excitement when given im to horses in pain (but use caution). Repeated doses can lead to poor motility and colic.

Butorphanol can reverse the effects of other narcotics so shouldn't be given until those have worn off.

Reversal: naloxone

https://equimed.com/drugs-and-medications/reference/butorphanol

Buprenorphine

Buprenorphine (5-10 ug/kg bwt iv) is a narcotic that has been found to be superior to butorphanol in managing equine surgical pain. As a narcotic, it should typically be given with sedation. The recommended dose is 7.5 ug/kg iv to avoid excitement. The antinociceptive effect lasts 6-12 hours.

Buprenorphine can be administered sublingually in foals.

It was not found to be associated with any increased risk of colic.

Reversal: naloxone.

A multicentre, prospective, randomised, blinded clinical trial to compare some perioperative effects of buprenorphine or butorphanol premedication before equine elective general anaesthesia and surgery. Equine veterinary journal, 2016-07, Vol.48 (4), p.442-450

Morphine

Schedule II

Morphine is a narcotic with similar effects to butorphanol but with lower level analgesia and longer duration. GI motility disturbances are more noticeable (constipation and colic). Systemic morphine causes hyperphagia (increased appetite) but also caused gastric distension and decreased intestinal activity. This could lead to significant issues, particularly gastric rupture or impaction.

Dose 0.1–0.3 mg/kg (0.045–0.15 mg/lb) IM q4-hr; often preferred as a CRI:

- Morphine loading dose: 0.16 mg/kg (0.07 mg/lb) IV
- Morphine CRI: 0.1 mg/kg/hr (0.045 mg/lb/hr) IV

Reversal: naloxone

Tessier C. Systemic morphine administration causes gastric distention and hyperphagia in healthy horses. Equine Veterinary Journal 51 (2019) 653–657

Fentanyl (patch)

Schedule II

Fentanyl patches are useful for pain relief in patients when NSAIDs are contradicted or not sufficient. Patches should be applied to an area with minimal hair covering and secured in place (upper forelimb).

One 10-mg patch per 150 kg of body weight is recommended. Patches can take 4 hours to provide analgesia and last 36-48 hours. There is great variability between horses in how much fentanyl is absorbed; this variability is increased in sick horses.

Humans can absorb the fentanyl from the patch so careful monitoring, handling and removal is indicated.

https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/duragesic

Gabapentin

Gabapentin is an anti-epileptic drug that has been used to treat neuropathic pain and prevent windup. It's mechanism of action is unclear but is thought to involve inhibition of neurotransmitter release.

It has been shown to be absorbed in horses when given iv but has poor oral bioavailability (16%). Studies on its efficacy are limited but it is being used to treat laminitic pain.

Check the literature for the latest recommendations.

https://onlinelibrary-wiley-com.ezp1.lib.umn.edu/doi/full/10.1111/j.1365-2885.2010.01161.x

Future drugs

NMDA antagonists – Ketamine and magnesium block the development of hyperalgesia and are being investigated in multiple species for pain control.

Other drugs with potential include grapiprant, epoxide hydrolase inhibitor, and antibodies against nerve growth factor.

Non-pharmacological pain control

Acupuncture, extracorporeal shock wave therapy, chiropractic and massage may help with pain.

Local anesthesia (epidurals, local blocks, neurectomy, etc) also have a role in selected cases.

Resources

Pain management in horses, by our own Dr. Guedes; VCNA 2017-04, Vol.33 (1), p.181-211

Non-steroidal anti-inflammatory drugs in equine orthopaedics, Equine Vet J. 2022;54:636–648. Nice review of options and side effects related to musculoskeletal injuries.

BEVA primary care clinical guidelines: Analgesia; EVJ l 52 (2020) 13–27- systematic review of the research, focusing on field practice

> *Excerpt:* Key guidelines produced by the panel included recommendations that horses undergoing routine castration should receive intratesticular local anaesthesia irrespective of methods adopted and that horses should receive NSAIDs prior to surgery (overall certainty levels high). Butorphanol and buprenorphine should not be considered appropriate as sole analgesic for such procedures
> (high certainty). The panel recommend the continuation of analgesia for 3 days following castration (moderate certainty) and conclude that phenylbutazone provided superior analgesia to meloxicam and firocoxib for hoof pain/laminitis (moderate certainty), but that enhanced efficacy has not been demonstrated for joint pain. In horses with colic, flunixin and firocoxib are considered to provide more effective analgesia than meloxicam or phenylbutazone (moderate certainty)

Perioperative pain management in horses, Equine Veterinary Education, July 2019, Vol.31(7), pp.374-383-review article with guidelines on what to use and when

Therapeutic developments in equine pain management, The Veterinary Journal, May 2019, Vol.247, pp.50-56-review article with more thoughts on future drugs- and case examples

Nonsteroidal Anti-inflammatory Drug Use in Horses, Veterinary Clinics of North America: Equine Practice, April 2017, Vol.33(1), pp.1-15- the entire volume is dedicated to NSAIDS; this is a nice review of actions, contraindications, side effects, etc.

NSAID hints by a horse vet – administration and choices

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=245#oembed-1

Study break– it isn't all about horses

Equine Antibiotics

For these surgery topics, the most common systemic antibiotics in horses are

Trimethoprim sulfonamide or sulfadiazine

Given orally, TMS has a relatively broad spectrum of action and penetrates into tissues well due to lipophilicity.

Crosses blood brain barrier. Elimination via renal excretion. Time dependent activity.

Side effects are rare but include hypersensitivity reactions, folate deficiency, and colitis.

Doses range from 15-30 mg/kg po every 12-24 hours.

Resistance patterns can help determine which formulation is best for a given population.

The combination of oral administration and broad spectrum activity makes it a favorite for at home care of horses. Owners are typically able to administer it. Generally it is crushed or dissolved in water and then mixed with flavoring and squirted into the horses mouth or added to the grain (some horses will not eat it in the grain).

Enrofloxacin

"Baytril" can be administered iv or orally. It works through concentration dependent killing, meaning it works best when used at high levels less often. Enrofloxacin works best against gram negative organisms and some gram positive organisms (Staphylococcus). It is not very effective against anaerobes.

Highly lipophilic with high concentrations found in the liver, spleen and kidney; moderate concentrations are found in most tissues; mild concentrations in CSF and eyes.

Elimination is primarily in the urine.

Enrofloxacin can cause joint disease in young animals as well as diarrhea and neurological disease in all groups. Recent research suggests it is safe for use in pregnant mares after the first trimester.

Generally, enrofloxacin should be reserved for cases with known resistance to other drugs or for cases in which other drugs have been shown ineffective.

Dose ranges:

- 5mg/kg IV q24h or 5-7.5mg/kg PO q24h

Procaine penicillin G

PPG is given intramuscularly and can cause anaphylactic reactions and death if given iv. It is most effective against gram positive agents and anaerobes.

Distributes widely in the plasma but penetrates poorly through biological membranes. Does not penetrate abscesses or sites of tissue necrosis well.

Elimination is via renal tubular secretion.

Time dependent activity.

The label dose is ineffective. Therapeutic and effective preventive doses start at 22,000 IU/kg.

It is cheap but does require im administration which can be tricky for some owners and with some horses.

Gentamicin

Gentamicin is generally given iv. It is effective against gram negative agents.

It is not effective in acidic (pus filled) or anaerobic environments and does not penetrate into tissues. It must be carried by the vascular system.

Elimination occurs via glomerular filtration

Concentration dependent activity.

Side effects are primarily renal damage. Be careful using gentamicin in dehydrated animals, particularly in combination with other renal toxic drugs (NSAIDs). Older references may suggest 2.2 mg/kg TID but it is safer to administer at 6.6 mg/kg SID as this creates the most bacterial kill with the least side effects.

Gentamicin is rarely given by owners; it is typically administered by veterinarians or in hospital settings.

Amikacin

Amikacin is primarily used as an agent for iv regional perfusion (local antibiotic therapy) and in foals. It is otherwise too expensive. As with gentamicin, it targets gram negative organisms and side effects are primarily renal damage.

Dose ranges:

- Adults: 10-20 mg/kg IV q24h
- Foals: 20-25mg/kg IV q24h

Ceftiofur

"Excede" is the most common formulation used today. It has good broad spectrum coverage into tissues but does not enter the CSF in adequate levels.

Hydrolyzed by the liver, eliminated by the kidneys.

Time dependent activity.

A single intramuscular dose lasts 4 days. The most common side effect is diarrhea, which can be severe. "Naxcel" is often used in hospitals but must be given daily for treatment.

Due to the prolonged effect, Excede is a favorite drug for castration surgeries – it covers prophylactic and treatment needs.

Dose ranges for ceftiofur:

- Adults 2.2-4.4 mg/kg im 24h (not more than 10 days of treatment)
- Foals 10mg/kg im, iv or sq, q6-12h
- CRI 2.2 mg/kg iv bolus, then 12 ug/kg/min

Dose ranges for Excede: 6.6 mg/kg im at 0 and 96h

Other antimicrobials are used for specific diseases or disorders.

See Perioperative medications for timing information and duration of therapy.

RESOURCES

Overview of the use of antimicrobial drugs for the treatment of bacterial infections in horses, EVE 2021. Discusses choice, appropriate use and misuse, as well as bacteria+ drug combos

Antimicrobial resistance learning site

Principles of Antimicrobial Therapy: What Should We Be Using? Vet Clin Equine 22 (2006) 279–296- good review of surgical use of antibiotics

Adverse Effect of Antibiotics Administration on Horse Health: An Overview – JEVS 2021 – nice overview of drug actions, effects, and side effects

OSU VMC Antimicrobial use guidelines – great place to start when choosing a drug

Veterinary Advances: equine drugs (untested)

Vin.com drug formulary (membership is free for students)

Equine Sedatives and Calming agents

The most commonly used sedatives and tranquilizers in horses are:

Xylazine

Xylazine is a common equine sedative. It can be given iv, im or (less commonly) sq and acts on alpha 2 receptors. It also provides analgesia and is synergistic with opioids for both sedation and analgesia.

Doses range from 100-200 mg iv (1-2cc of 100mg/ml) for most horses. Larger horses are more sensitive and young horses generally need more per kilogram of bodyweight. Allow horses to sedate fully before stimulating or the sedation may not take effect.

Side effects include decreased GI motility, bradycardia, nasal congestion, and decreased thermoregulation. Sedated horses put most weight on their forelimbs, making them light behind. If startled, they are more likely to kick and less likely to give warning. Xylazine alone should not be used to sedate horses for hindlimb procedures including rectal palpation. Don't use in horses on iv TMS (this drug formulation is rare in the US).

Occasional horses become xylazine aggressive and turn mean when sedated. Excessive or sudden stimulation can override the sedation.

Reversal : yohimbine (off the market); atipamezole

Contraindications: Be cautious in horses with heart disease. Do not use in neonates as it impairs cardiac output. Use benzodiazepenes instead.

https://equimed.com/drugs-and-medications/reference/xylazine

Romifidine

Romifidine is an alpha-2 agonist that is similar to xylazine but with longer duration and less associated ataxia. It is popular with equine dentists.

Sedative dose: 0.04-0.12 mg/kg slow iv (10mg/ml)

Side effects and contraindications: Side effects are similar to xylazine with occasional episodes of colic after its use. Rarely a horse will become excited rather than sedated.

http://equimed.com/drugs-and-medications/reference/romifidine

Detomidine

Detomidine is yet another alpha-2 agonist with even longer duration effects. Detomidine does a better job of balancing the horse's weight (4 point stance) and is safe to use when working on the hindlimbs.

Detomidine is routinely given iv or im but does come as an oral gel that can be used for fractious horses (it does take 30 min to kick in). Typical doses are 0.5-1 ml (10 mg/ml).

Detomidine has a ceiling effect so increasing doses increase duration rather than increase sedation.

Side effects are the same as for xylazine but more significant due to the longer duration.

https://equimed.com/drugs-and-medications/reference/detomidine-hydrochloride

https://www.zoetisus.com/products/horses/dormosedan.aspx

Acepromazine

Acepromazine is a tranquilizer or calming agent. It does not have analgesic properties. It can be given orally, im or iv. It does have a delayed onset of action; 20 minutes may be required even with iv administration.

Dose iv or im: 2-4 ml (10mg/ml) for 1000# horse

Side effects: Ace is safe in most horses. Caution is needed in stallions and those horses in shock or with anemia. Ace lowers blood pressure and hematocrit. Ace can cause penile prolapse and priapism (persistent erection) in stallions and in geldings with urethral irritation. This condition can rapidly lead to fertility issues.

https://onlinelibrary.wiley.com/doi/full/10.1111/j.1365-2885.1982.tb00495.x

Diazepam and Midazolam

Schedule IV drugs.

Diazepam and midazolam are primarily used to relieve anxiety and enhance the sedative effects of other drugs. They act as sedatives in neonates.

Diazepam and midazolam are the preferred sedatives for neonates. Neonates cannot adjust stroke volume so have significant cardiovascular depression with the alpha-2 agents. (Cardiac output = SV * HR)

These benzodiazepenes are used interchangeably. Price variations are common so the cheapest drug is generally the one used. Diazepam must go iv, is light sensitive and cannot be stored in plastic (syringes). It generally cannot be mixed with other drugs (ketamine is okay). Midazolam can be given im and does not bind to plastic. It can be mixed with most other drugs and rectal administration may be effective.

Dose: 0.02-0.4 mg/kg

Side effects: both drugs are metabolized by the liver and the cytochrome P450 system. As such, they can be affected by and can affect the metabolism of other drugs.

The drugs are also used as anticonvulsants, muscle relaxants and appetite stimulants.

https://equimed.com/drugs-and-medications/reference/diazepam

https://www.sciencedirect.com/topics/neuroscience/midazolam

RESOURCES

Anesthesia, Sedation, and Pain Management of Donkeys and Mules, 2019 VCNA Vol.35(3), pp.515-527

Practical standing chemical restraint of the horse, AAEP 2009

Anesthesia and analgesia for standing equine surgery, Vet Clin N Amer 2014

Plumb's Veterinary Drug Handbook and app (lots of versions out there in different formats and prices)

Equine Standing Sedation Protocols

Many procedures are performed in horses using standing sedation and local blocks. This avoids the risk of general anesthesia and can make surgery easier due to the position, height and decreased blood loss (lower flow to the head and back). However, it can be more dangerous for the veterinarian and any assistants; patient selection is important.

General anesthesia in horses can be challenging due to horse's fight or flight response. Horses tend to react rather than think; this can lead to dangerous situations particularly when they are waking up from anesthesia. Large horses can also develop myopathies and neuropathies due to the pressure of the large body weight on bony prominences. Finally horses tend to not ventilate well and hence have poor oxygenation under anesthesia.

Xylazine alone

Xylazine is used daily in the equine world as a sedative + analgesic. Xylazine can cause significant bradycardia and arrhythmias. To minimize these effects, we want to use low doses. We can use low doses if we add other drugs. Combining xylazine with butorphanol potentiates xylazine sedation and analgesia, meaning we don't need as much xylazine.

Remember, there are times when xylazine is a bad idea:

- Neonatal animals – cardiac output is HR x stroke volume. If you use xylazine, you slow HR. However, neonatal animals can't adjust stroke volume. So you end up with minimal cardiac output. Not good. You can use butorphanol alone in this age group – they get sedated vs excited. We also use the benzodiazepines – diazepam and midazolam for calming.
- Hot days –xylazine interferes with thermoregulation and animals can become dangerously overheated.
- Horses with xylazine aggression –every once in awhile a horse will become a biter when given xylazine. It is rare but if you see it, make a big note in the record and only use detomidine.
- Heart conditions and arrhythmias – probably not a good idea if the horse already has an abnormal heart rate. Always listen first.

Xylazine + butorphanol

While excitatory on its own, butorphanol potentiates the sedation and analgesia of xylazine. Adding butorphanol to xylazine also helps with human safety by creating a better balanced stance and less risk to anyone standing behind the horse.

Remember, butorphanol is a partial opioid agonist/antagonist so can actually reverse the effects of other narcotics. Do not combine it with other narcotics.

Detomidine and romifidine

Xylazine is also fairly short acting. It lasts about 15-20 min. If you are doing surgery, it can be challenging to stop every 20 min and re-dose. That is when we change to detomidine. Detomidine is another alpha-2 agent and lasts much longer. It also provides a better balanced stance so sometimes we use it instead of the xylazine/butorphanol combination for hind end work. Detomidine can last 30-60 minutes. For surgeries, we often combine it with butorphanol to prolong the duration and add more analgesia.

Romifidine is another alpha-2 agent. Equine dentists like romifidine as the horses are less ataxic (wobbly) with romifidine than with xylazine. Horses often sway with xylazine, probably due to the weight shift. You can add butorphanol to minimize the swaying but some horses get tics or muscle twitches with narcotics and that can be annoying if you are doing stuff around the head (dental surgery, eye surgery).

Typical protocols involve an alpha-2 agent and a narcotic, either given as repeated injections or as an infusion.

Example 1. Xylazine 1.5 ml and butorphanol 0.5 ml ("150 & 5")

Example 2. Detomidine 0.5 ml and butorphanol 0.5 ml iv ("5 & 5")

Example 3. Butorphanol 1ml + detomidine drip- bolus of 0.01 mg/kg iv followed by an infusion of 0.01 to 0.04 mg/kg/h

We say "1.5/5" to mean 150 mg xylazine and 5 mg butorphanol. Or "5/5" to mean 1/2 ml detomidine and 1/2 ml (5 mg) butorphanol. Agreed – it is terribly inconsistent in terms of mgs and mls.

Acepromazine combinations

Acepromazine is another drug used in standing procedures. Ace is a tranquilizer. It calms rather than sedates. It also causes severe hypotension so is used in healthy animals only. Ace can be added to the sedation protocols, as well. Horses that are super excited do not respond well to alpha-2s. They can override the sedative effect. Ace can help take the edge off.

Really misbehaving horses can get RAT –rompun (xylazine), ace, and torbugesic (butorphanol).

Butorphanol combinations

Butorphanol is rarely used as a sole agent in horses. Narcotics cause excitement in horses and cats. Generally avoid giving butorphanol or other narcotics to these species unless they are already sedated. However, butorphanol is a sedative in neonatal foals.

For general sedation and for front end procedures such as skull rads or forelimb surgery, we can sedate with an alpha 2 drug – xylazine, romifidine or detomidine. To prolong the sedation and better balance the horse's stance, we add butorphanol. These drugs can be re-dosed or be administered as an infusion for longer procedures.

Dr. Branson's constant rate infusions- sedation and/or analgesia

All are for a 450kg horse at the low end of the range and all should be preceded by a loading dose.

Xylazine	0.55mg/kg/hr	250 mg/hr for 450kg horse
Detomidine	0.01-0.04 mg/kg/hr	5 mg/hr*
Romifidine	0.03 mg/kg/hr	14 mg/hr*
Dexmedetomidine	0.0025-0.005 mg/kg/hr	1.1 mg/hr*
Butorphanol	0.01-0.025 mg/kg/hr	5 mg/hr*
Morphine	0.025-0.05 mg/kg/hr	11 mg/hr*
Ketamine	0.4-0.8 mg/kg/hr	180 mg/hr*
Lidocaine	3 mg/kg/hr	1350 mg/hr* (1.3 mg/kg loading dose)

Resources

Anesthesia and analgesia for standing equine surgery, Vet Clin N Amer 2014

How to maximize standing chemical restraint, AAEP 2013- by our own Dr. Guedes

Practical standing chemical restraint of the horse, AAEP 2009

Ch 24 Sedation and Anaesthesia, Equine Medicine, Surgery & Reproduction 2nd edition

Manual of Clinical Procedures in the Horse– see Ch 9. Chemical restraint

Equine General Anesthesia Protocols and Procedures

Anesthetizing horses is quite different from anesthetizing dogs and cats.

Watch this video for a general overview. FWIW I have *never* had someone put a tarp over me and I tend to be less hands on but this is pretty typical for the induction and recovery (the castration bit has been removed):

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=397#oembed-1

Preoperative care

It is always important to do a complete physical exam. The death rate for healthy horses that undergo procedures using anesthesia is 0.9% and this is increased to 1.9% in sick horses. Elective procedures should be performed only in healthy horses.

Food should be withheld for 6-12 hours prior to surgery and horse allowed free access to water. The longer food is withheld, the more likely GI upsets are to occur. The normal stomach empties in about 1-2 hours.

Tetanus vaccination should be up to date (within 6 months).

Preoperative NSAIDs are almost always indicated! Surgery causes inflammation and the effect of the drugs is much better if given prior to windup. Preoperative antibiotics should be given for GI, urogenital and respiratory surgeries and with any known infections. See the perioperative medications chapter.

Anesthetizing horses

As with other species, anesthesia involves

1. **sedation** – xylazine, romifidine, detomidine
    1. optional additional sedatives or analgesics –

butorphanol or acepromazine (given with sedatives) diazepam or midazolam (given at induction)

2. **induction** – ketamine, telazol, guaifenesin (GG)

3. **maintenance** – repeated doses of sedatives and induction agents or infusion of drugs and drug combinations – infusions of drugs iv, repeated doses of induction agents, intubation and inhalants

This narrated powerpoint works more slowly through the steps of anesthesia for castration of a pony, including some short videos. Watch through 3:50. You will see this again in the castration section.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=397#oembed-2

Horse are generally **not** intubated or maintained on inhalant anesthetic agents except in specialty or referral settings. Horses are easy to intubate but intubation requires a deeper plane of anesthesia than does the surgery. Camelids are NOT easy to intubate. In both situations, it isn't common to carry oxygen cylinders in trucks (explosion hazard) and LA anesthesia machines are not portable. Intubation holds the airway open but does not bring the same advantages in the field setting as it does in a hospital where it is conduit for oxygen and inhalant anesthetics.

Monitoring is typically through vital signs (pulse quality and rate, respiratory quality and rate, ocular reflexes and positioning). Pulse oximeters are portable and easy to use. Doppler blood pressure monitoring is useful, particularly in foals.

Common induction and maintenance drugs

Ketamine

Schedule III

Ketamine is a **dissociative anesthetic agent** used to induce recumbency in horses after sedation. It is commonly combined with diazepam to prolong the anesthetic duration and to enhance relaxation.

Ketamine is a relatively safe drug with minimial cardiovascular or respiratory depressant effects. "It is hard to kill with ketamine." However, horses will pass through an excitatory phase so it should be given iv after strong sedation and given rapidly. If redosed, ensure horses are still sedated (eg with xylazine) prior to recovery. They should not recover on ketamine alone.

Initial dose is typically 1cc/100# (100mg/ml). Eg a 1000# horse gets 10cc ketamine. A redose is typically 1/2 the original dose.

Ketamine is also used as an iv infusion and epidurally for pain relief to awake horses.

Injectable field anesthesia, 2011 ACVS

Telazol

Schedule III

Telazol is a combination of tiletamine (dissociative agent like ketamine) and zolazepam (benzodiazepene like diazepam). It lasts longer than ketamine/diazepam but is more expensive.

The drug needs to be reconstituted prior to use and then has a limited shelf life.

It seems to work better when paired with detomidine vs xylazine.

Ketamine, telazol, xylazine and detomidine. A comparative anesthetic drug combination study in ponies. Acta Vet Scand 1992

Triple drip

Triple drip is a combination of xylazine, ketamine and guaifenesin used to maintain anesthesia.

Xylazine (500 mg), ketamine (1000 mg or 1 g), in a liter of 5% guaifenesin (50mg/ml), given at 1ml/lb/hr.

Guaifenesin (GG) is a muscle relaxant that helps counteract the rigidity associated with ketamine.

Injectable GG is only available through compounding pharmacies at this time.

Side effects: Very irritating perivascularly. Use a catheter. Overdoses of GG can lead to increased muscle tone, making the horse appear too light vs too deep.

Equine anesthesia: triple drip. Int J Pharm Cmpd, 2008

http://www.r-vets.org/Anesthesia_Basics.pdf

Other

Other drugs and drug combinations are possible and used. Newer ones are being developed all the time.

Currently thiobarbiturates are not available in the US. Propofol has been used but is costly.

Overview

If I want to anesthetize a large animal species, I start with a (mental) base of xylazine +ketamine and adjust from there. For general anesthesia, medetomidine is gaining some use as another alpha-2 agent that can replace xylazine. Detomidine (0.02 mg/kg) or romifidine (0.1 mg/kg) could also replace the xylazine if needed.

Basically any sedative that would relax the horse sufficiently to have its nose on the ground works. As with standing sedation, using more types of drugs generally decreases the amount of each drug needed and can increase the safety and duration.

To prolong the surgery time, we can add butorphanol. It potentiates the sedation and analgesia and decreases the amount of xylazine needed. Butorphanol (0.01-0.02 mg/kg iv) can also be helpful if the horse is excited and not responding well to the xylazine. The benzodiazepines also prolong the effects of the xylazine/ketamine. Adding midazolam or diazepam (0.03 mg/kg) to the protocol not only prolongs the duration of surgical anesthesia but also decreases the dose of xylazine required and smooths out the process. These drugs also relax muscles which is handy because ketamine tenses muscles and can make some procedures harder to perform (eg castration due to cremaster tone). Too much can hinder recovery.

Acepromazine can be used for healthy agitated animals and can help smooth their recovery. Ace does take at least 20 min to kick in and can last for hours so give prior to anesthesia.

For small animal, the sedatives are often midazolam + butorphanol or acepromazine + butorphanol. Those can work in pigs but aren't enough for most of our healthy large animal patients.

Ketamine is an induction agent and "induces" general anesthesia. In the "old days" when I was a new grad, we gave xylazine to create heavy sedation, then gave ketamine. Longer procedures got smaller doses of both as needed until we were done.

Ketamine is a very safe drug as it has minimal cardiovascular or respiratory effects. There are rare times we won't use ketamine. It can be assumed safe as long as appropriate sedation is present. However it causes excitement during induction and recovery. It is important to ensure the horse is very sedate prior to injecting ketamine and that a sedative is still acting for recovery. E.g. don't give a top off dose of ketamine near the end of your procedure without also giving a sedative. There is no reversal agent for ketamine at this time.

The other common induction drug is guaifenesin, otherwise known as GG. Yes, as in the cough syrup. GG is an infusion and is given iv to effect. It leads to muscle relaxation and the infusion makes it easy to adjust anesthetic planes. It is very useful for agitated animals, donkeys and stallions that tend to require frequent redosing, as well as for longer procedures.

For small animals, the induction drug is often propofol. Propofol works in large animals but is expensive and leads to poor recoveries in horses. Thiopental and thiamylal are similar drugs that are no longer available but will still appear in the literature. Anesthesiologists are also starting to play with alfaxolone in horses but so far not too successfully.

To maintain anesthesia, we can continue the GG infusion. If GG isn't available, we usually give repeated 1/2 doses of the sedative and ketamine. The benzodiazepines, acepromazine and narcotics tend to have long enough half lives that redosing isn't needed. You can create an infusion of xylazine and ketamine as well. Recently, medetomidine/ketamine/midazolam infusions were shown to be similar to medetomidine/ketamine/GG. Medetomidine is primarily in use in referral centers as it lasts longer than xylazine but shorter than detomidine.

For small animals, maintenance of anesthesia is commonly managed by moving them to an inhalant (isoflurane etc).

For most large draft breeds, decrease doses by ~10%. Propofol has gotten cheaper and can be useful for induction of donkeys or minis.

If you need an all intramuscular protocol for a wild child

- detomidine 0.04 mg/kg im
- dissolve a bottle of telazol powder in 2.5 mls of ketamine
- either give detomidine first or all together (eg dart or pole syringe)
- let them be for 15 min

Inhalants (isoflurane and sevoflurane) just aren't used in the field. The machinery is too expensive and cumbersome. For that reason, any procedures anticipated to last longer than an hour should be referred. As should sick animals that will need oxygen support.
Field anesthesia is typically safe for up to 60 minutes. After that time, complications are more likely.

Recovery

Watch this video about the recovery after castration:

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=397#oembed-3

While field recoveries are generally safe, they are not as safe as for other species. Horses are flight animals and, when faced with pain or strange situations, attempt to run away. This can be problematic if the animal can't stand well yet. The environment is also important. It can be hard to control a horse that is awake, much less on that is fuzzy and light headed. Make sure the horse isn't on an incline or near a ditch, pond, cars, or fence. Finally, many are really big animals. Don't get underneath them or think you can do much other than point them in the right direction. You can use their smaller brains to your advantage. Keep it dark and quiet and they may keep sleeping. Push on them and they will push back. Talk quietly and softly and they will often calm down. Another horse whinnies at them and they wake up [keep other horses away unless you want them to wake up….]

Common complications include facial and radial nerve paralysis as well as traumatic injuries (bitten tongue, lacerations). Prolonged field anesthesia (more than 60 minutes) should be avoided as the risk of complications increases greatly. These complications include hypoxia, myopathies and death.

Resources

Total intravenous anesthesia in horses, The Veterinary clinics of North America. , 2013, Vol.29(1), p.123-129

How to produce 20 minutes of equine anesthesia in the field, AAEP, 2013

R-vets anesthesia basics– for more challenging cases- these guys work with wild ones

Field anesthesia in the equine, Clin Tech Eq Pract 2007- provides step by step instructions

FOAL RESOURCES

Foal sedation, anesthesia, analgesia, ACVS

Eq Surgery anesthesia analgesia foals highlighted, Auer & Stick (use the study questions in the ruptured bladder section to work through this)

Plumb's Veterinary Drug Handbook and app (lots of versions out there in different formats and prices)

Practice: NSAID review

Level A. Review your pharmacology notes on NSAIDs and/or try this quick knowledge check. Many questions have two parts and all have a feedback section. If you go too fast, you will miss part II and the feedback.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=5356#h5p-83

Level B. Challenge yourself!

Exercise

Zoey, a 15 year old TB mare presents with mild signs of colic 3 days after foaling. She has been off feed and won't eat her grain and is only picking at her hay. The colt is alive and is nursing frequently but isn't putting on much weight. The mare has chronic knee (carpal) issues from being on the track and has seemed reluctant to get up so the owners have been giving her phenylbutazone. She was on 2 grams of bute once daily in the last month due to the extra weight of the foal and they have increased it to twice daily after foaling. It doesn't seem to make much difference; she still lies down a lot. She has major medical insurance.

On physical examination she is quiet and depressed. You observe small dry fecal balls in the stall. Her mucous membranes are tacky and pale. Her udder is fairly empty but not inflamed or sore on palpation.

HR : 64bpm

RR: 30 bpm

T 100.2.

GI sounds quiet. No reflux on nasogastric intubation. Vaginal exam shows bruising but you do not identify any tears. On rectal examination it seems that the intestines are higher in the abdominal cavity than normal and there is some ingesta in the pelvic flexure but not a huge amount. Her uterus seems to be involuting normally. Abdominal ultrasound shows large quantities of free fluid. Abdominal tap results in large quantities of light yellow fluid with low protein and low cellularity. Creatinine of the fluid is off the high end of your test capability (~8 mg/dL is the limit of the test).

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=5356#h5p-84

Practice: Selecting equine drugs and protocols

Level A Practice choosing drugs (LAS I -ignore the last question)

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=2260#h5p-164

Level B Develop an anesthesia plan:

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=2260#h5p-165

Vetprep

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=2260#h5p-171

Food Animal Drugs

This section discusses choosing antibiotics, analgesics, NSAIDs, sedatives and anesthetic agents for food and fiber species.

Food Animal NSAIDs and Analgesics

Remember : Analgesics need to be given prior to the pain stimulus to prevent hyperalgesia and wind-up phenomenom. This preemptive analgesia decreases the amount of pain produced but does not prevent pain. Analgesics should also be used after the stimulus to control the resultant pain. Pain is generally but not always related to the release of inflammatory mediators.

Our current practice "standards" are to 1) give nothing or 2) give it after the procedure. ***Neither of these make economic or physiological sense***. It makes more sense to give the drug before the procedure, particularly if a single dose. The same dose given after the procedure has less effect. We have spent the same amount of money and effort for less result. Since our goal is generally production, avoiding drugs is also nonsensical. When drugs are given, production losses due to withholding are typically minimal and are offset by minimized drop in production of milk or meat related to pain.

Flunixin meglumine

Flunixin meglumine is the only NSAID currently (6/2018) approved in food animals in the USA. In cattle, it needs to be given intravenously unless in the new topical formulation (below). Besides being off label, intramuscular injections are very irritating to tissues and can lead to Blackleg (clostridial myositis). Standard doses are 1.1 mg/kg iv BID or 2.2 mg/kg iv SID. You will find references for 2.2 mg/kg BID but that dose increases the risk of side effects.

FDA Approves First Medication for Pain Control in a Food-producing Animal

July 25, 2017

The U.S. Food and Drug Administration announces the approval of Banamine Transdermal (flunixin transdermal solution), an animal drug approved for the control of pain associated with foot rot and the control of pyrexia (fever) associated with bovine respiratory disease.

Meloxicam

Meloxicam is an NSAID that has gained widespread popularity. It seems to have better analgesic properties than flunixin meglumine. It is being used under ELDU (extralabel drug use) regulations for its analgesic effects. This does require a VCPR (veterinarian-client-patient relationship),

Castration Guidelines– AABP.org

There are no approved pain drugs for use in cattle in the US. The AMDUCA allows extra label drug use (ELDU) provided a valid VCPR exists and the drug selection decision process is followed. Although flunixin meglumine is an NSAID labeled for use in cattle and has been shown to have short acting analgesic effects, long acting NSAID analgesics, such as meloxicam, are more desirable to mitigate the pain associated with castration and dehorning.

While most oral medications are not effective in ruminants and camelids due to passage through the forestomachs, meloxicam is effective when given orally to both cattle and camelids. It may also be effective in piglets if fed to the sow.

Impact of Transmammary-Delivered Meloxicam on Biomarkers of Pain and Distress in Piglets after Castration and Tail Docking–2014, PLoS One

The objectives of the study were to demonstrate meloxicam transfer from sows to piglets via milk and to describe the analgesic effects in piglets after processing through assessment of pain biomarkers and infrared thermography (IRT)… This study demonstrates the successful transfer of meloxicam from sows to piglets through milk and corresponding analgesia after processing, as evidenced by a decrease in cortisol and PGE_2 levels and maintenance of cranial skin temperature.

FARAD suggests 21 days meat withholding after a single dose of 1mg/kg meloxicam po or 0.05 mg/kg im or iv: Considerations for extralabel drug use in calves, FARAD Digest, 2017

Poultry can also be given 1 mg/kg meloxicam. Contact FARAD for egg and meat withholding

Narcotics

Narcotics are increasingly used for pain in ruminants and camelids. None are approved in food animals so AMDUCA guidelines must be followed. These are the most common choices:

Butorphanol

Used for acute pain, generally perioperatively. The short duration of action makes it expensive and challenging to use long term. Provides sedation when combined with other drugs.

Butorphanol is a partial agonist-antagonist so should not be used in combination with other narcotics (it will decrease their effectiveness).

Minimal side effects.

Dose at 0.05–0.2 mg/kg IM or IV, every 1-3 hours

Reversal: naloxone

Morphine

Commonly used in ruminants for pain. Inexpensive and lasts up to 8 hours. Does decrease GI motility and is a schedule II drug so requires careful monitoring of access to the drug.

Doses range from 0.05 – 0.1 mg/kg im or iv. Start with the lower dose to minimize side effects. If given iv, give slowly. The dose can be repeated in 4-6 hours.

Reversal: naloxone

Buprenorphine

Most commonly used for postoperative pain management in goats. Should be used with caution in sick animals due to side effects. Relatively expensive but a single dose is often effective.

Dose 0.0015–0.006 mg/kg IM or IV. Can be repeated in 4-6 hours but may last longer.

Reversal: naloxone

Fentanyl

Rarely used. May be used iv for perioperative pain control. The patches are more useful for control of camelid pain.

Try 150–225µg/kg/h.

Patches can take 4 hours to provide analgesia and last 36-48 hours.

Reversal: naloxone

One more transdermal option for poultry (warning – not serious):

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=134#oembed-1

Resources

Clinical Pharmacology of Analgesic Drugs in Cattle. Veterinary Clinics of North America: Food Animal Practice, March 2015, Vol.31(1), pp.113-138- bovine review with more pharmacology included

Assessment and Management of Pain in Small Ruminants and Camelids. Veterinary Clinics of North America: Food Animal Practice, March 2013, Vol.29(1), pp.185-208. Nice review with recommendations

A Review of Analgesic Compounds Used in Food Animals in the United States, 2013 VCNA Vol.29(1), pp.11-28

Approaching Pain in Cattle, AABP brochure

Formulary – Wiley Library

Food Animal Antibiotics

Due to the restrictions on antimicrobial use, choosing antimicrobials for food and fiber animals is somewhat simpler than in dogs and cats in many regards.

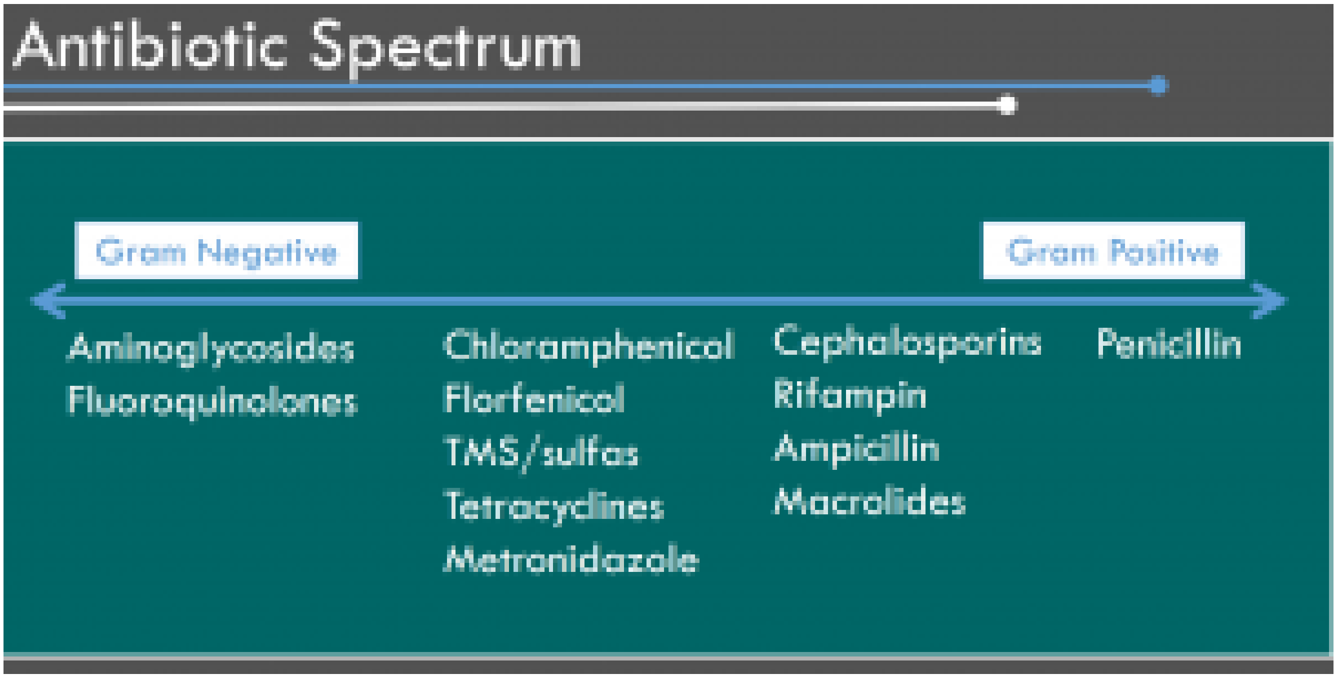
Primary considerations:

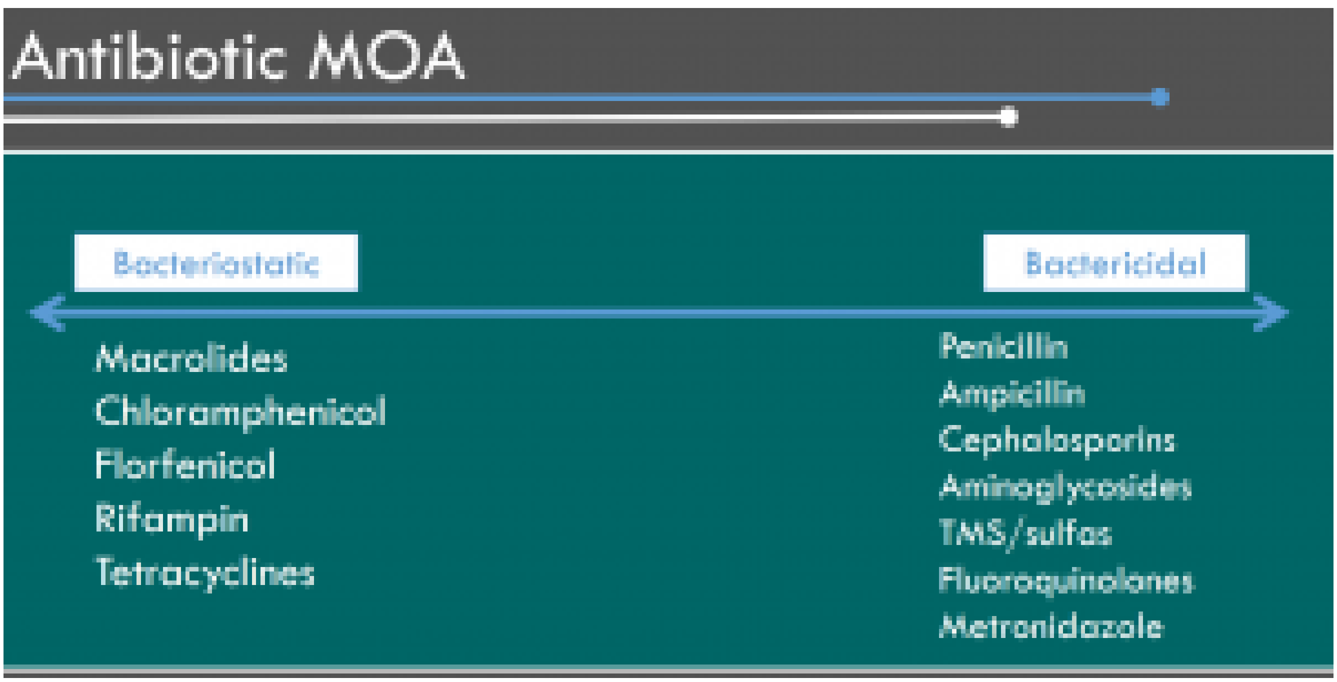
- are you likely dealing with gram positive, gram negative or both types of organisms?
- is there a drug labeled for the species and the disease?
- what drugs are legal in the species?
- where is the infection? can the antibiotics reach it? what drugs will be effective in that environment?
- how sick is the animal? can you use a bacteriostatic drug or do you need a bacteriocidal drug?
- does the animal have any other conditions that would increase the risk of certain drugs? e.g. renal disease or liver failure
- what drugs should you avoid using in order to save them for human use?

Secondary considerations

- is the animal milking or likely to go to market soon? what is your withholding window?
- how valuable is the animal and how expensive is the drug?
- what routes of administration are available to you and how frequently can the drug be administered?
- what are the resistance patterns in your area? can you assume certain drugs will be more effective than others?

Selecting antimicrobials (Dr. Alex Bianco)

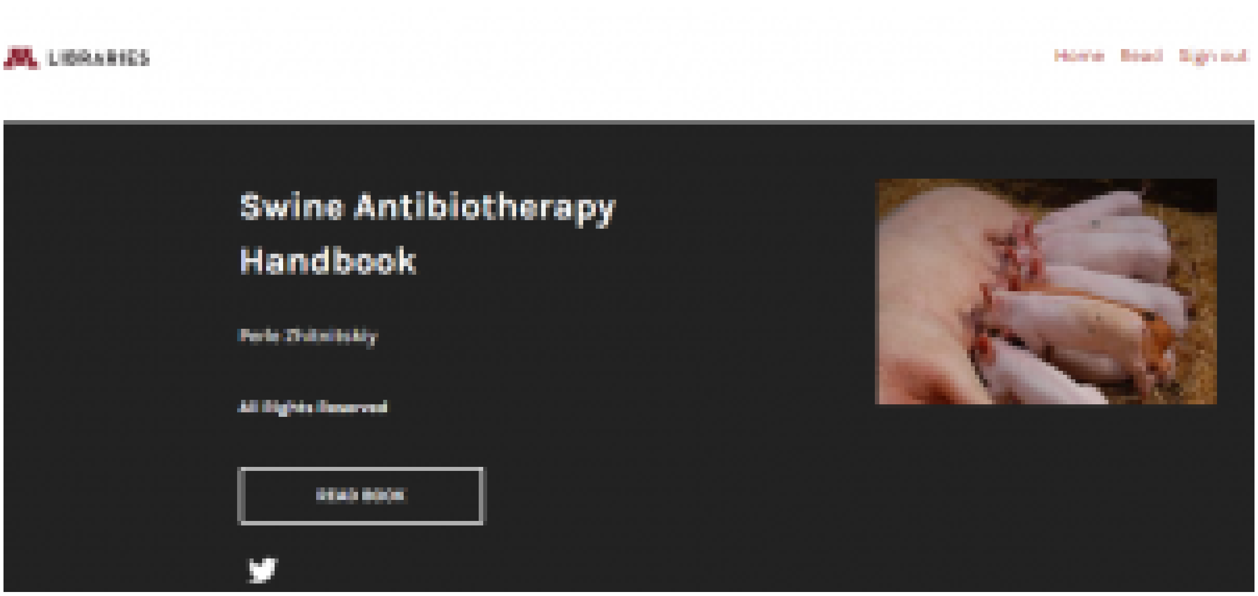

Antibiotic Spectrum
Gram Negative
Gram Positive
Aminoglycosides
Fluoroquinolones
Chloramphenicol
Florfenicol
TMS/sulfas
Tetracyclines
Metronidazole
Cephalosporins
Rifampin
Ampicillin
Macrolides
Penicillin


Antibiotic MOA
Bacteriostatic
Bactericidal
Macrolides
Chloramphenicol
Florfenicol
Rifampin
Tetracyclines
Penicillin
Ampicillin
Cephalosporins
Aminoglycosides
TMS/sulfas
Fluoroquinolones
Metronidazole

Drug	IV	IM/SQ	PO	Anaerobes	Good penetration	Use in a dairy cow
Penicillin	x	x		x		x
Ampicillin	x	x				x
Cephalosporins	EQ/SRC	x				x (on label only)
Fluoroquinolones	EQ	FA	EQ			
Macrolides		FA	FA/foals			
Chloramphenical/Florfenicol		FA	EQ	x	x	
Tetracyclines	x	FA				x

[Swine Antibiotherapy Handbook:](#) (also has good info for other species)

Gamithromycin SQ (macrolide)is being studied for use in camelids.



While I tend to assume prophylactic is important, this article suggests that antibiotics are needed pre/postop for Csections, that antibiotics should not be used for elective abdominal surgery.

Noteworthy

Procaine Pencillin G is labeled for administration at a very low dose. This label dose is NOT effective and should be avoided. Generally doses of 22,000 – 66,000 IU/kg are recommended rather than the label dose of 6600 IU/kg.

This article does a great job of fairly painlessly explaining why and how pharmacodynamics and pharmacokinetics play a role.

Update on withdrawal intervals following extralabel use of procaine penicillin G in cattle and swine. JAVMA | JAN 1, 2022 | VOL 260 | NO. 1

RESOURCES

Antimicrobial resistance learning site

Pharmacology chapter, Dairy Production Medicine ebook

Randomized prospective trials to study effects of reduced antibiotic usage in abdominal surgery in cows. J. Dairy Sci. 101:8217–8223. With careful attention, maybe we can pick which cases get preop antibiotics.

Food Animal Drug Regulations

OSU VMC Antimicrobial use guidelines – great place to start when choosing a drug

PRUDENT ANTIMICROBIAL USE GUIDELINES FOR CATTLE

PHARMACOLOGY MODULE

Wikipedia– often has very good pharmacological information

For Future Reference | Create a drug reference table

Pharmacology course notes and the online drug monographs

Food Animal Sedatives

In many cases, sedatives are not required in adult cattle. Pain is controlled through local blocks and systemic drugs.

Acepromazine

Acepromazine is an effective calming agent in ruminants. Give prior to additional stimulation and give it at least 20 minutes to work. It does cause penile protrusion but not dangerous levels of priapism.

Xylazine

If needed, xylazine works well in ruminants. However, they are very sensitive to the drug and take only 1/10 of the horse dose. It is almost impossible to make a horse lie down just with xylazine. It is easy to do that in cattle. As with horses, butorphanol can potentiate the effects of xylazine in ruminants, prolonging its duration.

There are times when xylazine is a bad idea:

- Pregnant cows – xylazine causes uterine contractions. If a cow is in her third trimester and is given xylazine, she might abort. It also makes Csections harder. This would be a better time for ace/ butorphanol.
- Neonatal animals – cardiac output is HR x stroke volume. If you use xylazine, you slow HR. However, neonatal animals can't adjust stroke volume. So you end up with minimal cardiac output. Not good. You can use butorphanol alone in this age group – they get sedated vs excited. We also use the benzodiazepines – diazepam and midazolam for calming.
- Hot days –xylazine interferes with thermoregulation and animals can become dangerously overheated.
- Blocked goats – xylazine increases sugars in the urine which leads to diuresis and more urine volume. This isn't good if the goat is blocked and can't pee. Only use xylazine if you are ready to empty the bladder.
- Pigs – xylazine doesn't work well (they are very insensitive) and they tend to vomit. Used but not a great drug. Benzodiazepines and butorphanol combos are better.
- Sheep – sheep can develop fatal pulmonary edema. This is a relatively new finding but obviously scary. The risk is highest with general anesthesia and with higher doses given iv. We aren't sure yet if the problem occurs in goats. So be aware of the risk and try to use other drugs such as the benzodiazepines. If you do have to use xylazine, avoid rapid iv injection and have reversal agents on hand.

Detomidine

Ruminants are NOT more sensitive to detomidine. Detomidine is used in small ruminants because the dosing is easier. However, it is an expensive drug so is rarely used in cattle.

Butorphanol

Butorphanol sometimes causes sedation and sometimes causes excitement in ruminants. It is best to use it with a sedative or tranquilizer to minimize the risk of excitement. However, unlike in horses where we make sure they are sedated first, we can combine the drugs in the same syringe for cattle and give at the same time. We use ace-butorphanol combos for standing surgery in cattle as well as xylazine- butorphanol combos. Morphine can be substituted for butorphanol.

Ketamine

Ketamine (**dissociative anesthetic agent**) can be used in combination with xylazine and butorphanol to create a standing sedated state in ruminants. It is not used this way in horses. See the general anesthesia chapter for more information about ketamine.

Reversal agents

If the animal is too sleepy, the alpha-2s can be partially reversed using drugs such as yohimbine (no longer available) and tolazoline. Narcotics can be reversed with naloxone. Butorphanol is actually a partial agonist-antagonist narcotic so it can reverse other narcotics.

Withholding – meat and milk

None of these agents are approved in food animal species. FARAD should be consulted for appropriate milk and meat withholding times

Food Animal Standing Sedation Protocols

Cattle surgery is typically performed standing. Bloat occurs rapidly in the recumbent animal and can lead to respiratory difficulty and poor venous return to the heart. Cattle may not even require sedation but will stand quite well for surgery using only local anesthesia (local block or epidural). Recumbent surgery is required for hernia repair, some abdominal procedures and for many teat surgeries.

Cow eating during abdominal surgery lab

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=556#oembed-1*

Any surgical procedure in a non-anesthetized cow (standing or recumbent) involves some form of local analgesia. We typically use lidocaine as a local infusion, inverted "L" block, or paravertebral block for abdominal surgeries. An epidural block with lidocaine may be used for rectal or vaginal procedures.

Note: Most small ruminant procedures are performed with the patient recumbent. Camelids will tend to kush (lie down) regardless of what you do but some will stay standing. Pigs do the opposite of whatever you want and noisily.

Local block

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=556#oembed-2*

Short clip of a DA surgery (all of mine show only close ups). Despite what he thinks, the cows do not usually need sedation or show any concerns with internal palpation. The skin incision does require a local block!

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=556#oembed-3*

This one is older (no drape, no sleeves) but is a cool explanation of how to do a Csection – see on youtube

Standing anesthesia protocols

The following protocols are useful for those dairy and beef cattle that are a bit more restless, worried, or aggressive, but not so recalcitrant that they throw themselves down on the ground (Scottish Highlanders) or so tired of life that they just lie down (pregnant Jerseys):

Acepromazine/Butorphanol or Acepromazine/Morphine

This combination provides **neuroleptanalgesia** for moderately to lengthy procedures. It is very useful for C-sections or penile exams/surgery in healthy animals that aren't hypotensive.

The onset of action is slow. Anticipate at least 20 minutes, even with iv administration. The drugs can be given iv, im or sq.

Acepromazine 0.035 mg/kg im + Butorphanol 0.05 mg/kg im or Morphine 0.1 mg/kg im

Xylazine/Butorphanol

This combination provides synergistic sedation + analgesia for shorter to midlength procedures.

The onset of action is rapid. The drugs can be given iv, im or sq. Too much sedation will lead to recumbency.

Xylazine 0.05 mg/kg im + Butorphanol 0.05 mg/kg im or Morphine 0.1 mg/kg im

Acepromazine/Xylazine

This combination provides sedation for moderate to lengthy procedures. It does cause significant cardiovascular depression; animals must be healthy. It avoids narcotics and narcotic management.

The full onset of action is delayed up to 20 minutes.. The drugs can be given iv, im or sq. Too much sedation will lead to recumbency.

Xylazine 0.05 mg/kg im + Acepromazine 0.05 mg/kg im

Standing Ketamine Stun (xylazine, ketamine, butorphanol)

This combination provides **dissociative anesthesia** and analgesia. Cattle get a stunned effect and don't seem to care about much of anything. Higher doses can lead to recumbency. Unfortunately, stunned cattle are resistant to attempts to make them stand up again. This is a lovely combo for hind limb work or when they just won't behave.

The bovine standing ket stun is basically Llama lullaby with lower xylazine amounts.

Bovine ketamine standing stun:

- IV: xylazine 0.02 mg/kg, butorphanol 0.01 mg/kg, ketamine 0.05-0.1 mg/kg
    - for a 500-600kg cow,this is ~ 5 mg butorphanol, 10 mg xylazine and 20 mg ketamine (25-50 mg)
- Double the doses for im or sq stuns (less intense, longer duration). Try SQ unless the animal is very unruly.
- Morphine can be used in cattle instead of butorphanol (0.05 mg/kg iv).

Cow prestun

Cow poststun

Remember withholding requirements apply! There are no labeled drugs for food animal sedation or anesthesia so everything is off label.

Recovery

Recovery is easy. Surgery is often performed in the cow's stanchion or in a "maternity" (calving) pen. When done, the cow is left to recover in the pen or stall or walked to another area. Cows are just plain cool.

Resources

Chemical restraint of ruminants- ketamine stun techniques, Abrahamsen circa 2008

Field Sedation and Anesthesia of Ruminants, August 2016, Veterinary Clinics of North America Food Animal Practice 32(3)– has good information on duration of effect of various protocols. *There are typos in the article. Correct the doses to xylazine 0.05mg/kg im + butorphanol 0.1mg/kg im + ketamine 0.5 mg/kg im for the ket stun*

Local blocks, Kathy Whitman, Great Plains Education Center (ppt will download)

Food Animal General Anesthesia Protocols and Procedures

Recumbent procedures are not common in adult cattle but do happen (sometimes when a standing procedure becomes a recumbent procedure due to cow factors) and are generally the norm for camelids, small ruminants, and pigs. Both standing and recumbent procedures are done in calves, depending on the age and size of the calf, the duration of the procedure, etc.

Field anesthesia is typically safe for up to 60 minutes. After that time, complications are more likely.

As with other species, anesthesia involves

- **sedation** – xylazine (occasionally detomidine, dexmedetomidine, romifidine or acepromazine)
    - optional additional sedatives or analgesics -butorphanol or acepromazine (given with sedatives) AND/OR diazepam or midazolam (given at induction)
- **induction** – ketamine, telazol, guaifenesin (GG)
- **maintenance** – repeated doses of sedatives and induction agents or infusion of drugs and drug combinations

Often sedation and induction are combined; ruminants do not have the same eventful excitement phase as do horses.

Ruminants, camelids and pigs are generally **not** intubated or maintained on inhalant anesthetic agents except in specialty or referral settings. Intubation is tricky so many are kept light (good respirations) and pain is controlled with narcotics and local blocks.

Ruminants do like to regurgitate and drool during anesthesia. Atropine only makes the drool thicker so we don't use it. It is important to ensure that drool and rumen contents drain out. The nose should be lower than the poll (top of the head), often with the neck elevated with a pad to ensure everything runs downhill and out, not back into the airways.

https://instruction.cvhs.okstate.edu/vmed5412/FoodAnimals.htm

Ruminants also like to bloat when sedated. This impairs respiration as the rumen compresses diaphragmatic vessels and impairs return of blood to the heart. To minimize rumen fill, adult large ruminants are held off feed for ~ 24 hours when possible (small ruminants need ~18 hours). Many references recommend removal of water. This may not be necessary unless animals are drinking excessively.

Monitoring is typically through vital signs (pulse quality and rate, respiratory quality and rate, ocular reflexes and positioning). Pulse oximeters are portable and easy to use. Doppler blood pressure monitoring is useful particularly in smaller patients.

Smaller ruminants and pot bellied pigs can be put on surgery tables and managed like big dogs.

Common induction and maintenance agents

Ketamine combinations

Schedule III

Ketamine is a **dissociative anesthetic agent** used to induce recumbency after sedation when given at higher doses.

It is commonly combined with other drugs (xylazine, diazepam or midazolam, guaifenesin) to prolong the anesthetic duration and to enhance relaxation.

Ketamine is a relatively safe drug with minimal cardiovascular or respiratory depressant effects. “It is hard to kill with ketamine.” Unlike in horses, there is minimal excitement phase in ruminants. Both the sedative and induction agents can be combined in the same syringe (eg ketamine/diazepam or xylazine/ketamine) and given at the same time.

Protocols typically combine sedation and induction drugs:

Cattle:

- xylazine 0.05-0.1 mg/kg and ketamine 2 mg/kg iv (double for im administration)
- diazepam/midazolam 0.1 mg/kg and ketamine 2 mg/kg iv
- recumbent iv ketamine stun: xylazine 0.05 mg/kg + butorphanol 0.05- 0.1 mg/kg + ketamine 0.5 -1 mg/kg
    - for a 500-600kg cow, this 20/25/250 mg of B/X/K
- infusion: 1-1.5g ketamine added to 1L electrolyte solution along with 50 mg xylazine or with 25-50 mg benzodiazepenes administered as iv drip

Llamas: xylazine 0.4-0.5 mg/kg and ketamine 4-6 mg/kg im

Alpacas: xylazine 0.6-0.8 mg/kg and ketamine 6-8 mg/kg im

Swine: xylazine 2 mg/kg and ketamine 20 mg/kg im

Telazol and Telazol combinations

Schedule III

Telazol is a combination of tiletamine (dissociative agent like ketamine) and zolazepam (benzodiazepine like diazepam). It lasts longer than ketamine/diazepam but is more expensive.

The drug needs to be reconstituted prior to use and then has a limited shelf life.

Telazol-xylazine: reconstitute telazol with 500 mg xylazine instead of the standard diluent. Give 3-5ml to large bulls im.

TKX: reconstitute telazol with 100-150mg xylazine and add ketamine to total volume of 5 ml. Useful with pole syringe administration or dart gun for wild or aggressive cattle (5ml/600-800 kg).

Other example protocols

cattle: 0.1 mg/kg xylazine + 1-2 mg/kg telazol iv

sheep: 2-4 mg/kg telazol iv

llama: 0.25 mg/kg xylazine + 2 mg/kg telazol im

swine: 2.2 mg/kg xylazine + 4.4 mg/kg telazol im

GG and BovineTriple Drip

Triple drip is a combination of xylazine, ketamine and guaifenesin (GG) used to induce and/or maintain anesthesia.

Xylazine (50 mg), ketamine (1000 mg or 1 g), in a liter of 5% guaifenesin (50mg/ml), given at 1ml/lb/hr.

Guaifenesin is a muscle relaxant that helps counteract the rigidity associated with ketamine. The combination must be compounded and can be explosive if done incorrectly.

Triple drip can be used for induction (0.5-2 ml/kg) but has a slightly delayed effect so overdosing is a risk. However, the gradual induction minimizes the apnea risk.

Maintenance with triple drip is relatively easy in cattle. The anesthetic plane is rapidly adjusted by changing the drip rate (0.5-2 ml/kg/hr).

Side effects : Very irritating perivascularly. Use a catheter. Overdoses of GG can lead to increased muscle tone, making the animal appear too light vs too deep. Ruminants are sensitive to xylazine and xylazine may cause pulmonary edema, especially in sheep.

Double drip

Double drip infusion avoids the risk of xylazine for ruminant anesthesia maintenance.

Ketamine (1mg/ml or 1g/L) is added to 5% Guaifenesin.

Butorphanol or morphine should be added for analgesia. Butorphanol (0.05-0.1 mg/kg IV or IM in smaller ruminants, 0.02-0.05 mg/kg IV or IM in larger ruminants) or morphine (0.05-0.1 mg/kg IV or IM).

https://www.acvs.org/files/proceedings/2011/data/papers/211.pdf

Llama lullaby

To one bottle of ketamine (10 ml of 100 mg/ml) add 1 ml of 100 mg/ml xylazine and 1 ml of 10 mg/ml butorphanol. Given 1 ml /50 lbs BW IM for 40-50 min procedures.

More specific doses of ket stuns for camelids:

- xylazine 0.22-0.55 mg/kg + ketamine 0.22-0.55 mg/kg + butorphanol 0.08-0.11 mg/kg im

Midazolam drip recipe: 5ml (25 mg) midazolam + 20 ml (2 g) ketamine +5 ml (100 mg) 20mg/ml xylazine in 1 liter bag fluids.

Xylazine/ketamine drip recipe: 50 mg xylazine and 1.0 to 1.5 g ketamine added to 1 L electrolyte solution

> Muscle relaxation should be satisfactory if an adequate dose of xylazine is used at induction, or it can be improved by administering 25 to 50 mg of midazolam or diazepam intravenously as a bolus or by increasing the infusion rate of xylazine and ketamine. Approximately 1 drop/5 secs for each 100# BW

Please double check all doses in these protocols before using. Withholding requirements do apply to these drugs! Nothing is approved so AMDUCA rules also apply.

Overview

Just as with horses, for general anesthesia in food animals, I start with a base of xylazine +ketamine and adjust from there.

- Butorphanol and/or the benzodiazepines can be added to smooth and prolong anesthesia.
- Ketamine is safe and effective at creating recumbency.
- Acepromazine can be used for healthy agitated animals and can help smooth their recovery.
- Guaifenesin (GG)is combined with xylazine and ketamine to create ”triple drip”, an infusion that works very well in cattle.
- Leave the xylazine out to make it even safer as “double drip”.
- If GG isn’t available, we usually give repeated half doses of the sedative and ketamine to increase duration of anesthesia.
- The benzodiazepines, acepromazine and narcotics tend to have long enough half lives that redosing isn’t needed.
- You can create an infusion of xylazine and ketamine as well.

Recovery

Our ruminant patients are much easier to recover safely than the horses. They like to lie still and can be left to their own devices in a stall if warm and dry. Cold patients need to be warmed up to enhance recovery. As long as the patient can swallow and keep themselves in sternal, they do fine. The ruminant will stand up when it is time, rarely before that.

As mentioned above, ruminants do develop rumen stasis on under general anesthesia so bloat can be an issue if they are under GA for too long and care needs to be taken to ensure they are sternal during recovery. If they cannot maintain sternal recumbency, the bloat can persist to danger points. Regurgitation is also common so it is important to ensure they will not aspirate any fluid that is regurgitated (sternal recumbency is good for this too).

Resources

Small ruminant anesthesia (chapter)

Camelid anesthesia (chapter)

Pig anesthesia (chapter)

Chemical restraint of ruminants- ketamine stun techniques, Abrahamsen circa 2008

Field Sedation and Anesthesia of Ruminants, August 2016, Veterinary Clinics of North America Food Animal Practice 32(3)– has good information on duration of effect of various protocols. *There are typos in the article. Correct the doses to xylazine 0.05mg/kg im + butorphanol 0.1mg/kg im + ketamine 0.5 mg/kg im for the ket stun*

Ruminant and swine anesthesia. OK State, Lyon Lee

Guidelines on Anesthesia and Analgesia in Ruminants, UMI, 2018

Large Ruminant Anesthesia, 2012 ACVS

Allweiler FA anesthesia lecture ppt

Plumb's Veterinary Drug Handbook and app (lots of versions out there in different formats and prices)

Fun hernia repair video – creative use of a wheelbarrow! See on youtube

Small ruminants are “minor” species in the food animal regulatory world so you have more leeway but still need to include meat and milk withdrawal information.

NSAIDs

Flunixin is the only approved NSAID in food animal species. Meloxicam is used off label. No products are labeled for sheep and goats.

- Flunixin 1.1mg/kg IV q 12 hours
- Meloxicam 0.5-1mg/kg PO q 24 hours

Meloxicam is gaining in use and the oral form appears to be highly bioavailable. Tablets are crushed and mixed with molasses or other flavoring.

Check FARAD for withholding!

Narcotics and others

Nalbuphine is gaining in popularity as it is typically not a controlled substance (laws do vary by state). It seems to be equally as effective as butorphanol and is cheaper. Subcutaneous nalbuphine (1 mg/kg) resulted in analgesia within 30 minutes in sheep.

Transdermal fentanyl (patch) can provide steady analgesia for 2-3 days.

Gabapentin has been used anecdotally with success for chronic pain management.

Sedation and anesthesia

Small ruminants are typically amenable to dog-like restraint, especially when sick. Light sedation and local blocks can go a long way as long as the animal is pain free. Tracheal intubation is very challenging and requires animals to be at a deeper plane of anesthesia. It is a trade off in safety of having a tube in place vs the safety of light anesthesia.

Sheep can develop fatal pulmonary edema with xylazine. This is a relatively new finding but obviously scary. The risk is highest with general anesthesia and with higher doses given iv. We aren’t sure yet if the problem occurs in goats. So be aware of the risk and try to use other drugs such as the benzodiazepines. If you do have to use xylazine, avoid rapid iv injection and have reversal agents on hand. Detomidine may or may not be safe for sheep. We just don't know.

For minor procedures:

- midazolam 0.2mg/kg IV + 0.1mg/kg butorphanol IV
  - add 2-5 mg/kg ketamine iv or im for longer or more painful procedures
  - add xylazine 0.05mg/kg iv but carefully and only if needed.
- ketamine stun in goats
  - see induction protocol 1 below

Typical general anesthesia protocols for healthy small ruminants

ANESTHESIA	Drug	Dose (mg/kg)	Route
Pre-operative analgesia	Flunixin meglumine	1.1 mg/kg	Iv
Sedative (if needed)	Acepromazine Detomidine	0.2 mg/kg 0.02-0.04 mg/kg	im im
Induction protocol option 1	Xylazine	0.05 mg/kg	iv
	Butorphanol	0.05 mg/kg	iv
	Ketamine	0.5-1 mg/kg	Iv
Induction protocol option 2	Midazolam	0.1-0.2 mg/kg	Iv
	Ketamine	2-5 mg/kg	iv
Maintenance	Redosing, iv infusions, inhalant anesthesia		

Xylazine also stimulates urine production and is not ideal in blocked goats unless you can perform cystocentesis or surgery.

Local blocks are good things and can minimize the need for general anesthesia. Go easy as small ruminants are very sensitive to the toxic effects of lidocaine. Assume maximum dose of 6 mg/kg. Lidocaine can be diluted to extend the reach; this does shorten the duration of numbness.

For small ruminants and pot bellied pigs, inhalants can be really useful for longer procedures such as Csections and enucleations. The standard SA anesthesia machines can be used. Boss doesn't want the goat in the hospital? Take the machine outside or to the garage. As mentioned above, intubation is more difficult than in dogs; the anesthetic plane needs to be fairly deep and you will want a longer laryngoscope. But once that is done, these animals do well with minimal effort on inhalant anesthesia.

Peri-anesthetic Support

Food should be withheld for 12-18 hours to minimize bloating in adult animals. Neonates should not be fasted more than 4 hours. Because of the danger of pregnancy toxemia in late gestation, late pregnant animals should be minimally fasted or carefully supported.

Young small ruminants can become hypothermic; this is usually not a problem in older ruminants.

Hypoventilation and apnea are relatively common. Be prepared to stimulate respiration.

Fluid therapy and supplemental oxygen should be considered for longer procedures.

Due to copious salivation and high risk of regurgitation, animals should be positioned so the head is tilted downward. It can help to elevate the neck, creating a "V" at the poll or withers.

head tilted down for drainage of saliva and regurgitant

Atropine is not useful in stopping salivation and can be detrimental as it makes the saliva thicker.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2206#oembed-1

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2206#oembed-2

Monitoring

Pulse oximetry and other monitoring devices can be very useful in small ruminants. Without these tools, monitoring is challenging and requires careful attention. If in doubt, reduce the anesthetic depth until signs of light anesthesia become apparent.

For most anesthesia, the pupil should be central and moderately constricted. Rotation of the globe is not useful for monitoring and the corneal reflex should be maintained.

Too light

- Mydriasis is observed at a light plane and again at a deep plane.
- Chewing, esophageal activity and limb movement indicates too light of a plane.
- Increased muscle tone (jaw tone)
- Nystagmus

Too deep

- Mydriasis combined with no palpebral reflux is likely a deep plane.
- Decreased muscle tone (jaw tone); some jaw tone persists even at deep planes
- Slowed heart rate
- Shallow or paradoxic respiration (chest contracts during inhalation vs expands)

Recovery

Recovery from anesthesia is usually uneventful. Hypothermia will prolong recovery so animals should be kept warm and dry. Animals should be placed in sternal recumbency and, if used, the endotracheal tube left in position with the cuff inflated until the animal can swallow. Once the animal can cough and swallow the tube can be removed; the cuff can be left inflated during removal if regurgitation occurred.

Resources

Pain management in small ruminants and camelids: Analgesic agents. Vet Clin North Am Food Anim Pract . 2021 Mar;37(1):1-16.

Field Sedation and Anesthesia of Ruminants, August 2016, Veterinary Clinics of North America Food Animal Practice 32(3)– has good information on duration of effect of various protocols.

Anesthesia and Pain Management Goplen 2016

Drugs approved for small ruminants, JAVMA, Vol.224(4), p.520-523, 2003

Camelid Analgesia, Sedation and Anesthesia

Accessing camelid veins is a bit tricky. Most drugs do work better iv but it is always nice to have an im plan ready to go. Llama lullaby is designed for IM use. Camelids fit into the “minor species” category so withholding is needed but you have leeway in drug choices.

NSAIDs

- Flunixin 1.1mg/kg IV q 12 hours
- Meloxicam 1mg/kg PO q 48 hrs
- Ketoprofen 1mg/kg iv or im – less effective but can be given im

Sedation

Camelids vary in how they respond to people and drugs. When upset, they tend to lie down (kush) so attempting standing chemical restraint is usually not worth the effort.

1. 0.5cc butorphanol (per alpaca) or 1cc butorphanol (per llama) IM or IV if you can restrain. [In my hands, this does very little to sedate them; they usually just stand there and look at me. Per others, it works if you blindfold them.]
2. xylazine 0.2 mg/kg IM and butorphanol 0.1 mg/kg IM for standing sedation and surgery
3. llama lullaby – recipe below for recumbent sedation

Llama lullaby

To one bottle of ketamine (10 ml of 100 mg/ml) add 1 ml of 100 mg/ml xylazine and 1 ml of 10 mg/ml butorphanol. The sedation should last 40-50 min procedures. ***Dose: 1ml/40# alpacas, 1ml/50# in llamas. Give IM**

More specific doses of ket stuns for camelids:

xylazine 0.22-0.55 mg/kg + ketamine 0.22-0.55 mg/kg + butorphanol 0.08-0.11 mg/kg im

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Camelid GA

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Camelids do ferment but have a much smaller fermentation vat than cows. Once they reach about 4 months of age, we generally hold them off feed 12-18 hours while still giving them free choice water.

Camelids can regurgitate and aspirate so the head position should be managed to ensure any regurgitation drains out of the mouth, not back down the throat, similar to small ruminants. As soon as the procedure is done, the animal can propped into sternal recumbency with the head supported until the animal can hold it up. Camelids have a tendency to coil their necks in all sorts of wrong ways. This may not cause any real issues but we usually sit with them until they can hold their heads up.

Sick camelids tend to develop metabolic issues after anesthesia so should be carefully monitored.

The alpha2 agents (xylazine, detomidine, romifidine) may be reversed in camelids but yohimbine is not currently available and tolazoline has significant side effects. Most practitioners use atipamezole and cautiously.

PS : It is really hard to open the mouth wide enough for intubation if the halter is still on. Just saying.

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Resources

Pain management in small ruminants and camelids: Analgesic agents. Vet Clin North Am Food Anim Pract . 2021 Mar;37(1):1-16.

New World Camelids, UTenn, Tom Doherty, 2011

Chemical restraint, anesthesia and analgesia for camelids, Abrahamsen, VCNA 2009

Camelid anesthesia and drugs– Merck Manual

Food Animal General Anesthesia Protocols

Veterinary Techniques for Llamas and Alpacas Chapter 7 Sedation and Tranquilization

Pigs are pigs. Since swine are a “major” species in the food animal world, all swine rules and regulations need to be followed, even in pet pigs.

NSAIDS

Flunixin meglumine is the only approved NSAID. Meloxicam is used off label due to its better analgesic properties.

- Meloxicam 0.4mg/kg PO q 24 hours – better oral bioavailability than po flunixin
- Flunixin meglumine 1.1-2.2mg/kg IM once (don’t often do more than once due to pig temperament and concern for muscle damage)

For pet pigs on continued NSAIDs, omeprazole is recommended at 0.5mg/kg PO q 24 as they are prone to gastric ulcers.

Other Analgesics

Transdermal fentanyl (small pigs) patches dosed at 3 ucg/kg/hr resulted in serum concentrations that were above the reported efficacy ranges in people.

Epidurals -The site for needle placement is on the midline and caudal to a transverse line between the cranial prominences of the wing of the ilium (iliac crest) on either side, 0.5 to 1.5 cm in pigs weighing 10 to 50 kg and 1.5 to 2.5 cm in pigs weighing 50 kg or more. A vertical line through the patella may be used as a guide to locate the lumbosacral space 2.5 cm caudal to the vertical line in large pigs in which the iliac wings are not palpable

> Lab Anim. 2006 Jan;40(1):16-27. doi: 10.1258/002367706775404453.

Effects of epidural morphine and transdermal fentanyl analgesia on physiology and behaviour after abdominal surgery in pigs

L M Malavasi [1], G Nyman, H Augustsson, M Jacobson, M Jensen-Waern

Sedatives and anesthesia

Pigs do not like being handled and create quite a lot of noise. The noise disturbs everyone around them. If you can work on the pig while the owner holds them, that might help your eardrums. Most pigs are heavily sedated for procedures. One exception is "forking "- it really works to calm them and has a slight residual. It is useful for injections, temperature taking, listening to hearts, etc.

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Other restraint methods

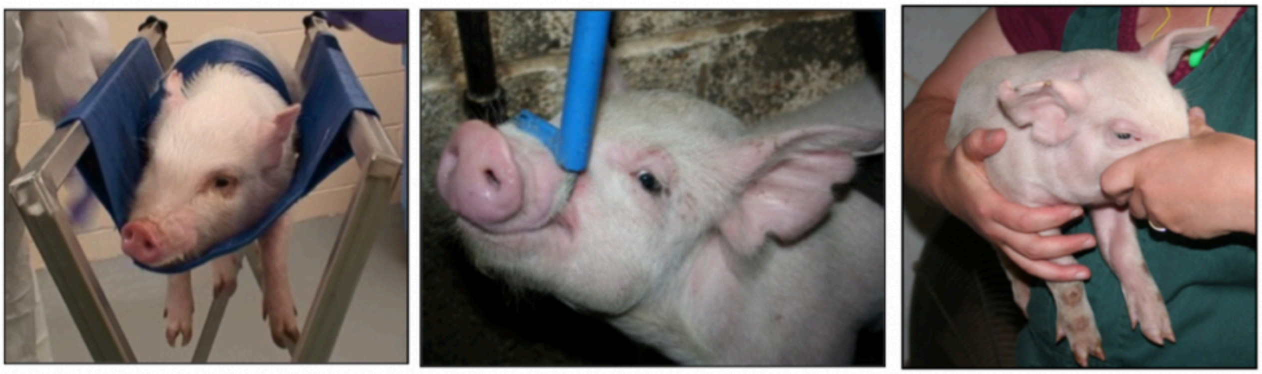

Figure 2. Restraint Methods

https://ouv.vt.edu/content/dam/ouv_vt_edu/sops/large-animal/sop-swine-injection-subcutaneous.pdf

Demo video from a pig hoof trimmer of how she restrains without sedation: https://www.facebook.com/354626021775605/videos/339929836629905/

Xylazine doesn't work well in pigs. Pigs are very insensitive to xylazine and they tend to vomit. It is used but is not a great drug in pigs. Benzodiazepines and butorphanol combos are better.

Sedation protocols used in the UMN VMC

- 4mg/kg ketamine IM + 0.4 mg/kg Diazepam IV or Midazolam IM
    - excited pigs may need other drugs or inhalant
    - may have dysphoria during recovery phase
- 0.2mg/kg Butorphanol IM + 0.2mg/kg Midazolam IM
    - good for induction prior to inhalant
    - allow 10 minutes for full effect
    - may cause nausea and vomiting, especially during recovery phase
- Piggy Magic – 0.2 mg/kg butorphanol + 0.2 mg/kg midazolam + 2-6 mg/kg ketamine combined and given im {typically use higher end of ketamine dose}. Piggy Magic provides a decent plane of

sedation for minor procedures and lasts 30-45 minutes.

- Intranasal midazolam can be used for calming

Telazol was a favorite for awhile but it leads to really long recoveries and has more issues.

- reversal with tolazoline improves things – 2 mg/kg im
- Newer protocols with tolazoline given at 45 min
    - TZDB (tiletamine-zolazepam [3 mg/kg], detomidine [0.18 mg/kg], and butorphanol [0.12 mg/kg]
    - TZXB (tiletamine-zolazepam [4 mg/kg], xylazine [4 mg/kg], and butorphanol [0.2 mg/kg]
    - KDB (ketamine [8 mg/kg], detomidine [0.18 mg/kg], and butorphanol [0.3 mg/kg])
        - From Comparison of anesthetic and cardiorespiratory effects of tiletamine-zolazepam-detomidine-butorphanol,
          tiletamine-zolazepam-xylazine-butorphanol, and ketamine-detomidine-butorphanol in pigs. JAVMA | APR 15, 2021 | VOL 258 | NO. 8. Pp 883-891

Inhalants can be really useful for longer procedures such as Csections and enucleations. And the standard SA anesthesia machines can be used. For shorter procedures, pot bellied pigs can be masked down. Since venous access can be tricky, this can be handy for nail trims and ear cleaning. Intramuscular sedation beforehand is advised. *Human exposure is higher with mask inductions*.

Pig can be intubated:

•Dexmedetomidine @ 20-40 ug/kg IM + ketamine @ 10 mg/kg IM + butorphanol @ 0.2 mg/kg IM
•Mix all in 1 syringe
•Reverse dexmed with 0.16 mg/kg atipamezole

Pig cannot be intubated:

•Dexmedetomidine @ 5 ug/kg IM + ketamine @ 2 mg/kg IM + butorphanol @ 0.1 mg/kg IM
•Detomidine @ 0.1 mg/kg IM + ketamine @ 5 mg/kg IM + butorphanol @ 0.1 mg/kg
•Dr. Barrell's preference
•Provides about 30-40 minutes of deep sedation (enough for moderate pain)
•But pig will be sleepy for the next 12-24 hours, so you could substitute benzo for ketamine

Pet pigs are really like spoiled dogs. They get wrapped in towels and held until awake.

Malignant hyperthermia (porcine stress syndrome) is possible with isoflurane, particularly with Landrace, Pietrain and Portland China breeds. One case has been reported in a potbellied pig.

Resources

Miniature Companion Pig Sedation and Anesthesia, JS Smith, VCNA/Exotics, 2022- lots of good hints about handling, restraint and drugs

Guidelines on Anesthesia and Analgesia in Swine, UMI, 2018

[Practical sedation and anaesthesia of pigs](), In practice, 2007

SEDATIVE AGENTS COMMONLY USED IN THE PIG

Agent	*Dose rate*	*Route of administration*
Azaperone	1 to 8 mg/kg	Deep intramuscular
Azaperone and ketamine	1 mg/kg 5 mg/kg	Together deep intramuscular
Azaperone, ketamine ± butorphanol	1 to 2 mg/kg 5 mg/kg 0·1 to 0·2 mg/kg	All together deep intramuscular
Acepromazine	0·03 to 0·1 mg/kg	Deep intramuscular
Acepromazine and ketamine	0·03 to 0·05 mg/kg 5 mg/kg	Together deep intramuscular
Midazolam	0·1 to 0·5 mg/kg	Deep intramuscular or intravenous
Midazolam and ketamine	0·2 mg/kg 5 mg/kg	Together deep intramuscular
Diazepam	0·5 to 2 mg/kg 1 to 10 mg/kg	Intravenous Deep intramuscular
Diazepam and ketamine	2 mg/kg 5 to 10 mg/kg	Intravenous followed by intravenous to effect
Xylazine, ketamine ± butorphanol	1 to 3 mg/kg 5 mg/kg 0·1 to 0·2 mg/kg	Together deep intramuscular

Note that none of the drugs listed above are licensed for use in pigs. An agent can only be used if it appears in one of the annexes (I to IV) of the Council Regulation (EEC) 2377/90

[Overview of Malignant Hyperthermia](), Merck

[Anesthesia agents and complications in Vietnamese potbellied pigs,]() JAVMA 01 July 2011, Vol.239(1), pp.114-21

Objective—To document complications associated with preanesthetic and anesthetic agents used in Vietnamese potbellied pigs and identify predictors of complications.

Design—Retrospective case series.

Animals—27 potbellied pigs (14 female and 13 male) ranging in age from 0.25 to 15 years old and ranging in body weight from 5.9 to 169 kg (13.0 to 371.8 lb) that were anesthetized on 32 occasions between 1999 and 2006.

Procedures—Data, including perianesthetic management, anesthetic agents and dosages, complications, and outcome, were retrieved from medical records. Patient information, anesthetic agents, and duration of anesthesia were evaluated as predictors for development of complications.

Results—Anesthesia was maintained with isoflurane or sevoflurane during 30 anesthetic episodes. Commonly used premedicants were butorphanol, atropine, and midazolam administered in combination with xylazine or medetomidine and a combination of tiletamine-zolazepam and butorphanol. Anesthesia was induced with an inhalation agent on 15 occasions, via injection of ketamine on 10 occasions, and via injection of propofol on 3 occasions. Complications included hypoventilation (16/24 [67%]), hypotension (16/25 [64%]), hypothermia (15/31 [48%]), bradycardia (9/32 [28%]), and prolonged recovery time (7/32 [22%]). None of the factors evaluated were associated with development of these complications. All pigs survived anesthesia.

Conclusions and Clinical Relevance—Results suggested that a variety of anesthetic agent combinations can be used to provide anesthesia in potbellied pigs with satisfactory outcomes. Although there were high incidences of hypoventilation, hypotension, and hypothermia, no specific anesthetic agent was associated with development of these complications.

Practice: FA drugs and protocols

Try your hand at choosing protocols

Level A. Bovine standing sedation

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https://open.lib.umn.edu/largeanimalsurgery/?p=5348#h5p-166

Level B. Food animal recumbent sedation

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https://open.lib.umn.edu/largeanimalsurgery/?p=5348#h5p-167

Level B. Camelid anesthesia

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https://open.lib.umn.edu/largeanimalsurgery/?p=5348#h5p-49

For Future Reference - Create a drug reference table

Exercises

Choose a species of interest (swine, beef cattle, dairy cattle, small ruminants, camelids) and create a table for the following drug classes to enable you to find drugs based on the criteria given on the preceding page. Not all drugs will be useful in all species.

Suggested table template:

Drug	Gram +/-	Static/ cidal	Indications	Distribution	Routes	Side effects	Restrictions

Amoxicillin	Oxytetracycline
Ampicillin	Penicillin
Ceftiofur (several formulations)	Sulfadimethoxine
Enrofloxacin	Sulfamethazine
Erythromycin	Tetracycline
Florfenicol	Tilmicosin
Gamithromycin	Tulathromycin
Lincomycin	Tylosin

RESOURCES

Antimicrobial resistance learning site

Injectable antibiotics approved for use in beef cattle

Considerations for extralabel drug use in calves, FARAD Digest

Swine antibiotics summary, Dr. Zhitnitskiy

Amoxicillin- current use in swine medicine, 2018 J Vet Pharm Therap – good discussion of first and second line drugs

Food Animal Drug Regulations

Keeping our food supply safe is crucial for all of us. It is also likely that our food sources will change and we will need to understand the basic principles regardless of species interests.

Regulatory Concerns

Ensuring we don't have unwanted drugs in our food supply is an important component of working with food producing species. In the USA, these species are primarily cattle, swine and chickens. Since we generally don't do surgery on chickens, those aren't discussed here. Sheep, goats and camelids are food producing animals but are considered as minor species and have different guidelines. While most pot bellied pigs are not considered food animals, they are still swine and must meet federal guidelines for a major species.

FARAD, the food animal residue avoidance databank, should be your first step for determining whether or not a drug can be used in your patient. FARAD is highly useful but can be confusing as it serves many different groups. And not everything you will want to know is on there. This section will help you navigate FARAD, let you practice applying drug withholding information to cases, and expand your ability to find information elsewhere.

RESOURCES

Milk and dairy beef residue manual, 2019

Drug residues in poultry – a review; 2018 JVPT

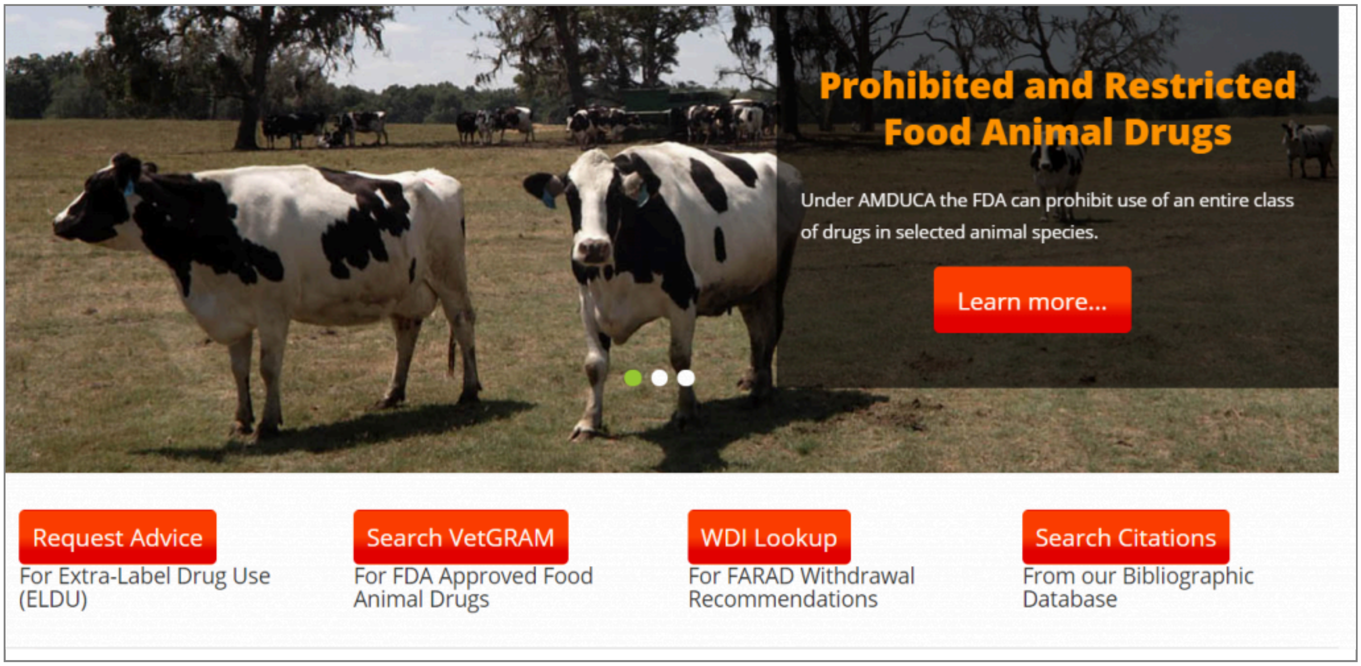
More resources including Veterinary Feed Directive

Extralabel drug use for mixed and small animal practitioners, NCSU CVM 2019 Forum

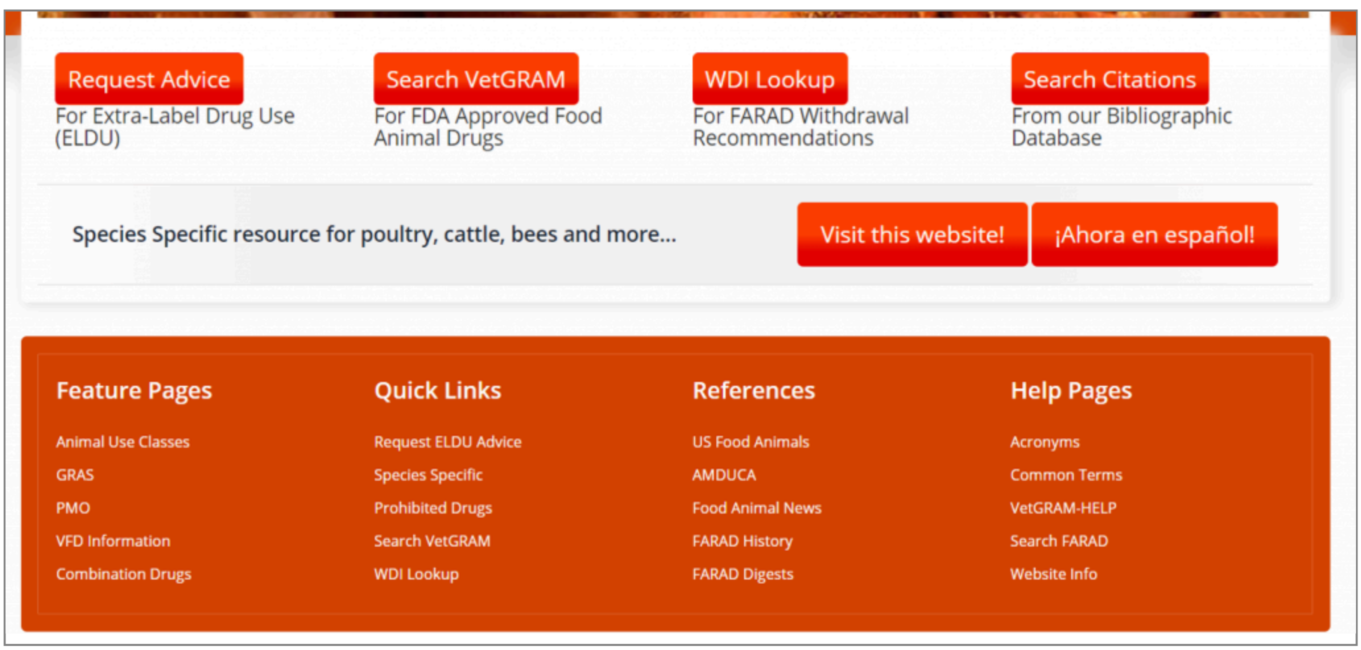
Small ruminant mini FARAD site

Navigating FARAD

Open up a browser window and go to FARAD.org. Scan through the four orange boxes below the image to explore the site.



There are more links below those too – this seems to be the new version of the boxes.



Use the following exercises to help you get more comfortable with the site.

As you work through these, also try to differentiate between

- FDA approved drugs
- non-FDA approved drugs with recommended withholding times
- drugs that can be used under AMDUCA guidelines, with or without recommended withholding times
- drugs that cannot be used in food animals or certain food animal groups regardless

FARAD tour (the links and how to use them are similar, just not the front page)

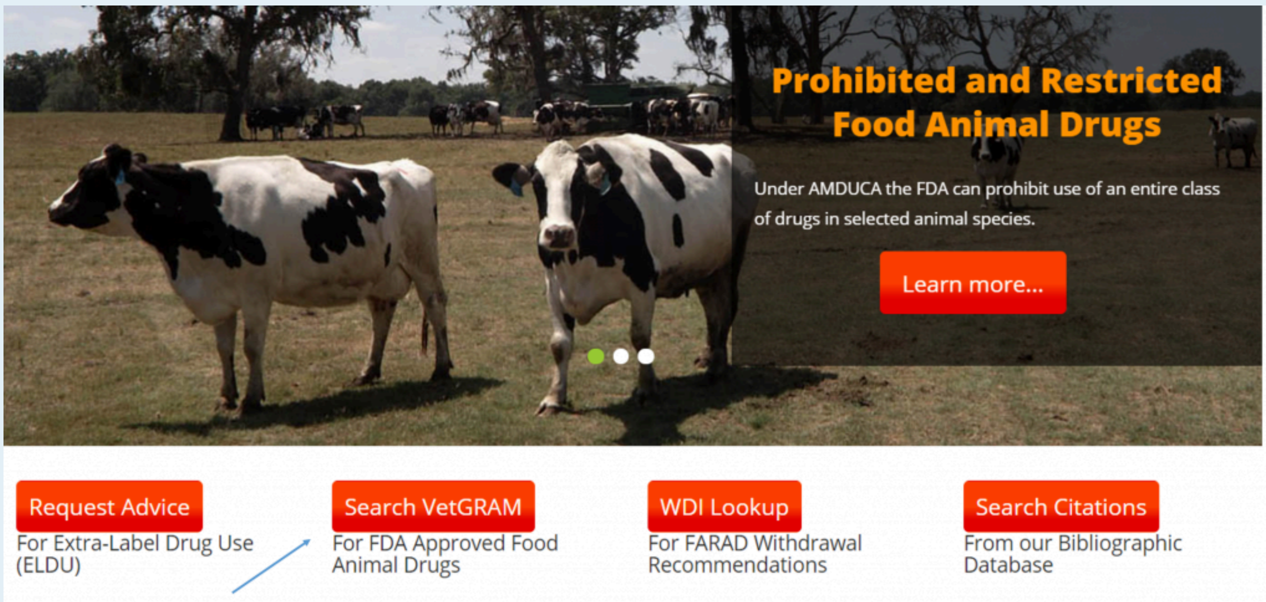
Guide to FARAD Resources, JAVMA 2017

Exercise 1 Finding approved drugs

Level A

Exercises

Use the approved drug search function http://www.farad.org/vetgram/search.asp to answer the questions below.



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Try it on your own first. After you are familiar with the tab, this video may help make the process more efficient:

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Exercises

Try your new skills again:

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https://open.lib.umn.edu/largeanimalsurgery/?p=65#h5p-6

Exercise 2 AMDUCA

Level A

Exercises

AMDUCA guidelines are also on the FARAD site. See if you can find them to answer the following:

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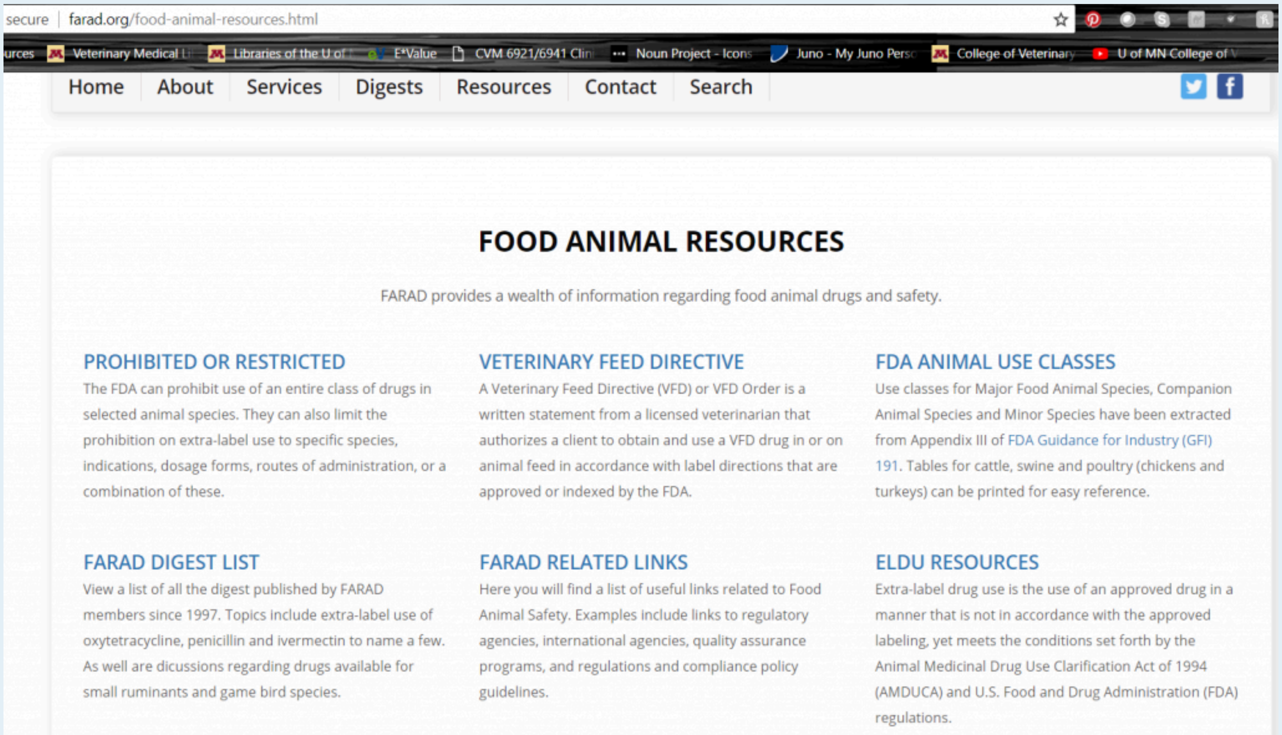
https://open.lib.umn.edu/largeanimalsurgery/?p=84#h5p-8

Struggling? Read more about what is considered Extra-label Drug Use.

Exercise 3 Illegal and restricted use drugs

Exercises

Level B. Use the FARAD site to find those [drugs that you can't use in food animals](https://open.lib.umn.edu/largeanimalsurgery/?p=98).



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https://open.lib.umn.edu/largeanimalsurgery/?p=98#h5p-10

Exercises

Level C. Potbellied pigs are a challenge:

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https://open.lib.umn.edu/largeanimalsurgery/?p=98#h5p-12

How I would go about figuring this out:

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https://open.lib.umn.edu/largeanimalsurgery/?p=98#oembed-1

And just in case you need a reminder of food animal potential:

Molly gets rescued and eaten

Exercise 4 Identifying withholding times

Exercises

Level A. Use the withdrawal recommendation look up http://www.farad.org/wdilookup/ to find the withholding on lidocaine used for a local block in a dairy cow.

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https://open.lib.umn.edu/largeanimalsurgery/?p=70#h5p-7

Exercises

Level A. What about xylazine? Is it FDA approved? Can you find withholding information?

CAUTION

Obviously we often use drugs that are not FDA-approved but that does mean we have to carefully follow AMDUCA guidelines (and are not uniformly good at doing so). While we tend to consider FARAD calculated withholding times as "approved" this does not equate to FDA approved drugs and label withholding.

RESOURCES

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One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=70#oembed-2

If the drug is approved, the label should have the recommended withholding information (or a google search for the drug label should work).

See this example for Ceftiofur in swine

Default withholding periods in New Zealand

Exercise 5 MUMS Act

Exercises

Level A.

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https://open.lib.umn.edu/largeanimalsurgery/?p=103#h5p-13

Minor Species: It is very expensive to get drugs approved; hence many drug manufacturers stop after one indication or species. Due to the limited financial gains from marketing for sheep and goats, these animals have limited to no approved drugs.

Minor Use: Similarly, it would not be financially acceptable for drug companies to test their drugs on every condition individually. The less common diseases (about everything except endotoxemia, fever, respiratory disease and footrot) don't often have approved drugs. Extra label use is required if not FDA approved drug exists.

The act was also designed to incentivize companies to actually get approval for these conditions and species but that has not worked very well.

MUMS Act

The UK uses 7 days milk/28 days meat minimum withhold if the drug is not specifically licensed for goats.

Exercises

Level A.

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https://open.lib.umn.edu/largeanimalsurgery/?p=103#h5p-14

Exercise 6 Extrapolating withholding data

Particularly for minor use and minor species, you will not find a withholding time in FARAD for the particular species or route.
Google sometimes can be helpful. Other countries may consider the drug legal and have published withholding times. You can find some of these by using the search bar in FARAD:

This will result in some ads and in articles or publications that you might find useful (below the ads)

You can also search for similar species and/or routes. The closer you can get the better. Trying to extrapolate oral swine medications for subcutaneous use in an alpaca is unlikely to be close.

Exercises

Level B

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https://open.lib.umn.edu/largeanimalsurgery/?p=95#h5p-17

RESOURCES

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https://open.lib.umn.edu/largeanimalsurgery/?p=95#oembed-1

New Zealand withholding info

Neonatal adjustments, 2003 VCNA FA- extra information about physiological changes

Exercise 7 Understanding half lives

Adjusting withholding based on half lives can seem very complicated. However, if you can't find any reasonable estimates or what to use a different dose in a particular animal, some basic understanding can help you adjust your plans.

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Exercises

Level C. What will need to happen to your withholding plans if you double the dose?

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RESOURCES

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Challenge yourself!

Exercises

Challenge questions

Level A.

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https://open.lib.umn.edu/largeanimalsurgery/?p=180#h5p-18

Level A.

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https://open.lib.umn.edu/largeanimalsurgery/?p=180#h5p-116

Level B.

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https://open.lib.umn.edu/largeanimalsurgery/?p=180#h5p-19

Practice Quizzes

Level A.

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https://open.lib.umn.edu/largeanimalsurgery/?p=180#h5p-20

Level A.

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Level B.

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https://open.lib.umn.edu/largeanimalsurgery/?p=180#h5p-175

FA Drug Regulation Summary

Food animal drugs are tricky

  - Pot bellied pigs have to follow pig rules
  - Camelids, sheep and goats are under MUMs rules and have more flexibility but are still food animals
  - Use FARAD and VetGram to identify prohibited drugs, ELDU allowances and withholding times
    - This can be very tricky for goats etc. – try to find a cattle version
    - You can contact FARAD and ask
  - Oral drugs in ruminants often don't work. Meloxicam does
    - Use of meloxicam is a bit edgy. We justify it as a better analgesic and there are no FDA approved analgesics in food animals yet

To determine withholding

- Typically count on 5 half-lives to clear a drug
- If you double the drug amount, add 1 half life
- Elimination is via the same process regardless of route of administration
  - if you can figure out the difference in peak values, that can help with half life calculations
    - Iv administration -> high, fast peaks
    - IM administration -> slower peaks but generally same peak level
      - will take a bit longer to eliminate
    - PO administration – slower peaks and lower peaks
      - usually take less time to eliminate since not as much drug available

General Surgery

Suture material, suture patterns, surgery knots and restraint knots

Skin incisions

Skin incisions can be made using the flat of the blade with a fingertip grip or the tip of the blade using a pencil grip.

The fingertip grip is useful for long incisions while the pencil grip is helpful for delicate or non-linear work. In all cases it is important to know where the tip of your blade is. Control the depth and keep the blade as flat as possible. If movement is possible (standing surgery or teat surgery) or if the tissues are of unknown depth, a groove director can be inserted in the tissue plane to create a barrier and guide the depth of the cut.

groove director

Practice video

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=4284#oembed-1*

https://youtu.be/Lyf9NxZ3vPY?list=PLLg0-sjiAoyNAUd7O_yMdIsILgf0kcAEu

Choosing suture material can seem overwhelming at first. There are a myriad of suture types out there, all with different needles and packaging. However, most times, our choices are more limited.

Suture related factors

Absorbable or not absorbable

Suture material such as polyglactin 910 (Vicryl) is absorbable. Nylon is not absorbable.

Absorbable suture materials are hydrolyzed by the body and dissolve over time. Absorbable suture is typically preferred when the sutures won't be removed (eg inner layers of the skin or body). The body typically reacts to suture, seeing it as a foreign body. The problem is resolved as the suture is dissolved.

Nonabsorbable suture material is used externally (skin) and when maintained strength or security is essential (eg tendon replacement). Most of these are fairly inert so the foreign body reaction is minimal.

Monofilament or braided

Monofilament sutures are single stranded. Such suture material tends to glide through tissue better than multifilament suture. However, many of these are more likely to fatigue and break. Braided suture is stronger but tends to wick fluids. This can lead to infections when braided suture is used in contaminated environments.

Chromic gut is extruded. It is multifilament but not braided. However, the filaments are easily damaged and lead to a fraying and a rough surface that can potentiate infection similar to braided suture material. For this reason, surgeon's knots are not recommended when working with chromic gut.

Duration and strength of duration

The suture needs to last long enough but not too long. Nonabsorbable suture materials last at least 6 months. Other suture materials vary in duration of relevant strength. In some instances, this is confounded by the environment. Eg Dexon dissolves rapidly in urine, monocryl in milk and many suture types in pus or infected fluids.

Reactivity

Some suture is minimally reactive (stainless steel) while other suture is highly reactive (Vetafil, chromic gut). In many instances, one or the other is preferred. If we would like to create an adhesion quickly, reactive material is typically good.

Size availability

Not all suture is manufactured in all sizes. Suture sizes range from 9-0 and smaller (ophthalmological, vascular surgery, etc) to 5 Vetafil (cow hide). Veterinary suture typically ranges from 4-0 to 3 in general practice. Only polyglactin 910 (Vicryl) currently comes in size 3.

Packaging

Suture on reels can be cut to a desired length but is sometimes only cold sterilized and may not be acceptable for all situations. Most other suture is packaged in smaller lengths. The suture may also be swedged onto a needle or be needle-less. The type of needle attached can also vary widely. Typically cutting needles are needed for skin and tough tissue; taper needles are safer for delicate tissues. Finding the right suture in the right length with the right needle on it can be challenging.

Price

Particularly due to the type of needle attached (and if a needle is attached), price can vary between manufacturers and suture sizes.

Surgeon preference

This category is typically called knot security or ease of use, but really each of us likes different suture material. If you are comfortable with a suture material, you use it more often and adjust to its quirks. Change is hard.

The suture packet will include many of the factors listed here

Patient related factors

External or internal

Is the suturing taking place in the skin or elsewhere? Will it need to stay permanently?

Duration of healing

How long will it take the tissue to heal? How long does the suture need to maintain strength?

Forces on the tissue (strength)

How much force is typically on the tissue? How strong does the suture need to be?

Risk of infection

Is the procedure clean, contaminated, or dirty? Is wicking an issue?

Needle and suture length

What are the needs of the procedure? How big/small a needle is desired to get through the tissue? How delicate is the tissue? How long a section of suture is required?

> Making your own swedged on needle

Other factors

Are there other factors that will alter healing or suture function? Is it in the bladder, the teat or the tendon? Is milk, urine or pus potentially in contact with the suture? Are adhesions desired or something to be avoided?

Suture table

Create a table for future reference, comparing the suture types in the clinic (UMN or other site)

Suture material	Absorbable?	Mono or multifilament?	Strength/ duration	Knots/ ease of use	Size available	Cost for 2-0 with needle	Reactivity	Misc/ comments

Suture choice practice

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An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=2902#h5p-131

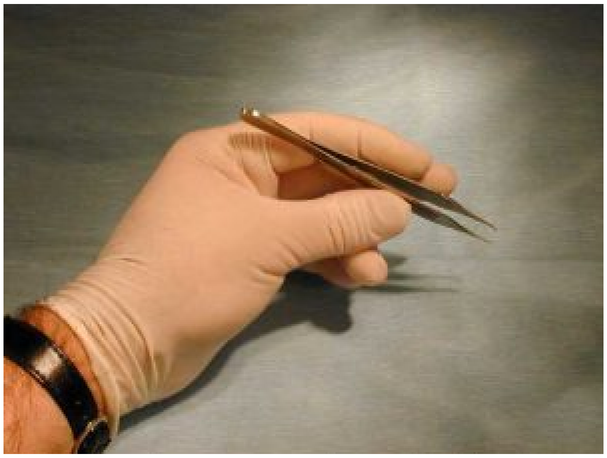
Key principles

Maintain a light grip on the needle holders

- Thumb and ring finger, first knuckle only
- Not a death grip!
- Advanced: no thumb in the ring – use your thumb pad to open and close the ratchet

Thumb forceps held like tweezers or a pencil

- No overhand grips
- Advanced: don’t set them down

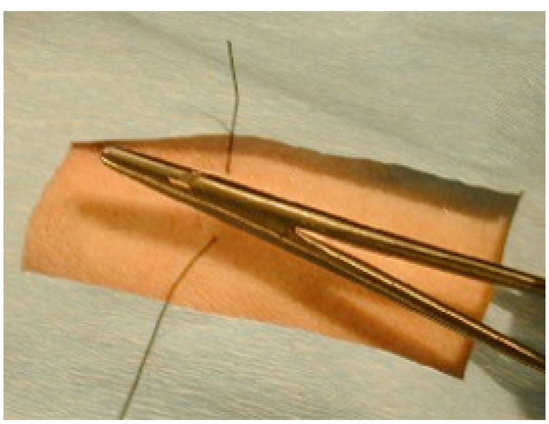


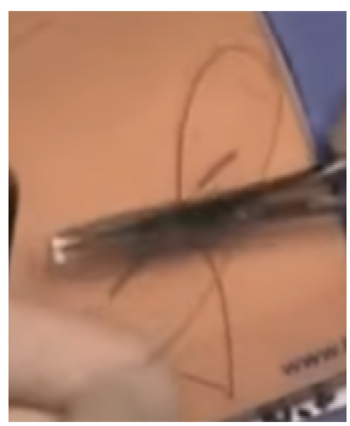
Rotate arm and wrist to move the needle

- Avoid pushing the needle through with a straight force
- If your needle is straightening on you, you aren't rotating your arm

Needle holders are positioned over the knot for tying

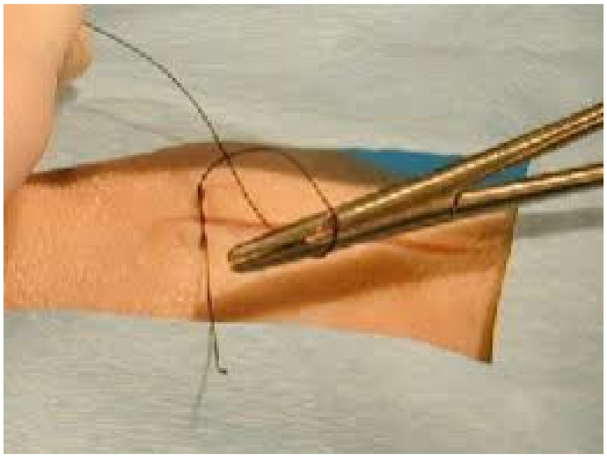
- Between the strands of suture
- Not underneath either strand





Don't pull up on the knot

- Keep needle holders close to the skin
- Don't move the needle holders up and down
- Use your opposite hand to wrap the suture around the needle holders



Control your suture

- Keep your hands where you can see them
- Wrap or fold the suture into your other hand to keep it under control

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How to use your thumb forceps to stabilize the needle

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General

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Suture selection

Cosmesis is often important in skin closure. A good subcutaneous closure or subcuticular closure can aid in making the incision heal well. Optimal healing comes with appositional patterns as the cells are already lined up and ready to join.

Large animal species are less likely to chew out their sutures than small animal patients so it is common to use a subcutaneous closure (if needed) + skin closure. Skin closure can be with either an interrupted pattern or a continuous pattern. Cruciates are a more efficient closure pattern than simple interrupteds. Both are more efficient than a subcuticular pattern. For skin closure, it is very hard to make a simple continuous pattern look pretty; it is much easier to make a Ford-interlocking pattern look pretty.

Subcutaneous tissue is similar across species and most can be closed with 3-0 suture material; however, the needle on 3-0 suture can be very tiny. 2-0 suture with a larger needle may be more appropriate in some situations. Subcutaneous layers are closed with a taper needle. Subcuticular patterns are typically performed with 3-0 suture on a cutting needle.

Cows have very thick skin (think leather) while other LA species have skin similar in thickness to a dog or cat. Cutting needles are required for skin closure in all species. Cow skin is often closed with size 1 to size 3 suture while the skin of horses, pigs, and SRC can be closed with 2-0 to 3-0 suture depending on the location. Ford-interlocking is the most common pattern chosen. Cruciates may be used for non-linear wounds or for a “drainage suture”.* Skin staples can also be used in non-bovine patients but do “pinch” on removal so should only be used in emergencies or where removal won’t result in injury to the person removing them.

Ideally, tension is minimized before skin closure. If tension is present, tension relieving patterns using larger suture may be needed. A near-far-far-near (NFFN) type pattern is cosmetic as well as tension relieving. As it is an appositional pattern and will stay in until the tissue is healed, it should not be bigger than 2-0 or 0 in nonbovine patients. If tension is greater than can be managed with a NFFN suture, vertical and horizontal mattress sutures may be placed temporarily to relieve tension. These patterns will evert the skin edges. The skin can then be closed with an appositional pattern. After 3-4 days, the mattress sutures can be removed, leaving just the appositional pattern. Larger suture (1-2) can be used for the mattress sutures. Stents (tubing or pads) are often used to prevent the larger suture from cutting through the skin.

*suture placed at the ventral aspect if infection is suspected. This suture can be removed to allow drainage without disturbing the continuous pattern.

Note: most ruminants heal quickly and it is often more efficient to leave the wound open rather than to try and close a wound under tension in a cow, sheep or goat.

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Youtube video

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How to use your thumb forceps to stabilize the skin

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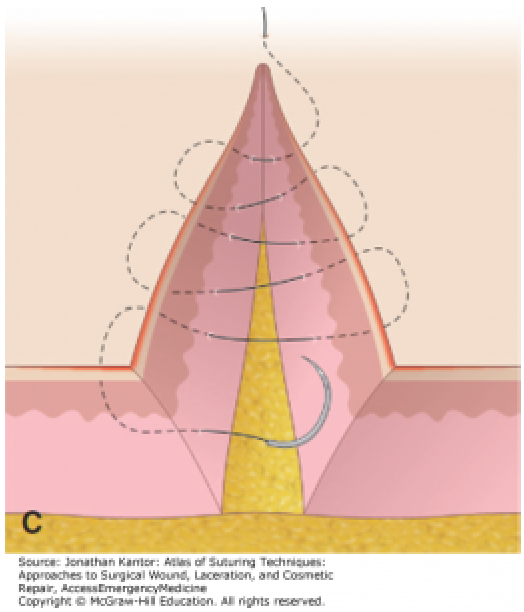
Suturing- intradermal/subcuticular pattern

This pattern requires a cutting needle and is typically performed using 3-0 absorbable suture.

Subcuticular closure



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Suturing - tension relieving suture patterns

Both vertical and horizontal mattress patterns are everting – they force the cut edges outward. NFFN patterns are appositional and bring tissue layers into direct contact with the same layer on the opposite side.

Vertical mattress

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Vertical mattress

you can start with the far bite or with the near bites

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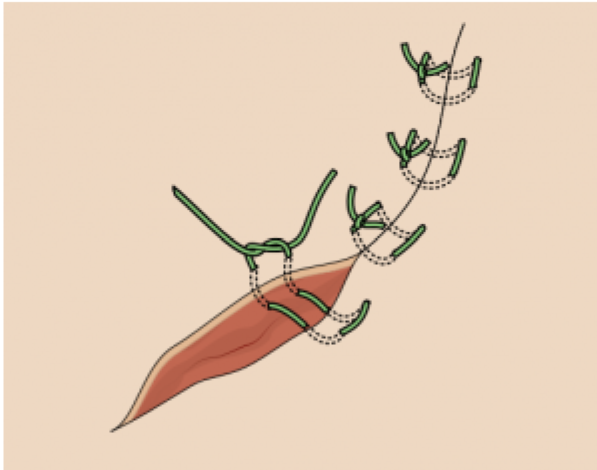
Horizontal mattress



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Horizontal mattress with stents – clinical case

With a mattress suture, you can also place a simple continuous pattern. With this approach, you can remove the larger suture used for the mattress pattern after the skin stretches (3-4 days), leaving the more cosmetic simple continuous suture to finish the job.

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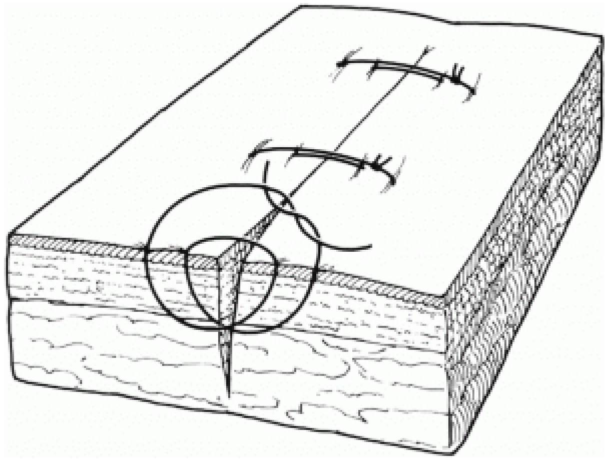
Near-far-far-near



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NFFN between stents – clinical case

You can change the letters around too

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2940#oembed-8

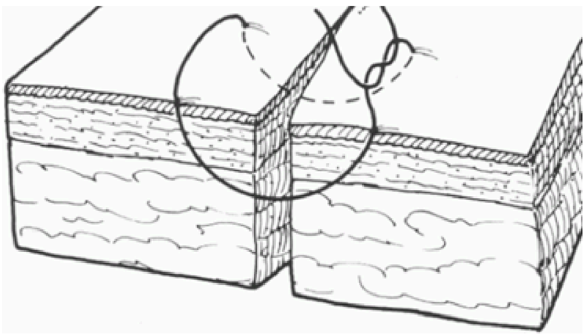
Resources

G Kelmer et al. Simple techniques to decrease tension on sutured wounds in horses, Equine vet. Educ. (2022) 34 (2) 67-72

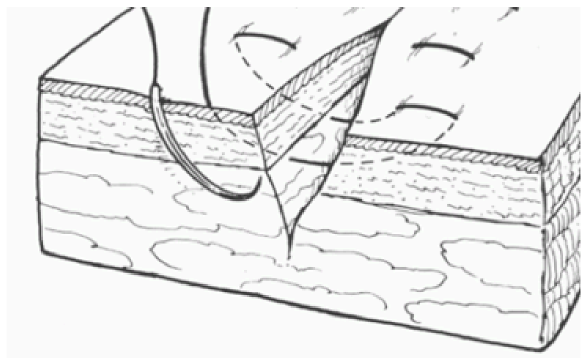
Suturing - split thickness and corner stitch

Split thickness

Using split thickness bites creates very cosmetic skin closures.



Full thickness bite enters SQ



Partial thickness bite stays in dermis

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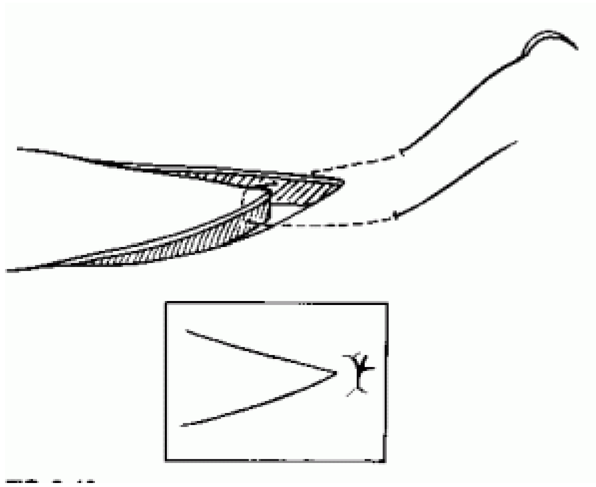
Corner bites

Corner bites are a split thickness version that helps preserve vascular supply



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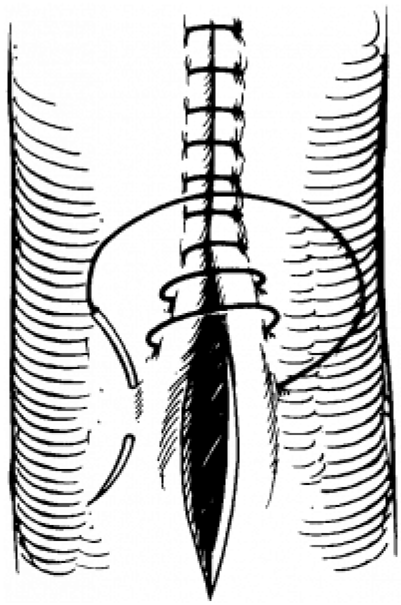
The buried horizontal suture

Suturing - inverting suture patterns

Inverting patterns turn the cut edges inward and minimize exposed suture.

Cushing



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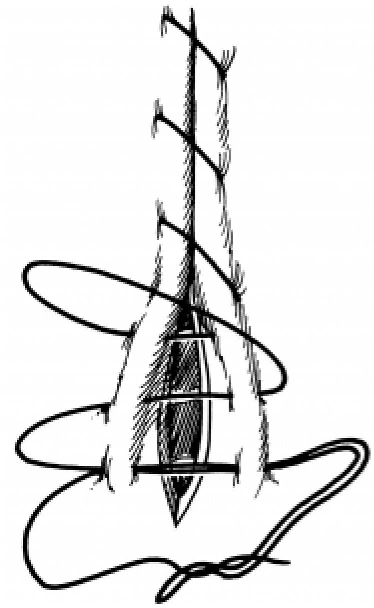
Lembert



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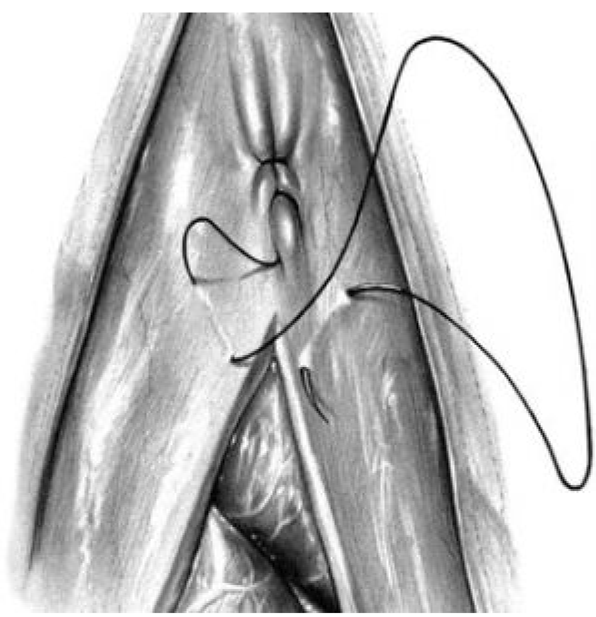
Utrecht



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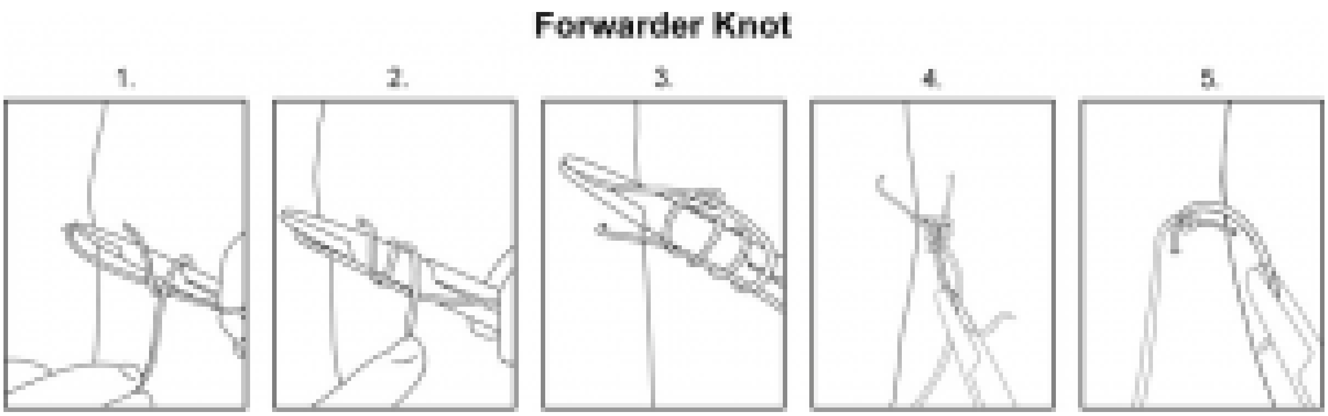
Resources

Newman and Anderson. Cesarean section in cows 2005 VCNA 21(1):73-100

Forwarder knots

Forwarder knots are more secure than square knots for the start of continuous runs and function well in fat and fluid media.



1. Take a bit through the tissue from left to right
2. Hold the working end of the suture in the left hand; needle holder and free end of the suture in the right hand.
3. Turn the working end around both the needle holder and the free end of the suture. Repeat twice more, creating three throws about the combination.
4. Grasp the working end with the needle holders, pulling the working end through the looped throws as the needle holder is withdrawn
5. Pull the working end and free end in opposite directions, tightening and locking the knot

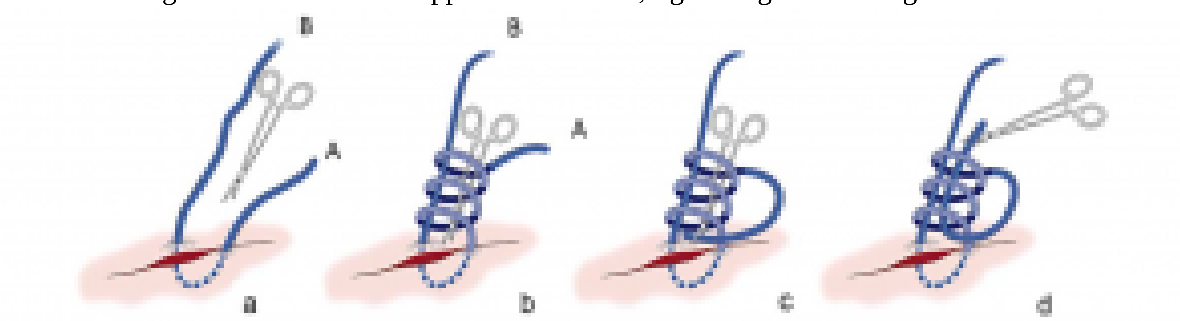


Figure 1 Formation of a forwarder knot. (a) A bite is taken through the tissue. The standing end (B) and the working end (A) of the suture are placed adjacent to each other and the needle holders. (b) The working end (A) of the suture is then turned around the needle holders and standing end (B) of the suture. The number of times this is performed depends on surgeon preference. (c) The working end of the suture is then grasped by the needle holders through the placed loops. (d) The needle holders are withdrawn, pulling the working end of the suture through the loops and locking the forwarder knot.

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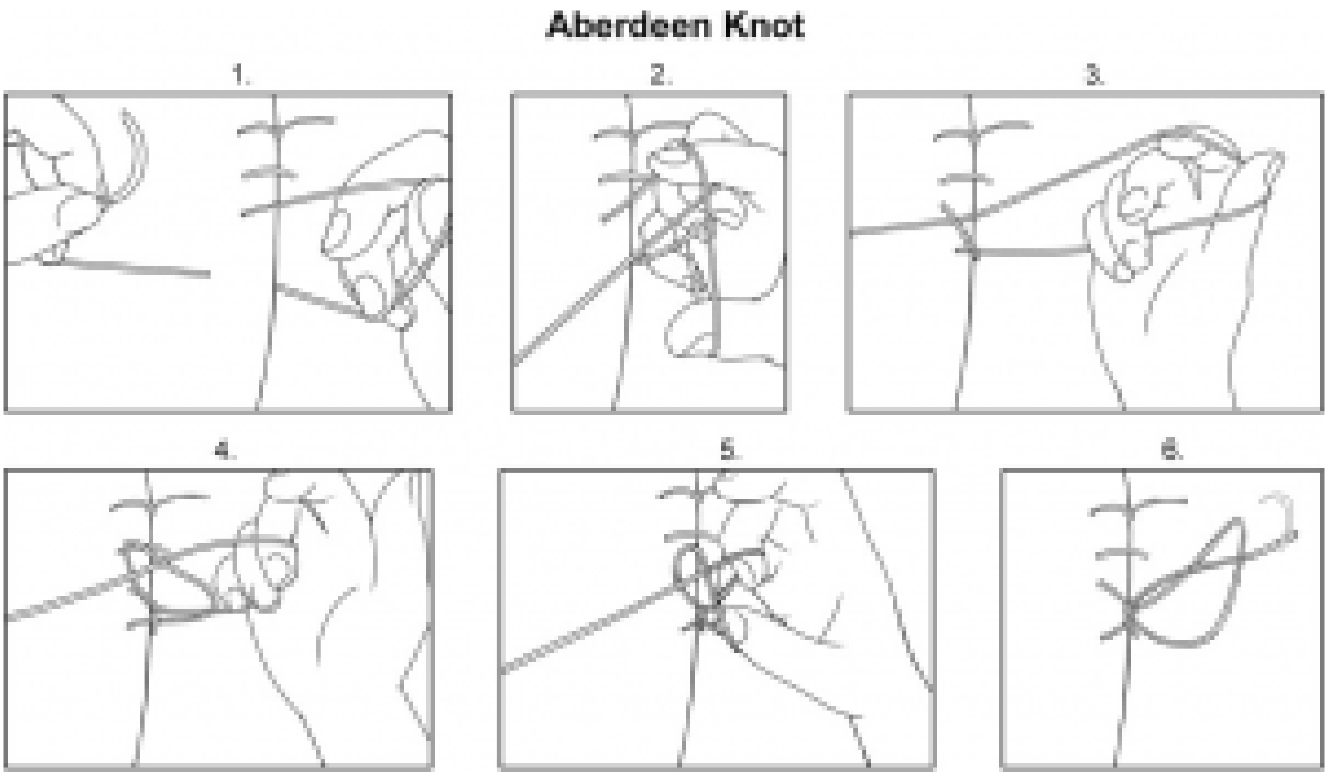
Aberdeen knots

Aberdeen knots are used at the end of a continuous run. They result in better security with less bulk than square knots, particularly in continuous runs.



1. Take the final bite of the continuous pattern through the tissue from right to left, leaving a large loop
2. Hold the working end of the suture (needle attached) in the left hand
3. Create a second loop in the working end and pass it through the first loop, while maintaining tension. This equals one throw
4. Repeat for 4 throws
5. Pull the working end through the final loop and tighten to lock the knot

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They are also an easier way to bury your knot

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Resources

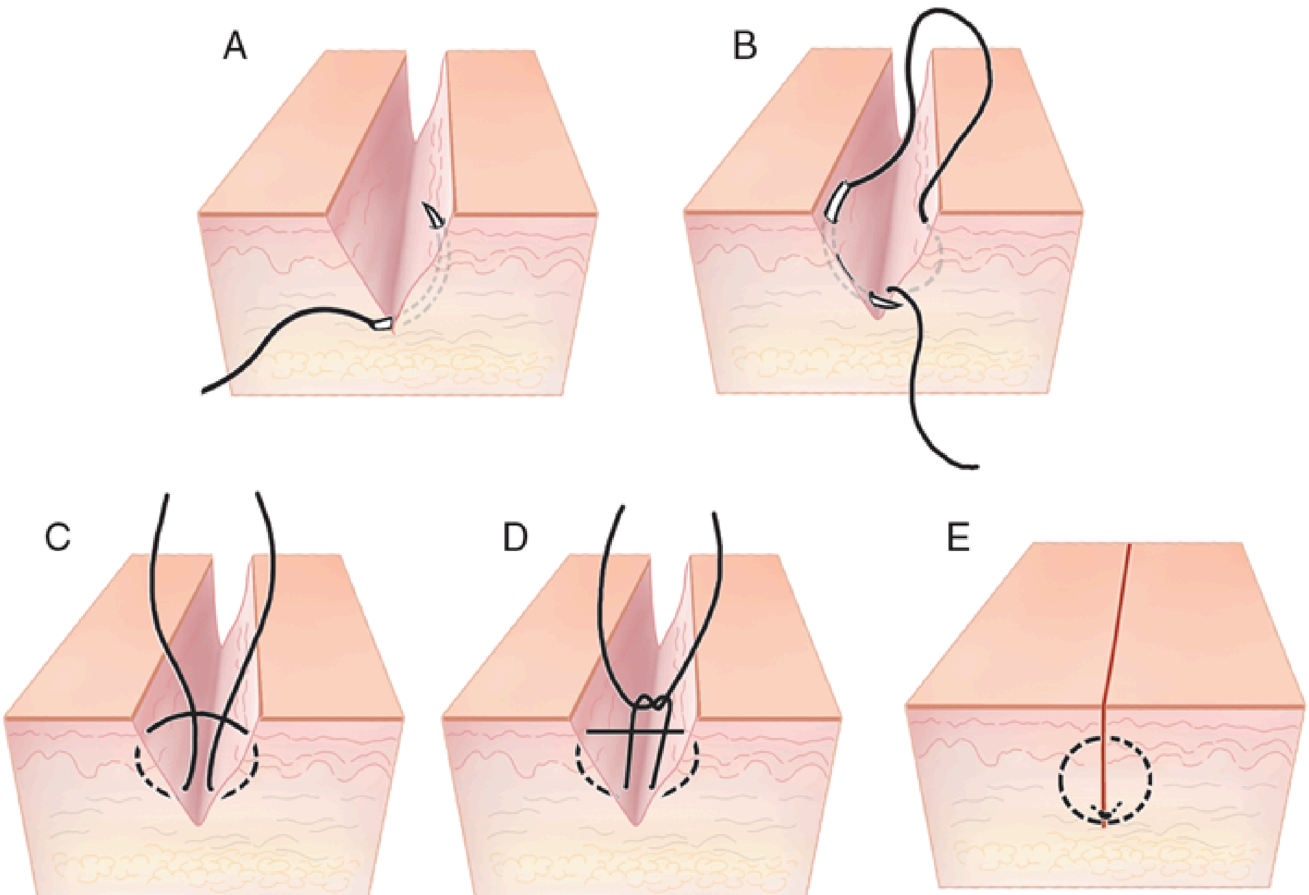
McGlinchey L et al. Bursting strength of surgeon's and self-locking knots for closure of ventral midline celiotomy in horses. Vet Surg 2018, 47(8):1080-1086

Gillen AM et al. In Vitro Evaluation of the Size, Knot Holding Capacity, and Knot Security of the Forwarder Knot Compared to Square and Surgeon's Knots Using Large Gauge Suture. Vet Surg 2016, 45:1034-1040

Knots - burying the knot

Techniques are similar between these two types. For skin – deep to superficial, superficial to deep. For lumen closure – near to far, far to near.

Burying the knot – skin version



Source: Reichman EF: *Emergency Medicine Procedures, Second Edition:* www.accessemergencymedicine.com

[University of Saskatchewan Lab](#) – step by step

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Watch this one on [youtube]()

Burying the knot – lumen closure (inverting patterns)

Utrecht Pattern - First Stitch.

The Utrecht pattern for uterine closure is a modified Cushing pattern, a continuous infolding pattern whereby the individual stitches are placed diagonally rather than parallel to the line of incision. The first stitch is placed just above the (dorsal) commissure, at the apex of an inverted, obtuse triangle.

Utrecht (1976)

Utrecht Pattern - First Knot.

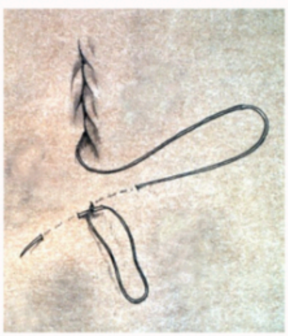
The second bite returns to the apex of the triangle.

Utrecht (1976)

Utrecht Pattern - First Tie.

As the ends of the suture are pulled tight, the base of the triangle folds in.

Utrecht (1976)



Utrecht Pattern - Ending the Incision.

The closure of the incision is ended with another triangle. The apex is where the needle last exited. The needle is essentially re-inserted in the same location, as shown in the illustration.

Utrecht (1976)

Utrecht Pattern - Final Knot.

The needle end of the suture is tied to the loop left behind at the apex of the triangle.

Utrecht (1976)

Utrecht Pattern - Final Tie.

By pulling up on both ends of the suture material the base line of the triangle folds in and the knot is buried.

Utrecht (1976)

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2966#oembed-2

Knots - finishing the Ford Interlocking

If you have a swedged on needle, just go backwards for the last bite.

If you don’t you can do this version or the Aberdeen knot

See video on youtube

Closing wounds under tension

In large animal practice, we often have to close wounds that are under tension. This isn't commonly an issue in dogs and cats. Ruminants, because of rapid wound contracture, often will do fine even if you don't close the wound. However, it is good to know several different ways to manage wound closure with tension as you may want to use a combination and some work better in some instances.

This video series takes you from mass removal (a common reason for needing to close a wound under tension) through several options including undermining, knot tricks and relief incisions.

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Options to consider:

1. 3 clamp technique or a temporary mattress suture in the center – this takes tension off until the suture line is advanced enough to distribute the tension
2. Undermining – creating dead space can be a necessary evil – undermine the tissue to minimize pull on the incision. This is to be avoided when possible.
3. Start from both ends – this method works by taking advantage of areas with less tension and gradually bringing the wound together
4. Tension relieving patterns – various pulley and mattress patterns are better than simple interrupteds and cruciates at relieving tension (see the following chapter)
5. Relief incisions – by creating smaller incisions that can heal well (due to the smaller size), you can remove tension on the primary wound
6. Special knots – a granny knot can be useful as it can be tightened after it is place. Other variants are performing a surgeons knot with 3 throws vs 2 (to increase friction) or lightly clamping the knot as you might with a Christmas ribbon (don't clamp monofilament suture please).

Broken suture, broken off needle, dysfunctional needle

- Remove the needle.
- Start a new strand near where you were working; tie a knot and secure
- Tighten up sutures associated with the broken strand
- Tie the new strand to the broken strand
- Trim the short ends and continue suturing

Watch on youtube

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Loose suture line

- Tie a knot with a new strand in the middle of the loose bit
- Tighten up the original suture line so you have a loose loop in the middle (the rest should be tight)
- Tie the loop to the new strand.
- Trim all suture ends and pretend it was that way all along.

Handties

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Type of tie	Right hand	Left Hand
Two handed tie	Two-handed, Righty (Links to an external site.)	Two-handed, Lefty (Links to an external site.)
One handed tie	One-handed, Righty (Links to an external site.)	One-handed, Lefty (Links to an external site.)

HELPFUL TAG WORDS ONE HANDED:

KARATE CHOP rope in R hand, DRAPE rope from left hand next to this rope, move middle finger OVER the left rope AND UNDER the right rope, then PULL right rope UP, next throw, make a CLAW shape with R index finger, rope in R hand, DRAPE left rope next to it, move index finger UNDER and OVER then rotate thru then PULL free end DOWN

HELPFUL TAG WORDS TWO HANDED:

make HOOK with rope on R index finger, make CROSS with rope in L hand, PINCH fingers together of R hand, PUSH pinched fingers thru, GRASP rope from L hand and PULL thru" repeat process using HOOK on R thumb instead of index finger, make CROSS, PINCH fingers together of R hand, PUSH pinched fingers thru, GRASP rope from L hand and PULL thru.

More videos

PennVet Instructional videos

Ligatures

Strangle knot- shown more effective than a transfixation suture and is considered easier to tie than a Miller's knot.

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Miller's knot with needle holders

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One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=3616#oembed-3

Transfixation ligatures are preferred over regular surgeons knots to prevent the ligature from sliding off

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Rope restraint

Knots and ropes can be very handy additions to your pharmacological restraint. These can be used on cattle (and supposedly cats) but are generally not appropriate for horses except for the quick release knot.

Casting cows is useful to make them lie down for recumbent procedures. There are two main methods:

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=3608#oembed-1*

Once cast, however, she may need lots of drugs or additional ropes to minimize the risk of human and cow injury.

The following knots are very useful:

- Quick release
- Bowline
- Tomfool knot
- Truckers hitch

Resources

https://www.animatedknots.com/complete-knot-list

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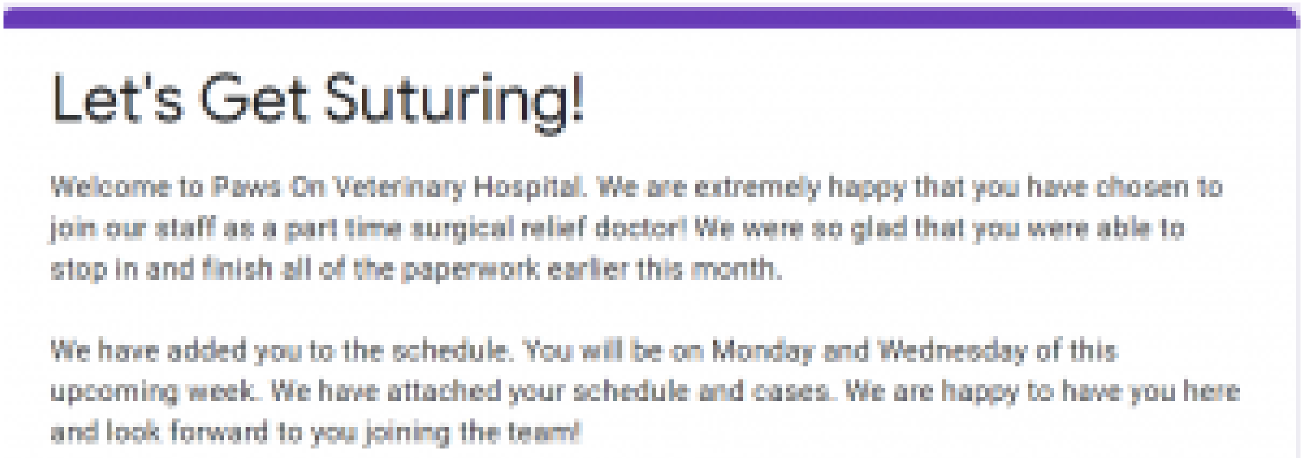
Practice

Small animal suturing challenge puzzle – Created by Theresa Heitz, UMN CVM CO 2022



Let's Get Suturing!

Welcome to Paws On Veterinary Hospital. We are extremely happy that you have chosen to join our staff as a part time surgical relief doctor! We were so glad that you were able to stop in and finish all of the paperwork earlier this month.

We have added you to the schedule. You will be on Monday and Wednesday of this upcoming week. We have attached your schedule and cases. We are happy to have you here and look forward to you joining the team!

Large animal masses

This chapter is designed to support the LA masses section of LAS I

Learning Objectives

- Be able to determine if a mass is an abscess, granuloma, hematoma, hernia, tumor or cyst
- Be able to prevent abscess development from wounds
- Be able to manage abscesses in large animals and avoid common mistakes
- Know when isolation of an animal with an abscess is indicated

Differentials and diagnostics

Podcast: LA Masses overview (< 9 min)

The main differentials for masses in large animal species are:
•Cyst
•Granuloma
•Hematoma
•Hernia
•Tumor
•Abscess

Diagnosis

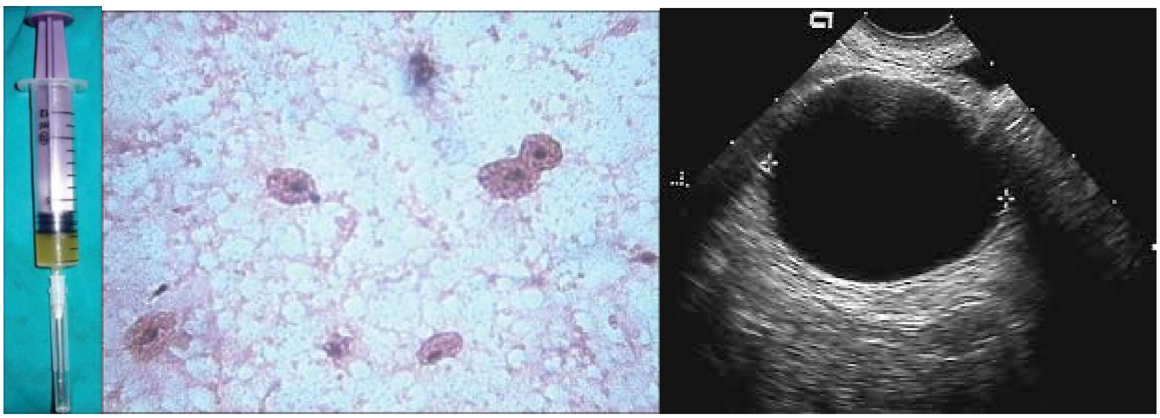
The first step in diagnosing a mass is starting broadly (common causes of masses) and then narrowing your differential list based on a good history and physical examination. These principles cross species. History of injury may point you toward abscesses, hematomas, granulomas and hernias. Fever is associated with abscesses and neoplasia. Cardinal signs of inflammation (heat, pain, swelling, redness, and loss of use) are typically usually identifiable with abscesses and sometimes with neoplasia. Ultrasound and other imaging studies can be useful to determine the type of tissue or cellularity of fluid, extent and size of the mass, infiltration (neoplasia) or capsules (abscesses) and to find foreign bodies. Typically the most useful diagnostic tool is fine needle aspirate – stick a needle in it. In most cases, this is safe and effective. There are exceptions! Needle sticks through contaminated regions (vagina, rectum, oral cavity, prepuce) or contaminated tissues (cellulitis) can easily *create* an abscess and should not be attempted.

Resources

Skin diseases in horses, VCNA 31(2): 359-376, 2015 – discusses sarcoids, granulomas, lymphomas, SCC and more

Cysts

Cysts are typically congenital and caused by the lack of development of a normal opening that would allow fluid to drain. They can be caused by repeated trauma and are the body's means of trying to create a fluid bursa for more padding. Cysts are often fluctuant (water balloon partially filled up) but can be quite turgid or firm. Needle aspiration usually results in a clear, nonodorous fluid that is mostly acellular. Ultrasound should show a clear fluid enclosed in a thin walled capsule.



Aspiration is usually not curative as the fluid redevelops. Formalin is commonly used in non-food animal species to stop the fluid production. The fluid in the cyst is removed and an equal volume of 10% neutral buffered formalin injected. The formalin can be re-aspirated after 5 min if desired. The formalin destroys the cells producing the fluid. If the cyst does not respond, is in a food animal, or is in an area that isn't easily injected, it can be removed surgically. It is important to remove the lining to prevent recurrence.

LA cysts

Goats can have wattle cysts. These are **branchial cleft cysts**, are benign and do not need removal.

Horses can be born with nasal epidermal inclusion cysts (atheromas). These are small cysts in the false nostril. These respond well to injection of formalin. The cyst desiccates and dries up/falls out in 2 weeks.

Horses can have ectopic teeth that lead to draining wounds near the ear – these are known as dentigerous cysts. Removal can be tricky as the tooth can be solidly attached to the skull.

Key Takeaways

Cysts are fluctuant, nonpainful and do not cause fevers.

- Ignore
- Treat with formalin injection
- Remove

Resources

Common questions from goat producers – DVM360 lumps and bumps

Granulomas

Granulomas are nodular, nonulcerative, and not usually pruritic. Some are mineralized. Granulomas form when the immune system walls off a foreign substance. Generally this is because the immune system can't eliminate it. Complexes of immune cells surround an infectious agent (bacteria, fungus, parasite) or material such as keratin or suture. Granulomas are typically composed of macrophages, often fusing to form multinucleated giant cells. The other cell types in the granuloma can be hints as to the originating problem (eg eosinophils with parasites or immune complexes). Granulomas develop as solid structures but loss of blood supply may lead to necrotic centers that appear caseated or cheesy.

The entire mass may be removed and submitted for histopathology, particularly if it is in a problematic area or is enlarging. Many respond well to intralesional or systemic steroids but it is important to biopsy first to ensure there isn't an ongoing infection. Finding and removing the irritant is important for recurrent or persistent granulomas. Many of these are due to insect bites so protection from insects can help mitigate the problem.

Fungal granulomas are found in warm, tropical climates, including SE USA. Generally these are aggressive, ulcerated lesions on the ventrum and limbs of horses where the animals come in contact with swampy water. Small, hard coral-like masses called "kunkers" are commonly found in these lesions and help with diagnosis. Many are caused by the organism *Pythium insidiosum* and are referred to as pythiosis. Treatment is challenging. Early aggressive surgical debridement and immunotherapy may help. In our area, Blastomycosis has been identified as a cause of granulomas in horses as well as dogs.

Equine glanders is not currently seen in the US but is an important differential for pythiosis (at least for NAVLE).

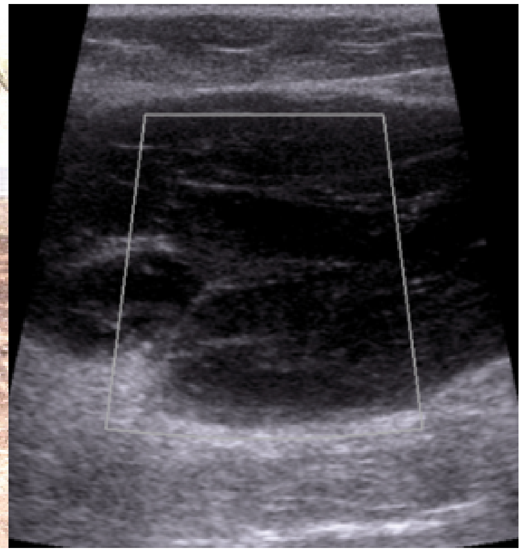
Key Takeaways

Granulomas are typically cool, firm, nonpainful and occasionally pruritic.

- Ignore
- Treat with steroids
- Remove

Fungal granulomas are bad news.

Hematomas



Hematomas generally develop after trauma or with bleeding disorders. A good physical examination and history will help determine if a bleeding issue is present. Otherwise most hematomas resolve on their own, albeit slowly. Generally equine hematomas turn into a seroma and then in a fibrous scar. Very big hematomas can calcify; most often this does not cause issues. If a large hematoma is in a sensitive area or is expanding, it is good to get a consultation with a specialist to determine if physical therapy or other treatment is indicated to minimize impact or motion restriction from the scar tissue. Penile or scrotal hematomas in horses and cattle also require specialist care to prevent further complications or additional injury.

Cattle can seed hematomas with bacteria from another site. A cow with mastitis, metritis or foot rot can rapidly change a hematoma into an abscess. Just wait it out (with good monitoring) and then treat the abscess. This complication is less common in other species; however, pigs may also be at higher risk.

Key Takeaways

Hematomas are cool, nonpainful, and typically resolve over time without treatment.

- Bovine hematomas often turn into abscesses

Hernias

The most common hernias are umbilical and inguinal.

Umbilical hernias

Often these are reducible and a hernia ring is palpable. Quarterhorse fillies are predisposed as are certain lines of Holsteins. Umbilical abscesses do develop and are generally associated with a hernia, particularly in calves. Umbilical abscesses without an associated hernia can be treated as regular abscesses. If a hernia develops due to trauma, it is essential to wait until a hernia ring (composed of fibrous tissue) develops prior to attempting repair; this usually takes about 60 days.

> **Exception**: **if the intestines are "stuck" in the hernia and the hernia is not reducible, this is an emergency.**

Inguinal hernias

Inguinal hernias present quite differently depending upon the age of the patient. Adult horses with inguinal hernia are emergencies and often require surgery to remove the intestines from the hernia; The intestines can become devitalized quite quickly.

Foals and calves with inguinal hernias are typically not an emergency. The intestines slide around and can be shoved back into the abdomen (but quickly slide back out). These usually resolve on their own over time. However, it is possible for the intestines to become stuck in the hernia. These cases do require emergency surgery.

Adult bulls with hernias are typically not an emergency. These are associated with large fat pads in the inguinal ring that protect the intestines.

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More info – Hernias section

Abscesses

These masses should show signs of inflammation: heat, pain, swelling, redness, and/or loss of use. Abscesses can result from trauma (puncture wounds, lacerations, surgery); can develop from necrotic tumor centers, bone **sequestra** or foreign bodies; or can be related to systemic infections. Wounds need to close from the inside out. If the opening of the wound closes too soon, it will trap the infection inside. Similarly, contaminated or infected wounds are rarely closed or at least not closed completely so that the infection can drain.

Abscess management podcast – overview (10min)- note that I said tap water is better than isotonic solutions; I meant to say hypo/hypertonic – these are less safe than tap water.

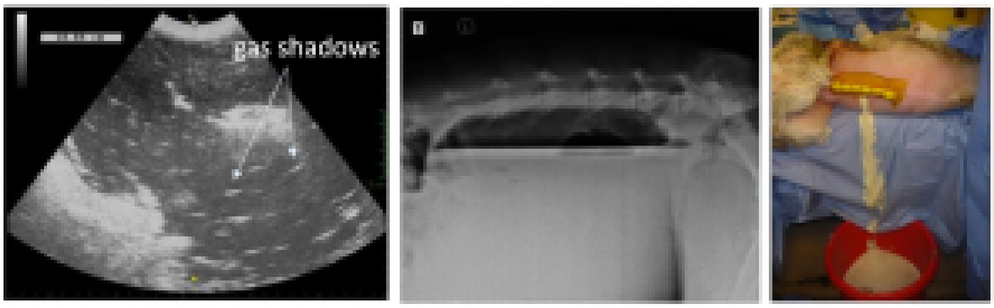
Ventral drainage

The primary principle of abscess management is ventral drainage. If the abscess isn't opened or if the opening is above the floor of the abscess, the abscess will generally continue to exist.

Ultrasound can be very useful to identify the extent and ventral aspect of an abscess. Ultrasound also shows blood flow (which is often increased) and allows the surgeon to avoid large vessels. Abscesses usually show a mixed echogenicity and a capsule is often visible. Ultrasound can also be used to identify the depth of the abscess and permit more accurate needle selection and incision depth.

Supramammary mass with ultrasound images from two sections

Gas in the abscess indicates either an opening to the environment or an anaerobic infection. Ultrasound is also useful for identifying foreign bodies or bone sequestra that are preventing healing in chronic abscesses or wounds. However, ultrasound isn't useful when there is gas in the wound; do your ultrasound before making holes to enable better evaluation of the structures.



Ultrasound and radiographs of an abdominal abscess containing gas. The abscess was treated by marsupialization.

Radiographs are useful for gas detection; fluid appears as a soft tissue density and may not be readily differentiated from soft tissue structures; gas will usually highlight the abscess but isn't always present.

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Creating ventral drainage of abscesses:

- Identify a site that is safe (not in or through an important structure) and most likely to be abscess. You can identify this through ultrasound, visual inspection (the lowest aspect) and /or palpation (feel for a soft stop). It is ideal if this is ventral but that isn't always possible. Inject lidocaine for local anesthesia.
- Insert a large gauge needle (at least 18ga for horses, at least 16ga for cattle) through the local block into the abscess to confirm pus. If pus is obtained, a second needle is inserted at least a centimeter away (2-3 cm is better). If this needle also yields pus, connect the two sites via sharp incision with a scalpel blade. If no pus, try again or return to step 1.
- Collect a sample of pus for culture and sensitivity
- Explore the abscess cavity to determine if the incision is ventral enough and/or where a ventral incision should be created. Digital palpation is ideal; sterile probes can also help identify the extent of the abscess cavity and appropriate drainage sites. If needed, the original incision can also be extended to allow better inspection or drainage. Having a finger or probe evaluate the pocket makes this safer.
- Enlarge the incision if needed. Ideally, ventral drainage is created with a big enough incision made to allow the wound to heal from the inside out. ***Cattle close holes very quickly – be generous (but safe) with the size of the incision.**

This horizontal drainage incision is reasonably sized and will be slower to close due to being perpendicular to the lines of tension – all good things in cattle.

- Penrose drains can be used to encourage drainage from wounds but are also irritants and only serve to wick the pus out. Drains should be time limited (use for only a few days). It is often more effective to make a bigger ventral hole rather than trying to use a drain. Penrose drains are not very effective in cattle due to the thickness of the pus.

Pigs – Draining abscesses on pigs kept with other pigs can actually make things worse for the affected pig as the others will root around in the wound. If the welfare of the pig is not impaired, the abscess may be left untreated. If treatment is needed, isolation of the affected pig would help minimize complications.

Abscess management

After the abscess is lanced, it needs to heal from the inside out. The wound can be kept open through flushing or packing (gauze, sugar, honey).

- The solution to pollution is dilution. Flush with copious amounts of isotonic fluids; tap water is fine in most of these. Sterile LRS and sterile saline are fine. Hypotonic and hypertonic solutions should be avoided as they cause cellular damage. Adding antibiotics is usually not helpful as most of your antibiotics drain back out again. Creating colored water through other additives is similarly not helpful.
    - Diluted iodine based solutions are more effective than strong iodine solutions as the iodine is released and active (weak tea color)
        - tincture of iodine is way too strong and is tissue toxic
        - example iodine based solutions – betadine, povidone iodine
    - Most betadine and chlorhexidine solutions are tissue toxic unless very dilute

    - Betadine and chlorhexidine should only be infused when they can drain back out, regardless of dilution
    - Distilled water is hypotonic and damaging to cells.
    - Twice daily flushing is often necessary to keep the abscess from sealing over prematurely
    - Keep hydrogen peroxide far away from wounds. It is damaging.
  - The wound can be packed with dry or betadine soaked gauze that is pulled out slowly over time
  - Honey and sugar are good packing agents in wounds as they help control infection and stimulate granulation tissue formation

If sterile fluids are needed, a 3 way stop cock and two extension sets can make it much easier to flush a wound or abscess. Just turn the stop cock to fill up the syringe and then turn again to force the fluid out the tubing. The faster but more physical alternative is to put an 18 gauge needle on the end of an extension set and just squeeze.

Antibiotic therapy

Antibiotics are generally **not** necessary if drainage can be obtained (but many graduate vets have a hard time with this). Antibiotics are indicated if the animal shows signs of systemic infection (fever, white blood cell changes after drainage is obtained), if ventral drainage is impossible or if vital structures are at risk (eg pleural cavity, mediastinum, abdominal cavity, joint).

Regional antibiotics (including infusion into the abscess) tend to be more effective than systemic antibiotics. Regional antibiotics include infusion into the joint, tendon sheath or local veins with a tourniquet in place to keep the drugs in the region. Many antibiotics cannot readily penetrate an abscess capsule and/or may not be effective in the abscess environment due to pH changes and other factors in the pus. Remember antibiotic choices are limited in food animals and require strict attention to withholding times to protect food safety. If an abscess doesn't respond, it is more often due to foreign material in the wound than it is to the bacterial infection.

Most wound infections will be inhabited by multiple species of bacteria and should be cultured to determine antibiotic selection if antibiotics are needed (generally antibiotics aren't needed!). Abscesses relating to infectious organisms are les s common but important to identify to prevent further spread.

The majority of bovine abscesses, regardless of cause, will be infected with *Truperella pyogenes* (last known as *Arcanobacter pyogenes*). This agent is sensitive to most antibiotics but creates a thick walled abscess that makes antibiotic penetration difficult. It Is also very hardy in the environment; try to collect the pus during surgery or separate the animal while the abscess is draining.

Common mistakes

- Insufficient ventral drainage – not drained, not ventral or not big enough
- Flushing with irritating solutions that make things worse
  - Avoid hydrogen peroxide, strong iodine and chlorhexidine solutions
- Contaminating the environment

If the abscess isn't resolving:

- Is there adequate ventral drainage?
- Is there systemic infection? (eg Streptococcus or Corynebacterium)
- Is there a foreign body or sequestrum?

The abscess over this horse's shoulder isn't resolving as ventral drainage is impossible to achieve in this area (the thoracic spines and scapula prevent it). This is a case of fistulous withers. Surgical resection was required to resolve the infection. [Brucella can cause fistulous withers; use caution and culture.]

Camelids can develop spontaneous bone sequestra, particularly in the head. As the body tries to resolve these sequestra, sterile abscesses develop. More often, they develop abscesses in the jaw region from infected teeth. Resolving these abscesses will require removing the tooth, tooth root or bony sequestrum.

Foreign bodies can be left in wounds from the initial trauma (stick) or be added by vets (suture). Remove to resolve the problem!

Key Takeaways

Abscesses are warm, painful and contain pus

- Create ventral drainage
- Flush or pack
- Minimize environmental contamination
- Avoid antibiotics

If abscesses are not resolving, look for a foreign body.

Resources

[How abscesses (pimples) form]

[Bad advice about antibiotic prophylaxis]

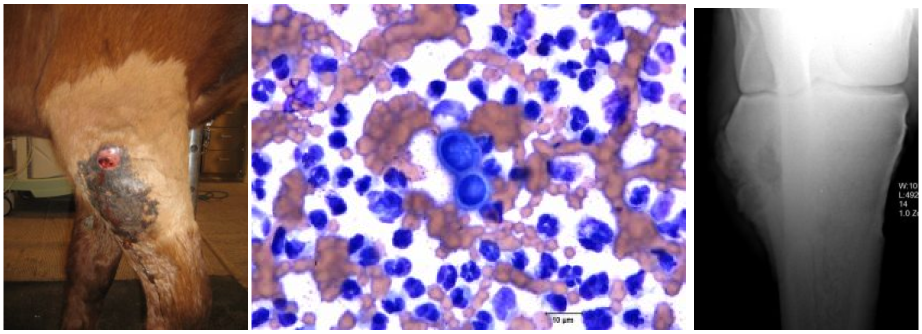
Abscesses related to systemic infections

Sheep and goats with abscesses may be infected with *Corynebacterium pseudotuberculosis* and have caseous lymphadenitis (CLA). Sheep tend to develop onion like abscesses (firm, layered pus) and are prone to internal abscesses, while goats get white creamy pus filled lesions and are more likely to have external abscesses. The abscesses are generally infected lymph nodes. This organism is very infectious and very hardy. Generally culling of all infected animals and avoiding placing new animals in the environment for at least 8 months is required to control this disease. This is often unpalatable to owners. Additionally, animals with more than abscess or a draining abscess are usually rejected at the slaughterhouse. Lancing abscesses will lead to more environmental contamination. Removing abscesses surgically can become expensive due to the frequent incidence of new infections in the herd (same patient and other patients). Tulathromycin injected into the lesion or subcutaneously into the goat helped resolve lesions in one study. At the UMN, we did not find it that effective. ***Culturing small ruminant abscesses is important and client education is a crucial part of therapy.*** Vaccination may be helpful in sheep.

*Corynebacterium pseudotuberculosis (*equine serovar) is a growing problem in horses and leads to superficial and internal abscesses. This disease has been localized to California and other western states in the past but is expanding as the vectors involved in its transmission enjoy global warming (likely horn flies, stable flies and house flies). The most common presentation is abscesses in the pectoral or ventral abdominal area, leading to the name “pigeon fever” as they look like they have big pigeon like breasts. It can also lead to ulcerative lymphangitis on the limbs of affected horses. Horses in endemic regions may have some resistance to the organism; as it enters new territory, it may be more virulent. Most cases are seen in the late summer and fall but it has been identified year round and the seasonality may be shifting to midsummer months. This version of the organism is also very hardy in the environment and can survive at least 2 months on fomite and in the soil for 8 months. **Affected animals should be isolated.** *Corynebacterium sp* can infect people.

Horses with abscessed lymph nodes may also have strangles (*Streptococcus equi*). The lymph nodes in the head are most commonly affected but the infection can affect any lymph node. If the horse has nasal discharge or if there is a history of strangles in the barn or the community, strangles should be at the top of your differential list and appropriate precautions taken to limit its spread. You and your vehicle can be fomites! Streptococcus equi can survive in the environment and on your gear for up to 4 weeks.

Other bacterial and fungal organisms can also create abscesses or masses in all species. Most of these are easily spread between animals of the same species and many have the ability to cross species lines (including humans). We have seen blastomycoses infections in horses in this area. Cytology and culture can help figure out what you are dealing with. Chronic abscesses may need a specialist.



Osteomyelitis blastomycoses in a Minnesota horse

Key Takeaways

Keep in mind those organisms that are serious environmental contaminants such as

- Corynebacterium pseudotuberculosis
- Streptococcus equi
- Blastomycoses

Resources

Can vaccinating sheep reduce the occurrence of caseous lymphadenitis? Veterinary Evidence, 2020 : Vol 5, Issue 1.

AAEP infectious disease guidelines: pigeon fever, revised 2017

Diagnosis of caseous lymphadenitis in sheep and goat, Small Ruminant Research, January 2015, Vol.123(1), pp.160-166

Control of caseous lymphadenitis, VCNA Vol.27(1), pp.193-202, 2011

Comparison of three treatment regimens for sheep and goats with caseous lymphadenitis, JAVMA Vol.234(9), pp.1162-6, 2009

Eliminating Chronic Disease Using a Farm-based Approach – Maine study, 2014

Practice

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You can find lots of abscess drainage videos on youtube -have a look and a critique!

Large animal cutaneous neoplasia

Learning Objectives

- When faced with a skin tumor on a large animal species, be able to develop a plan for diagnosis and treatment, based upon the presenting clinical signs, the likely differentials and the latest evidence

The numbers of LA tumors are limited due to the shorter lifespan of horses and cattle. The most common equine tumors are sarcoids, melanomas and squamous cell carcinomas (SCC). These can often be differentiated on appearance. The most common bovine tumors are lymphosarcoma and SCC. These present differently and in different age groups.

Diagnostics

LA Neoplasia podcast – overview; ~19 min

Signalment can help identify some tumors (age, coloration). Options include visual identification (obviously not 100% accurate but often pretty good), fine needle aspirate, surgical biopsy or removal and submission for histopathology. Neoplasia should be considered with fever of unknown origin. Inflammation may or may not be detectable on physical examination. Ultrasound can be useful to determine if the mass is invading tissues and to identify the level of vascularity. Necropsy is a diagnostic tool but doesn't do much to help that animal. Because we are dealing with larger animals that permit minor procedures with standing sedation, an incisional or excisional biopsy often is the most productive. Remember to try to include some normal tissue in your biopsy so that the interaction between normal and diseased tissue can be assessed. Sedation with xylazine or detomidine and a local block is often sufficient to obtain these biopsies.

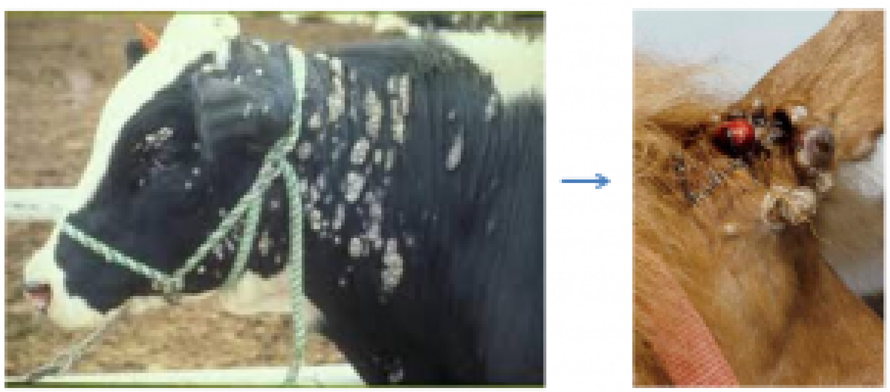
Treatment in food animals is restricted to methods that do not affect the food supply. Any drugs must have appropriate withholding. Laser therapy, **cryotherapy** and surgical removal are the primary treatment methods available. Most cattle are culled.

Sarcoids

Presentation

Sarcoids are the most common skin tumor observed in horses and are not seen in other species. While not malignant, they are very resistant to treatment and can occasionally lead to severe consequences for horses, including euthanasia or retirement.

Sarcoids develop in the skin and dermal tissues due to an atypical immune reaction of horse skin to a bovine or equine papilloma virus. We assume the papilloma virus is in the horse's skin and is "activated" by trauma. This seems to explain the common predilection sites: scrotal area, limbs, and head.



Bovine Papilloma Virus — Persistent tumor in horse

Sarcoids present in several different forms. A nodular form occurs in the dermal tissues, often with chains of nodules connected by bridges that may or may not be palpable. These can remain unchanged for many years and/or can start growing aggressively with trauma (including biopsy and fly bites). Some sites may be covered by normal skin; others can have ulcerated surfaces as the affected area does not heal well. Other forms of sarcoid develop an external "cauliflower" like appearance, growing into raised, often bumpy tumors of various shapes. Mixed versions are common.

Sarcoids can be grayish or can look like proud flesh (exuberant granulation tissue) and can be mistaken for such. If “proud flesh” is noted above the carpus or hock, it is most likely sarcoid (or it is another tumor).

Sarcoids can also be flat, hairless, gray and scaly. These areas look more like ringworm or other dermal lesions rather than tumor. They are disfiguring. Many owners complain that other horse owners worry that the lesions will be contagious. Horses cannot “catch” sarcoids from other horses but it is important to rule out a true fungal disease.

Treatment

Many treatments exist for sarcoids. Whenever we have multiple treatments, it generally means nothing is 100% effective. The treatments most often used at the UMN include laser **debulking** (CO2 laser), **cryotherapy**, cisplatin beads and/or topical imiquimod. Imiquimod (Aldara®) was studied at the UMN and was found to be very effective in many sarcoids (see UMN Aldara studies). Imiquimod is a topical cream that owners can apply. It acts on toll-like receptors in the region. While we used imiquimod on its own for the study, we prefer to use it after laser therapy or with cisplatin beads, particularly in larger tumors. Combination therapy minimizes the treatment frequency and seems to optimize the results. Other treatments include electroporation (new research), radiation therapy, cisplatin or 5 -fluorouracil injections, Xxterra (blood root extract), BCG injections, autogenous vaccines, skin grafting and even topical application of fluoride toothpaste (no evidence to demonstrate efficacy). Surgical removal alone is **not** usually recommended. Most sarcoids include tendrils that grow new sarcoids as they are cut. Much like the Greek Hydra, when the main tumor is removed and these tendrils are transected, you can end up with a much bigger problem. Wide margins are a necessity and generally surgical debulking is combined with other therapies. Sarcoids that aren't growing, aren't ulcerated and aren't being traumatized should be left well enough alone. As more research is done and new treatments are explored, it will be important to be able to assess study design. Most of the research on sarcoids has not been done in a controlled or blinded manner. Note : **Not all sarcoids require treatment! If they aren't ulcerated, raised or growing, we try not to treat. You may enter into a battle you can't win.**

Imiquimod Use

Imiquimod is a cream used in people for genital warts. It comes in small packets and prices vary widely. Imiquimod stimulates a strong local reaction without systemic effects. Imiquimod does cause reactions in normal horse skin. It can be difficult to differentiate normal reaction from flat tumor until the inflammation resolves.

- Apply 3x/week to small tumors or 1x/week to the base of tumors removed by laser or debulking. No bandage or covering is necessary.
- Clean off the concrete-like exudate prior to the next application. Soaking the area with mineral oil or warm water can help.
- Treat for 2 months. Stop treatment and re-evaluate one week later. If hair is growing back, the tumor has

resolved. Restart treatment if required.

Aural plaques are another papilloma virus complication. These white plaques grow in the ears of horses and can cause ear sensitivity. Many are benign and don't cause any issues. Those are irritating can be treated with imiquimod. The amount of inflammation can be significant; the treatment works but can be challenging.

Key Takeaways

Sarcoids are the most common horse tumor and are seen in all age groups over 2.

Sarcoids develop and get angry with trauma. Plan on multimodal therapy and leave well enough alone if not growing or ulcerated.

Sarcoids grow in the dermis – NOT mucous membranes.

Resources

The Equine Sarcoid Why Are There so Many Treatment Options? VCNA Vol.35(2), pp.243-262, 2019

Management of equine sarcoids, In Practice 39:83-88, 2017

Efficacy of imiquimod 5% cream in the treatment of equine sarcoids: a pilot study, Vet Derm Vol.17(4), pp.259-265, 2006 (UMN study)

Treatment of aural plaques and sarcoids with imiquimod

The future?

Electrochemotherapy as a single or adjuvant treatment to surgery of cutaneous sarcoid tumours in horses: a 31-case retrospective study. Vet Rec Vol.179(24), p.627, 2016

Glycolysis inhibition improves photodynamic therapy response rates for sarcoids. Vet Comp Onc Vol.15(4), pp.1543-1552, 2017

Squamous cell carcinoma

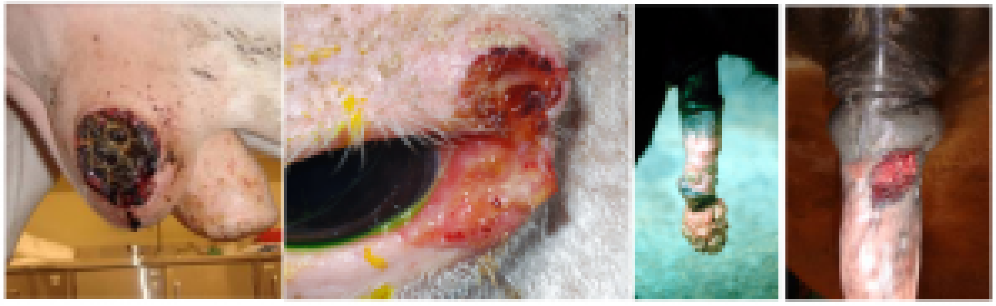
Presentation

As in other species, SCC affects light colored skin and external mucosa in older animals. Predilection sites in large animals include the eye (white faced cattle, Appaloosa and Paint horses), the penis (especially older geldings, potentially related to smegma buildup), the vulva and areas of trauma (eg burns or chronic wounds). Risk factors include papillomavirus infections, UV irradiation and trauma. Haflinger and Belgian horses have been shown to have genetic mutations that put them at increased risk.

Perineal SCC in a goat

In the eye, common sites are the limbus and eyelids.

SCC skin lesions are often ulcerated rather than raised. Penile lesions can be ulcerative or proliferative.



Nonhealing wounds should be biopsied to rule-out SCC. If it looks like proud flesh and is above the carpus and hock, think SCC, sarcoid or fungal infection. Horses with penile SCC are at greater risk of having ocular SCC so both areas should be checked carefully.


Habronemiasis (below) also affects the periocular area and penis; it can look like SCC but isn't common in Minnesota.

For differential lists between sarcoids, SCC and melanomas, if the tumor is:

- on skin and raised, think sarcoid
- on skin (or mucocutaneous junction) and ulcerated, think SCC
- on mucosa (eg penis), think SCC
- black -> melanoma (be aware that the normal skin covering eyelid sarcoids can make them look black; if a gray horse, think melanoma; if a bay horse think sarcoid)

Similar to other species, SCC's are locally invasive and are slow to metastasize but can do so in rare cases. It is important to assess regional lymph nodes. The nodes may be enlarged due to metastases or to inflammation.

Equine glanders is not currently seen in the US but is an important differential (at least for NAVLE).

Treatment

Treatment generally involves resection with wide margins. This can mean enucleation, third eyelid resection and penile amputation or ablation. The wound margins are then monitored closely for recurrence and/or treated to remove any remaining tumor cells. This can mean laser ablation, radiation treatment or cryotherapy. Penile and vulvar lesions are often treated with 5-fluorouracil (5FU) cream. Periocular tumors may be treated with imiquimod, mitomycin C, specific NSAIDs and/or photodynamic therapy. While vulvar lesions are treated daily and still tend to be very aggressive, penile lesions can be treated every 2 weeks with good efficacy for smaller lesions. The sheath seems to maintain effective levels of the drug between treatments.

Key Takeaways

Squamous cell carcinoma acts similarly across species:

- Most frequent in white skin areas, near the eye and on the penis
- Associated with uv radiation and chronic trauma
- Locally invasive but rarely metastasize
- Affects older animals (chronic genetic damage)

Treat with wide margin excision, cryotherapy and/or laser **debulking**.

Resources

Cutaneous squamous cell carcinoma (SCC): “What’s the problem?”. Equine Vet Educ Vol.31(12), pp.635-646, 2019

Penile and preputial tumours in the horse: literature review and proposal of a standardised approach. Eq Vet J 42:746-757, 2010

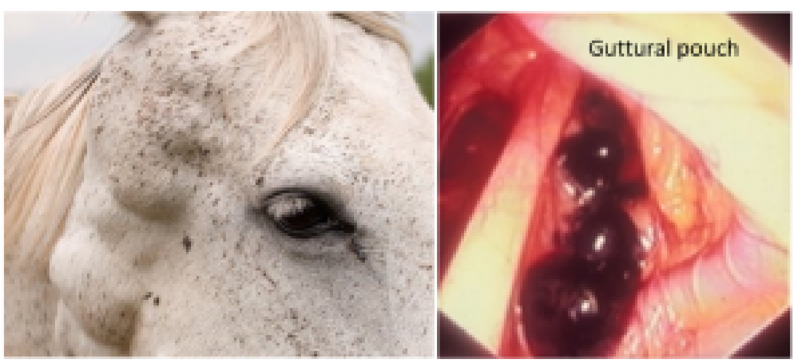
Integumentary disorders including cutaneous neoplasia in older horses. VCNA 32:263-281, 2016

Melanomas

Presentation

Melanomas are classically associated with gray horses and are generally black in color, raised and rounded. Many gray horses over the age of 10-12 will have melanomas and 80% will have them by the age of 15. Some horses can be born with melanomas. Common sites include the base of the tail and perineal region, the parotid salivary gland and guttural pouch area, the lips/cheeks and the prepuce. Many horses will have multiple melanomas with no related problems. Occasionally melanomas will lead to problems with defecation as they expand in the perineal region.

The parotid masses can grow quite large but don't usually impinge on the airway. Parotid melanomas can be seen as black areas on the internal surface of the guttural pouch (making it pretty obvious that resection is unlikely to be an effective or safe measure).



Many melanomas become more aggressive with age and rarely melanomas become metastatic to other internal organs. We have not yet identified a grading scheme that will let us identify which black melanomas will become problematic; amelanotic melanomas and melanomas on non-gray horses tend to be much more aggressive. Melanomas are rare in other LA species (mini pigs can get them but they can spontaneously regress too).

Treatment

Treatment of melanomas in horses is not currently very effective. Many don't require treatment. Surgical removal can be difficult as a large expanse of skin and dermis is generally removed, making closure difficult. Oral cimetidine has helped stabilize or regress a few tumors but isn't very effective and isn't frequently used. Cisplatin injections and beads, autogenous vaccines and laser therapy have also been used. More recently, interleukins, frankincense injections and the canine melanoma vaccine have been trialed but efficacy results have not been published. Imiquimod may be effective but has yet to be proven. If removal is indicated, we will usually start with laser **debulking**, followed by cisplatin beads or chemotherapeutic injections. We plan to trial microwave ablation techniques for tumors that are causing issues.

Key Takeaways

Equine melanomas are common in gray horses, particularly in the parotid region, mouth/lips and under the tail. Many adult horses are affected- not just old horses.

- Black tumor on a gray horse = melanoma
- We don't know how best to treat them. Many will never need treatment.
- We also don't know how to figure out which will become problems. Biopsies do not help in staging.

Resources

Treatment Options for Melanoma of Gray Horses, VCNA Vol.35(2), pp.311-325, 2019

Melanoma in horses: Current perspectives, EVE Vol.25(3), pp.144-151, 2013

Equine Melanocytic Tumors, VCNA Vol.29(3), pp.673-687, 2013

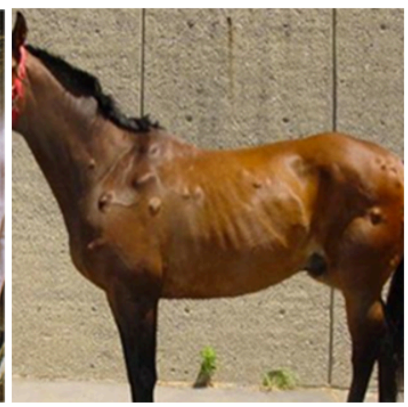
Integumentary disorders including cutaneous neoplasia in older horses. VCNA 32:263-281, 2016

Researchers Study Plant-Based Treatment for Equine Melanoma, The Horse 2016

Lymphosarcoma

Presentation

Cutaneous lymphosarcoma occurs in both horses and cattle. It tends to affect young animals and is unrelated to bovine leukosis virus (BLV) infection (cattle). Tumors can develop in subcutaneous tissues (horses particularly), lymph nodes, and in various tissues including the retrobulbar area (cattle), the jaw bone (cattle), the prepuce (horses) as well as internally (eg mediastinal). It is less common in horses than in cattle. Lymphosarcoma does tend to metastasize. Biopsies in horses can be helpful as those with a primarily lymphocytic population do tend to spread internally while those with a combination of histiocytes and lymphocytes are related to improved horse longevity.



Diagnosis is often delayed and the disease progresses quickly.

Treatment

Treatment is often ineffective with aggressive forms (lymphocytic). Some early cases will respond to glucocorticoid treatment and/or surgical removal. Systemic chemotherapeutic agents are generally not used in horses due to the associated costs. Microwave ablation holds some promise if the tumor has not yet metastasized. Treatment options are even more limited in cattle due to the restrictions for meat and milk (anticancer agents in the food supply is frowned upon).

Key Takeaways

Lymphosarcoma is a young animal tumor

- Treatment is not attempted in cattle

- Horses with combination cell type lymphosarcoma tend to respond to treatment while those with only lymphocytes do not.
- Metastasis is common by the time of diagnosis.

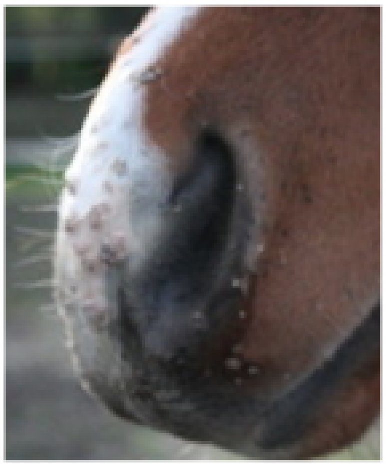
Resources

Equine lymphoma tutorial EVE 23(4): 205-213, 2011

Papillomatosis

Presentation

Papillomatosis (warts) can occur in horses (generally on the muzzle) but is more frequent in cattle (head, teats and penis). It is caused by a papilloma virus and immunity occurs with age. Transmission is via animal-animal contact, often through abrasions.



Warts on horse muzzle

Bovine penile fibropapilloma

Treatment

Warts are usually self-limiting. Pinching one off may stimulate regression of the others. Penile papillomas may need treatment (**debulking**) if hemospermia or problems with penile retraction are noted. Just be careful to not cause more issues by removing penile tissue along with the tumor.

Key Takeaways

Warts are caused by the papilloma virus. Young animals are affected and develop immunity with age.

- No treatment is required for muzzle lesions.
- Penile fibropapilloma looks aggressive and also resolves; debulking can help with secondary issues.

Resources

Surgical Procedures of the Genital Organs of Bulls VCNA Vol.32(3), pp.701-725, 2016

Surgical debulking

Surgical debulking is the removal of as much of the tumor as possible, particularly when it is not totally removed. Tumors can be removed using standing sedation or general anesthesia. Remember to obtain wide margins and to submit a section for histopathology. This is the primary option available for your food animal patients. In general, most tumors will also need another form of treatment. Surgical debulking alone is considered inappropriate for sarcoids; ALWAYS plan to include another form of therapy for sarcoids.

When removing a mass, remember that circles don't heal well. Most tumors are removed using a fusiform incision (football shaped, pointy at the ends). Check out the lines of tension so that you are closing with them vs against them. If you incise parallel to the lines of tension, the incision will gap the least and the resulting scar will be the smallest. Incisions made at oblique angles to the lines of tension will become curvilinear and incisions made perpendicular to the lines of tension will gape most widely and heal with the largest scars.

Presuturing can be used to stretch the skin in advance of removing the tumor. This procedure relies on the stretch that occurs when skin is kept under tension. Edema develops after 24 hours and interferes with the stretch benefit. Presuturing for 2.5-8h has been useful.

From Auer & Stick:

The direction of suture placement is chosen according to the anticipated direction of primary closure. Wounds of the body and upper limb are generally the most amenable to presuturing. Large, nonabsorbable sutures (No. 1 or No. 2, polypropylene or nylon) are placed through the skin perpendicular and 2 to 6 cm to either side of the lesion. The sutures are then tightened to elevate and fold the skin over the lesion or wound. If presuturing is used in conjunction with tumor excision, the surgeon should be careful to place the sutures distant to the lesion to avoid iatrogenic seeding of tumor cells into healthy tissue.

See how to article: http://veterinarymedicine.dvm360.com/skills-laboratory-reconstructive-surgery-techniques-part-1-presutures-skin-stretching

Cryosurgery

Cryosurgery damages the tumor cells through the creation and melting of ice crystals. To get the best ice crystals, freeze the tissue quickly and let it thaw slowly. This is repeated at least once. The second and third time, the precooled tissues freeze faster, creating a better kill. Don't try to heat the tissues to speed the thaw. Let them return to normal temperature on their own. For people, they keep freezing until the tissue stays cold.

Liquid nitrogen used for cryosurgery does need to be carefully stored and transported. It is delivered to the tissue through spray guns or super chilled probes. It is important to protect surrounding tissues when using the spray guns. Vaseline and Styrofoam cups (easily torn to the right size) are commonly used. Many tumors will respond to cryotherapy and it can be used after debulking to treat the wound margins. You may need to wait until bleeding subsides in order to obtain a good ice ball as the blood is warm and keeps heating the area. While thermocouples are nice to have, most clinicians gauge the amount of freeze by the size of the ice ball. The central 75% of the ice ball will be sufficiently cold to kill tumor cells.

After cryosurgery, the tissue will swell over the next 48 hours and will necrose in 14-21 days. Hair may turn white or may not regrow. Tissue will scar: "do not freeze where scars may squeeze". Eg freezing a SCC on the urethra might not be a good option. Cartilage is very sensitive to freezing and may be damaged or misshapen if it becomes too cold (eg be very careful freezing tumors on ears). Repeated treatment is often necessary.

The investment cost and cost of the liquid nitrogen is relatively small making it one of the more affordable options for practices.

Cisplatin beads and chemotherapy injections

Cisplatin (a chemotherapeutic agent designed to kill tumors) is often effective against tumor cells if it can be kept in the region. In horses (and non-food animals), the bead form has been the easiest and seems to be the most efficient. Commercially produced beads are inserted into the tumor through small stab incisions to cover as much of the tumor as possible. The beads release cisplatin over time and generally need to be replaced every two weeks. Cisplatin injections are cheaper but require mixing with oils to prolong their activity and can be quite messy and therefore dangerous for the user. Users should take appropriate precautions with both and avoid contact with the beads or solution. 5FU is also available in an injectable form.

Topical agents

Topical agents can be dispensed and applied by the owner. Many of these result in irritation to the horse so cleaning and reapplication may require veterinary assistance. The most common compounds are imiquimod (useful for sarcoids and probably SCC) and 5-fluorouracil (used for penile and vulvar SCC). Xxterra is also being used for tumors but is not well studied. Watch for more options to appear; always check the literature vs the website or sales rep!

Referral

Most other therapies will only be available at referral centers due to equipment cost or health/safety restrictions. Laser debulking is frequently used for tumors that come into the UMN. The CO2 laser removes cells layer by layer, making it one of the safest options to use in tricky areas. It also destroys the nerves to the tissue, giving the horse some pain relief as well.

It is often useful to get the initial treatment performed at a referral center and then rely upon the field treatments to continue the therapy and/or keep the tumor at bay.

Other options

Autogenous vaccines have been tried (and given up on) for melanomas. They are currently resurfacing for sarcoids. BCG has been used to stimulate an immune response for ocular tumors but does carry a risk of death; imiquimod is safe to use around the eye and no deaths have been reported. Radiation therapy is possible but is often cost prohibitive for horses. You can always call us for the latest info on a tumor or treatment option!

Key Takeaways

Field management is possible but is often more successful after initial treatment at a referral center. Multimodal therapy is recommended.

Field therapies include:

- Surgical removal
- Cryotherapy
- Topical or local agents – imiquimod, 5 flurouracil, cisplatin beads

Resources

Review of the Treatment of Equine Cutaneous Neoplasia, AAEP 2009

Indications

Mass removal is indicated for known and suspected tumors. Excisional biopsy works well in many situations in which full mass removal is possible. Portion of the mass is submitted for histopathology. Follow-up treatment may or may not be needed.

Relevant anatomy

Masses should be removed along the lines of tension.

To find lines of tension – pinch the skin. Try again at a slightly different angle. The angle at which it is easiest to pinch up skin (skin seems loosest) is the same angle in which you should make the incision. Try this on the dorsal surface of your forearm. Lines of tension run longitudinally. 

Preoperative management

Food restrictions: NA if performed standing. If under general anesthesia, food should be withheld for 6-12 hours in horses and 24-48 hours in adult ruminants.

NSAIDs/analgesics: Preoperative NSAIDs or narcotics are used to prevent windup.

Antibiotics: Often not required but preoperative antibiotics may be indicated in contaminated environments or when surgery involves the GI tract, respiratory tract or urogenital tract.

Tetanus prophylaxis is recommended in horses.

Local blocks: Regional blocks are often used to circumscribe the mass to be removed.

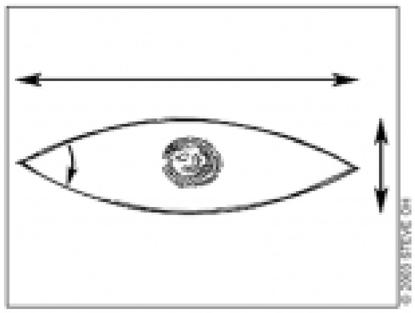
Position/preparation: Standing sedation is preferred when possible. Local blocks may be all that is required in cattle. Presuturing for 2-8 hours may help stretch skin for larger masses.

Surgery Supplies:

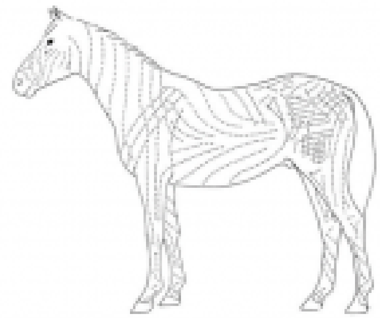
- Scalpel and handle
- Hemostats
- Metzenbaum scissors
- Thumb forceps
- Needle holders
- Suture – 2-0 to 3-0, cutting needle for skin
- Suture – 2-0 to 3-0 taper needle for subcutaneous tissues
- Penrose drain (optional)
- Formalin for histopathology

Surgical procedure

- A fusiform incision is made around the mass, long axis along the lines of tension. The length should be approximately 3-4x the width needed to remove the mass.

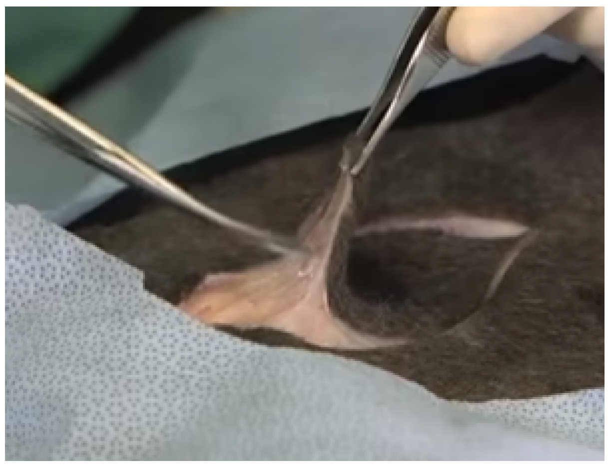


Length: width ratio 3:1 to 4:1

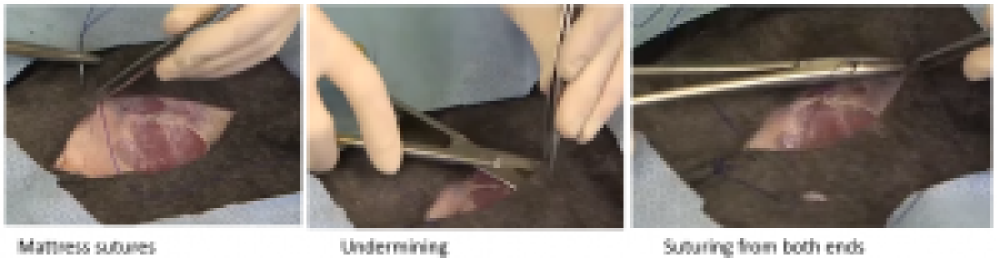


Lines of tension

- The subcutaneous tissues are dissected, freeing the mass from the underlying tissues.



- Subcutaneous closure may be skipped; alternately a simple continuous pattern is used to close deadspace.
- If the deadspace is large, a penrose drain may be placed.
- Skin closure
    - Routine – simple continuous or Ford interlocking
    - Options for closure under tension
        - Start closing from both ends
        - Tension relief sutures in key parts – NFFN, vertical mattress or horizontal mattress
        - Undermine tissues to allow stretch
        - Relief incisions
        - Secure knots by first placing granny knots or using 3 throws rather than 2 for the surgeon's knot. Follow with a square knot. The granny knot can be tightened with the later throw meaning you can tighten down in two steps. Three throws provides more friction that keeps the knot in place.



- Place a stent over the incision or bandage the area if needed to compress deadspace.

Postoperative care

- Minimize motion for 3-5 days and then limit motion until suture removal.
- Suture removal in 10-14 days.
- NSAIDs for 3 days will help minimize swelling

Complications

- **Dehiscence** (usually about day 3)
- Infection
- Tumor recurrence
- Poor healing (tumor cells at wound margin)

Videos

Mass removal and closing wounds under tension

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=3818#oembed-1

Resources

https://www.cliniciansbrief.com/content/surgical-tension-lines-where-cut

Practice

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Large animal wounds

This section is designed to support LAS I wounds and lacerations discussions. The chapters are focused on horses due to the frequent occurrence and higher likelihood of complications compared to other large animal species.

Wounds are common in horses, particularly on the limbs. While many principles apply across species, early identification of secondary issues due to the trauma or problems with healing improves the prognosis.

Ruminant wounds usually heal well due to the thick hide and strong myofibril response. Urogenital wounds are an exception (teat, prepuce etc) and need special attention. Eyelid wounds are common in horses and camelids and also need unique management.

Learning Objectives

- Identify factors that could slow wound healing or lead to long term issues (bone, joint, tendon or ligament involvement; skin or blood loss).
- Start initial treatment to ensure optimum wound healing and recovery.
- Manage wound healing complications such as proud flesh and sequestration.

Wound management overview

Wound evaluation overview – podcast (8 min)

The most common horse wounds are limb degloving injuries (the horse kicks through something and the skin is pulled away as the limb is pulled back through the glass/wound/metal) and puncture wounds.

Puncture wounds are easy to miss and can immediately penetrate deeper structures and lead to life threatening infection.

Degloving injuries can readily traumatize joints, bones, tendons, ligaments and vessels due to the limited soft tissue covering of horse limbs. Skin injury can prolong healing for months. Many of these injuries are manageable but require extensive time and money. Giving clients appropriate information from the beginning helps everyone fully understand decisions.

Wounds to the thorax, shoulder and abdomen usually occur as animals run through fences, gates and in wooded areas. Solid structures tear skin and muscle as the animal passes through. Occasionally bony prominences are also removed form the parent bone.

Triage plan for emergency care:

- ABC assessment – Airway, breathing, circulation+
    - Any involvement of the chest cavity, airway or vessels?
    - Any involvement of the abdominal cavity?
    - Significant blood loss?
    - Loss of blood supply to the limb?
    - Significant lameness?
- Any risk of joint or tendon sheath involvement?
    - Wounds near tendon sheaths or the "bendy bits"?
- Any risk of flexor tendon involvement?
    - Does the wound affect the palmar/plantar surface of the lower limb?
- Any risk of long bone fractures?
    - Is there any abnormal angulation or instability?

Complicating non-urgent factors:

- Is the wound below the hock or carpus or involve eyelids?
    - Distal limb wounds are prone to **proud flesh**

- Eyelid lacerations can lead to exposure keratitis if not managed appropriately
- Is the horse knuckling over?
    - Stabilization will be needed
- Is there skin loss in a wound on the distal limb?
    - Predisposed to proud flesh
- Is bone exposed or damaged?
    - Predisposed to **sequestrum** and/or infection
- Is there muscle injury to the hindlimbs?
    - At risk of fibrotic myopathy
- Sharp or blunt trauma?
    - Blunt trauma will lead to delayed damage
- How heavily contaminated?
    - Closure may not be recommended
- Horse factors
    - Will the horse allow treatment standing? tolerate bandage changes?
    - Intended use and timeline for performance, if any?
    - Adequate BCS and nutrition?
- Chronicity
    - How long has it been going on and has it been treated appropriately?

Resources

Managing degloving wounds – Malone, Comp Cont Educ 1996

Evaluation for critical structure damage

Some wounds require emergency care, either on farm or at a referral center or both. Identification of these factors early on can dramatically improve prognosis.

Triage plan for emergency care

ABC assessment – Airway, breathing, circulation+

- Any involvement of the chest cavity, airway or vessels?
- Any involvement of the abdominal cavity?
- Significant blood loss?
- Loss of blood supply to the limb?
- Significant lameness?

Any risk of joint or tendon sheath involvement?

- Wounds near tendon sheaths or the "bendy bits"?

Any risk of flexor tendon involvement?

- Does the wound affect the palmar/plantar surface of the lower limb?

Any risk of long bone fractures?

- Is there any abnormal angulation or instability?

Body cavity trauma

Wounds over the thorax or abdomen can penetrate either the abdominal cavity, the thoracic cavity or both. Due to the shape of the diaphragm, any wound after the 6th intercostal (between rib) space can enter the abdominal cavity.

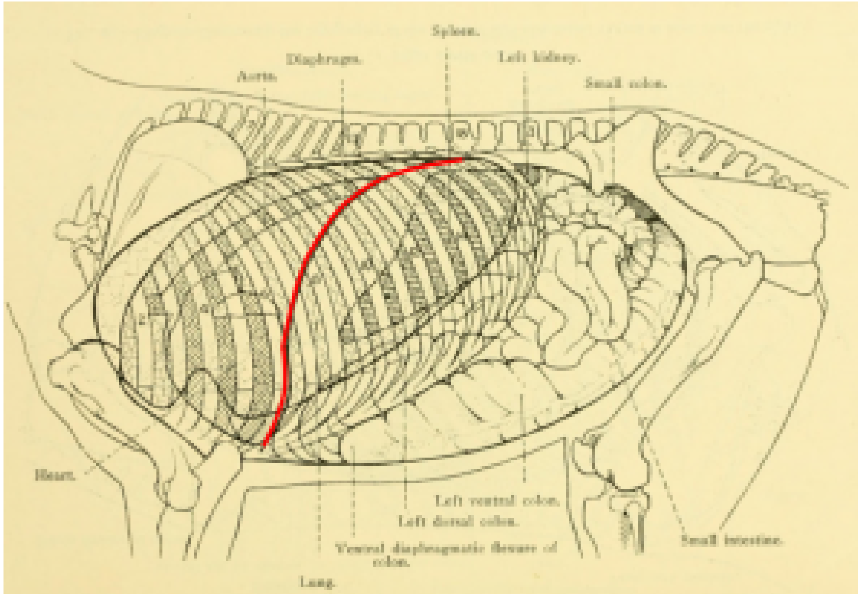

FIG. 41.—Diagram illustrating the topography of the thoracic and abdominal viscera as seen from the left.

If the thoracic cavity is penetrated, the horse may develop life threatening pneumothorax.

Body cavity damage should be suspected in any wound over the torso that goes deeper than 1-2 cms, particularly if the patient is showing abnormal respiratory movements, nostril flaring, elevated heart rate or change in mucous membrane color.

Vascular damage

Most wounds do not lead to significant blood loss. However, if an artery is cut, blood loss can be fatal. In distal limb wounds, the palmar/plantar digital artery can be damaged. Arterial damage leads to pulsatile and audible spurts of blood. These cases need on farm management to stop blood loss followed by in hospital care.

Some injuries will transect or crush vessels, leading to vascular compromise. Distal limb temperature and sensation should be evaluated prior to further treatment. Blood supply is required for healing and cannot currently be surgically replaced in large animals. Larger animals should be euthanized. Goats can tolerate limb amputation.

Significant lameness

Significant (lame at a walk or non-weightbearing) lameness is unusual with wounds. Evaluation for deeper or more extensive damage is indicated. Check for fractures and tendon/ligament injury.

Synovial damage

Limbs of large animal species have minimal protective muscle or fat. It is relatively easy for wounds to penetrate joints and tendon sheaths or to damage nerves and tendons. Knowledge of limb anatomy is crucial. Any wound over a joint or in the region of a tendon sheath should be evaluated for penetration of synovial structures. Remember the joint capsules extend beyond the bones of the joint and that the deep flexor tendon sheath runs on the palmar/plantar surfaces of the lower 1/3 of each cannon bone and down through the pastern region.

One of the easiest ways to evaluate synovial penetration is to attempt to distend the joint or tendon sheath. These structures should pressurize with added fluid, meaning the fluid shoots out of the needle or forces the syringe plunger outwards. If the structure cannot be pressurized, it is leaking. To pressure the structure, the needle should be inserted through a cleaned area with intact skin and not over the wound or disturbed tissues.

Flexor tendon injury

The flexor tendons run on the palmar/plantar aspects of the limbs and are responsible for limb support. If the superficial tendon is damaged, the animal may have a slightly dropped fetlock. If the deep flexor tendon is disrupted, the toe will be elevated when the horse walks. Damage to the suspensory ligament (breakdown injury) is associated with a markedly dropped fetlock and often includes damage to the vascular supply from overstretching. If flexor tendons are partially damaged, weight bearing can lead to complete tears. It is important to stabilize these injuries as soon as possible to minimize further damage.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=1310#oembed-1

Limb instability

Wounds leading to long bone fractures, joint dislocations, collateral ligament damage, nerve damage, and/or flexor tendon transection will lead to limb instability. Horses that cannot bear weight on a limb or that have limb angulation should be sedated, splinted and referred. See Emergency Orthopedics

Key Takeaways

Referral is indicated and prognosis potentially drops if any of the following are possible:

- synovial or body cavity involvement
- limb instability
- major vascular damage

Resources

See the following sections for management.

Wound Management: Wounds with Special Challenges, VCNA Vol.34(3), pp.511-538, 2018

Evaluation for factors that impair wound healing

Many factors can impede wound healing and make the after care challenging. Owners should be fully aware of the main risks and time line before starting on the journey.

Complicating non-urgent factors

Is the wound below the hock or carpus or involve eyelids?

- Distal limb wounds are prone to proud flesh
- Eyelid lacerations can lead to exposure keratitis if not managed appropriately

Is the horse knuckling over?

- Stabilization will be needed

Is there skin loss in a wound on the distal limb?

- Predisposed to proud flesh

Is bone exposed or damaged?

- Predisposed to **sequestrum** and/or infection

Is there muscle injury to the hindlimbs?

- At risk of fibrotic myopathy

Sharp or blunt trauma?

- Blunt trauma will lead to delayed damage

How heavily contaminated?

- Closure may not be recommended

Horse factors

- Will the horse allow treatment standing? tolerate bandage changes?
- Intended use and timeline for performance, if any?
- Adequate BCS and nutrition?

Chronicity

- How long has it been going on and has it been treated appropriately?

Wound location

Wounds below the hock and carpus are much more challenging to manage than wounds above the hock or carpus due to the risk of damage to deeper structures and to the risk of exuberant granulation tissue.

Wounds on the upper limb tend to heal well, even with muscle damage or skin loss. “Proud flesh” doesn’t happen above the carpus or hock for strange and mysterious reasons.

Wounds of the head tend to heal well due to the high vascularity of the head structures, including bone. However, wounds of the eyelids or periocular structures should be evaluated and managed carefully to identify and prevent globe damage from incomplete lids (exposure keratitis) or uneven lids (corneal ulcers from rubbing).

Extensor tendon damage

The extensor tendons run on on the dorsal aspects of the limbs and are important for limb position. The extensor tendon flips the foot forward so that it lands on the solar surface. When the extensor tendon is transected, the horse will tend to knuckle forward and be unable to flip the foot into the normal position. Once the limb is flipped forward, the horse can weight bear normally. These injuries heal quickly with little residual deficits. Suture repair of the tendon is not needed or warranted.

Skin flap or skin loss

Horse wounds often have missing skin or large skin flaps. Skin flaps will survive only if they have adequate blood supply. If the base of the flap is proximal (on the body side) it generally has good blood supply if it is wide enough. Flaps that have the base distal (on the foot side; away from the blood supply) often do not survive. Flaps with a thin base will often die off, as will the tip of triangular flaps. These flaps can be used to "bandage" the wound but will generally need to be debrided to permit complete wound healing.

Often the flap is based toward the foot; this limits the blood supply

Many wounds cannot be closed primarily. Horse limbs have very little loose skin to cover wounds and wound healing is often delayed or impaired by missing skin. Missing skin leads to wound dessication (drying) and potentially to bone sequestration. Wounds below the hock and carpus that are left open to heal often develop exuberant granulation tissue.

Periosteal or bone damage

Due to limited soft tissue covering, many injuries to the equine distal limb damage the periosteum and expose the bone. This can lead to sequestrum formation. Sequestra are pieces of dead bone that develop over 2-3 weeks and lead to persistent draining tracts.

Muscle injury

Muscle heals well and muscle injury does not usually complicate wound healing unless the resultant scar tissue is restrictive. This is a concern when the semitendinosus and semimembranosus muscles are damaged. Injuries in this area (caudal aspect of the hindlimb above the hock) can lead to fibrotic myopathy. Fibrotic myopathy is a gait abnormality in which the forward stride is restricted. As the limb moves forward, the muscles are designed to stretch to allow full arcing motion. However, if there is scar tissue in the muscles, they only stretch so far. The limb is then slapped down to the ground suddenly. The gait abnormality is most readily seen at a walk and is nonpainful.

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Sharp or blunt trauma

Injuries with sharp objects (including incisions) are less traumatic than blunt trauma and ripping forces. With blunt trauma, the wound tissues continue to deteriorate over time. This may mean any initial repair falls apart. Swelling continues to increase over the first 3 days. Natural wound debridement is also occurring over this time period, sometimes leading to weaker tissue in the repair. If the wound is going to **dehisce**, that process usually starts between 2-3 days after wounding.

The heel bulb laceration was sutured but the repair was starting to fail a few days later

Clean or contaminated wound

Unless the wound occurs during surgery (eg an incision), most equine wounds are considered contaminated. Some are heavily contaminated with mud or manure from the start; others are minimally contaminated. As with other species, all wounds are considered to be infected after 6 hours (the golden period). Closure at this stage will often lead to abscess formation unless the wound is well debrided and/or drainage is created.

Wounds entering the sinuses or airways are considered contaminated as are those entering the GI tract.

Wounds to the urogenital structures are considered contaminated. These wounds tend to swell significantly with the swelling leading to secondary issues such as preputial prolapse, **paramphimosis** and urinary obstruction. These tissues do have good healing potential but the healing process should be monitored to detect issues early.

Horse factors

Due to the risk of general anesthesia and recovery, horses are treated standing whenever possible. If the horse does not tolerate standing surgery, risks are increased. Similarly, some horses do not tolerate bandage changes. Depending on the wound, that can increase complication rates.

Horses that are underweight, parasitized or otherwise have low protein will have more difficulty with healing. Adequate nutrition and protein stores are necessary.

Cushingoid horses or horses on steroid treatment will also have delayed healing.

Age of the wound

Not all wounds are identified immediately. Maggots and granulation tissue do not happen in the first 24 hours. Older wounds may also have been treated with various topical agents. Many agents damage epithelial cells and increase the likelihood of delayed healing.

Key Takeaways

Healing can take quite awhile in many situations. Owners need to be well informed to better make decisions and plan. The most common factors that slow healing are lack of skin covering leading to proud flesh, bone surface damage leading to sequestration, and extensor tendon damage leading to a few days of required splinting.

Resources

See the following sections for management.

Wound Management: Wounds with Special Challenges, VCNA Vol.34(3), pp.511-538, 2018

Emergency Conditions in Horses: Opinions and Decision Making of Livery Yard Owners, Vet Evidence 2019

Factors that Affect Equine Wound Repair, Vol.21(1), pp.33-44, 2005

Common complications

Wounds on the head, neck, upper limbs and torso usually heal rapidly and well. Occasionally the wounds need to be kept open to ensure they heal from the inside out or abscesses will occur. Ventral drainage is key. Packing with gauze, honey or sugar can also help encourage wound healing without premature closure.

Lower limb wounds frequently have issues even if the damage is not life or performance threatening. These should be discussed with the client as applicable as these will add costs and time:

- Proud flesh management
- Skin grafting
- Sequestration management
- Splinting for extensor tendon damage
- Bandaging
- Rehabilitation needs for muscle damage
- Stall rest

Resources

Wound Management: Wounds with Special Challenges, VCNA Vol.34(3), pp.511-538, 2018

Wound evaluation

Wound management in the field involves balancing the three parts of the equation:

- The wound
- The patient
- The environment

Wound care can be straightforward in the appropriate environment with a well mannered horse. However, referral should be strongly considered with an ill-tempered horse or an unsafe environment even with simple wounds. Horses with significant blood loss, unstable limbs (fractures or tendon damage) and with potential synovial involvement should be referred as soon as possible. Call the hospital to determine what splints or medical therapy is needed to support the animal during the drive. The following describes steps for cases without complications. If critical structures are damaged, the process should be stopped, conversations held and the horse readied for transport if indicated.

Sedation

Sedation is often necessary to evaluate equine wounds. Remember: xylazine should not be used alone for hindlimb procedures. We typically combine alpha adrenergic agents with butorphanol:

> Standard sedative doses for a 500kg horse –
>
> 150-250 mg xylazine +/- 5-10 mg butorphanol iv
>
> 5 mg detomidine +/- 5 mg butorphanol iv

Acepromazine is a long acting sedative that is hypotensive. It should not be used in stallions, geldings with penile injuries or in horses with significant blood loss. Otherwise, a combination of xylazine, acepromazine and butorphanol (“RAT”; 10mg ace + 200 mg xylazine + 10 mg butorphanol/500kg horse) is very useful for ill-tempered horses.

Most cattle do not need sedation. If sedation is required, xylazine (10-20mg) is usually effective. Cattle do not typically have the head down/kick fast response that horses do (unless it is a Swedish Highlander). Injured small ruminants can be safely sedated with midazolam/butorphanol. Camelids may sedate with butorphanol if not already excited; otherwise xylazine + butorphanol may work better. Pigs are generally best when held by their owners, if possible.

See the chapters on sedation for more details.

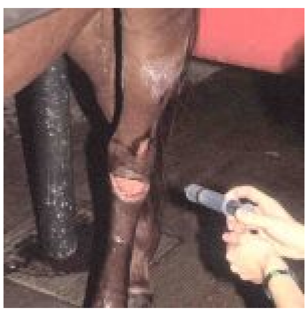
Wound cleaning

The wounds should be cleaned of gross debris. The wound can be covered with sterile lube to protect it while the hair surrounding the wound is clipped and the wound margins cleaned with betadine scrub. The soap can be removed with distilled water or alcohol. Chlorhexidine is more toxic and should be used only in very dilute concentrations.

Once the wound edges are cleaned, the surface of the wound can be wiped off with sterile saline or commercial wound cleanser (0.05% chlorhexidine, 0.1% povidone iodine).

Sharp debridement is then used to remove the contaminated tissue surface unless the removal of tissue could lead to issues (open a synovial structure, prevent eyelid laceration closure). Exposed bone may be rasped to clean and bleeding layers.

While lavage is useful, avoid high pressure lavage that may force bacteria and debris deeper into the tissues. A 35cc syringe + 18ga needle creates a good level of force.



Hydrogen peroxide is also bad for wounds. The bubbling creates new tissue planes and it is cytotoxic.

At this stage, the wound should be evaluated for damage to deeper structures.

- Is bone directly palpable? fragmented?
- Is cartilage palpable?
- Is there additional debris in the wound?
- Are there tissue pockets that will collect debris and bacteria?
- Other structures damaged?

Resources

Diagnostic Approaches to Understanding Equine Limb Wounds, VCNA Vol.34(3), pp.461-471, 2018

Medications

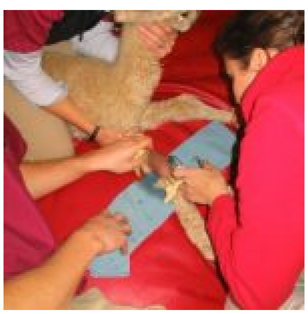
NSAIDs will slow wound healing but so will swelling. NSAIDs are useful to control the initial inflammation (first 72 hours) but then should be discontinued. Most horses are not painful after the incident. Signs of pain would indicate deeper trauma to bone, tendons or ligaments.

Horse NSAIDs – phenylbutazone, firocoxib, flunixin meglumine

Food animal NSAIDs- flunixin meglumine (approved), meloxicam (off label use)

Systemic antibiotics are generally **not** indicated unless deeper structures are involved or infection would be life threatening (eg near the chest or abdominal cavity). In these cases, iv antibiotics may be needed.

Regional perfusion of antibiotics can help with deeper wound management in the distal limb. For regional perfusion, a tourniquet is placed on the limb and a dose of antibiotics given iv below the tourniquet, concentrating the drug in the area needed. Antibiotics may also be injected directly into the synovial structures.



Regional limb perfusion performed on a cria

Once granulation tissue has developed, it will protect the wound from outside contamination. This typically means antibiotic coverage is needed for about 5 days maximum.

Tetanus toxoid

Horses and small ruminants are very sensitive to Clostridium bacteria and to tetanus infection. Any wounded horse, goat, sheep or camelid should be boostered with tetanus toxoid if it has been more than 6 months since the annual vaccine. If a horse has a deep wound and no history of tetanus toxoid, the horse should also be treated with tetanus antitoxin. Tetanus antitoxin does carry the risk of serum sickness (immune response to equine antibodies) and is not given if the horse has been vaccinated previously.

Wounds left to heal by second intention generally do very well, particularly those above the hock or carpus. The wounds should be kept clean and dry, potentially covered by a water based ointment to maintain tissue moisture. Lower limbs may be bandaged until granulation tissue fills the defect. Wounds on the upper limbs or torsos may be difficult to bandage.

Wound debridement

Sharp debridement (using a scalpel to remove damaged or contaminated layers) is less traumatic than rubbing and scraping the wound. Tissues are debrided back to bleeding layers, minimizing debridement to critical structures and over joints.

NOTE: Eyelid wounds should not be debrided; this area has good blood supply but do not tolerate missing skin. Never trim the flap of an eyelid wound; all parts should be reconnected to avoid lid margin scarring and exposure keratitis. If concerned, these cases should be referred. See Eyelid lacerations

Wound closure

After complete evaluation and cleaning, the veterinarian must decide if the wound should be closed primarily, with delayed closure or left to heal by second intention. Many wounds cannot be closed, making the decision easy. If closure is possible, most vets will attempt it. However, it is important to avoid creating an abscess in the area. Ensure the wound can drain ventrally if needed. Often this is most readily done with an incision at the ventral aspect or by leaving the wound partially open. If the incision is made perpendicular to the lines of tension, it will stay open longer. Penrose drains can be used; these should not exit the wound or incision and should be pulled in 2-3 days as they create additional inflammation.

While delayed primary closure can be useful in small animals, in large animals it doesn't often work as wound retraction occurs, enlarging the wound surface area and making it even harder to close.

Expect dehiscence in areas of high motion or high tension. Warn owners that the wound may fall apart in 2-3 days. Managing the swelling may help. Distal limb casts can support the wound and allow primary closure.

Topical wound agents

If the wound cannot be closed, topical salves may help keep tissues moist and minimize wound healing delays. Water soluble ointments are preferred over oil based ointments. Agents should be safe for new epithelial cells. Avoid toxic compounds. Generally triple antibiotics (neomycin + polymyxin + bacitracin) or silver sulfadiazine are used. Nitrofurazone (yellow goo) and chlorhexidine (blue goo) were used historically but are less commonly used now. Various bacteria can grow in nitrofurazone and it can actually delay wound healing. Chlorhexidine has been shown safe. Efficacy is unknown. Medical grade honey may even improve wound healing and decrease the risk of dehiscence if applied prior to closure.

Drains

Penrose drains can be used to assist drainage of wound fluids. They should not be exited out an incision or healing wound but should exit the most ventral aspect of the pocket. Remember: drains are foreign bodies and will cause additional inflammation. Drains can also wick bacteria into the wound. Generally a drain should be removed in 3-5 days or when the drainage slows. Do not expect drainage to stop with a drain in place. In many cases, extending the incision to the ventral aspect or creating an incision for ventral drainage is more effective.

Restrict motion

Generally limited motion will improve healing. Stall rest without hand walking is recommended at least initially. Bandages and splints may be useful. Horses don't often like stall rest and extra attention may be needed to improve horse and owner attitudes, including drugs and enrichment activities (for the horse).

Bandaging – lower limb wounds

Generally horse wounds are bandaged initially to prevent further contamination. Bandages do promote granulation tissue formation so are generally only needed in the initial stages of wound healing unless the limb is unstable or bandaging is needed to minimize motion.

Antibiotics and/or antiseptics may be applied to the wound and then the wound covered by a nonstick pad that is held in place with a soft wrap. A support wrap is then placed on the limb. This is often a manufactured bandage or sheet cottons. This layer is held in place with brown gauze or vetwrap. The brown gauze and/or vetwrap is applied snuggly with even tension. Bulges or bumps in the support layer can lead to tendon damage. A bandage that is too loose will fall down, creating folds and bulges. After a vetwrap layer to hold the support wrap in place, the ends of the bandage may be taped to the limb to minimize contamination from either the top or the bottom openings.

After granulation tissue fills the defect, bandaging of lower limb wounds is generally contraindicated. Exceptions include wounds near the ground or in very contaminated environments. Occasionally horses will chew at the wounds; these wounds may need bandaging for protection (and additional methods to prevent chewing may still be required).

Many horse owners will want to apply various solutions to the wound to prevent proud flesh (exuberant granulation tissue) formation. While most of these agents do control proud flesh, they also damage the new epithelial cells. If needed, corticosteroid cream can be applied in a light layer once weekly.

Bandaging – upper limb wounds

Bandages can be sutured over the wound if needed (stent bandage). Circular loops of suture are placed adjacent to the wound and a fresh towel or pad held in place by "laces" threaded through the loops.

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Key Takeaways

The main steps for wound management are

- cleaning
- sharp debridement
- closure or management for second intention healing
- restrict activity

NSAIDs are helpful. Antibiotics are typically not needed or are only needed until granulation tissue develops. Corticosteroid may be used weekly to control granulation tissue.

Horses are not always good patients. Warn your clients that any repair can fall apart – generally in 2-3 days.

Most limb wounds will need to heal by second intention. This means lots of bandage changes and prolonged stall rest. Topical antibiotics help everyone feel better for the first 5 days.

Resources

Topical Wound Medications, VCNA Vol.34(3), pp.485-498, 2018

Equine Practice on Wound Management Wound Cleansing and Hygiene, VCNA Vol.34(3), pp.473-484, 2018

Things You Should and Should Not Put on a Horse's Wound, The Horse, 2016

Wound Care in Horses, VCNA Vol.28(1), pp.83-100, 2012

Body cavity involvement

Due to the risk of pneumothorax and life-threatening peritonitis, wounds potentially involving the thoracic or abdominal cavity should be managed as emergencies. Body cavity damage should be suspected in any wound over the torso that goes deeper than 1-2 cms, particularly if the patient is showing abnormal respiratory movements, nostril flaring, elevated heart rate or change in mucous membrane color.

These wounds should be closed or covered with saran wrap or vaseline impregnated gauze and transported to the nearest referral hospital. If the abdominal cavity is penetrated, evisceration of intestines is common. Any exposed intestines should be rinsed and forced back into the abdominal cavity. The hole should be closed or wrapped to minimize movement of any other intestines out of the wound prior to transport to a referral hospital. Gravity works and intestines can slide out of small holes. Take the steps needed to close any holes at least for transport.

Pneumothorax is rapidly life threatening for horses. Cattle usually have a complete mediastinum (air doesn't leak across to the other side) and can continue just fine on one lung.

Peritonitis and pleuritis are treatable but require hospitalization, iv antibiotics and potentially surgery. Prognosis depends on the time line before effective treatment.

Key Takeaways

Body cavity involvement is a bad prognosis. Get these animals referred after closing or covering any chest wounds and ensuring intestines stay where they belong (even if it means anesthetizing the horse to temporarily close the wound).

Resources

How to Manage Penetrating Wounds in the Field, AAEP Proceedings, 2012

Vascular damage

Blood loss

Arterial bleeding requires rapid hemostasis. If the animal will tolerate it, the owner can be asked to apply tight bandages or pressure while waiting for the veterinarian. Under veterinary care, bleeding may be controlled by ligatures, clamps and/or a fresh pressure bandage. Tourniquets can be placed and maintained for ~30min with minimal risk.

Historical blood loss can be assessed through the physical examination. Horses with low blood volume will have elevated heart and respiratory rates and may have pale mucous membranes. The PCV and TPP will not change until the horse is rehydrated as the relative amounts of red blood cells remain stable with whole blood loss.

Horses with blood loss should be kept calm and referred to a hospital capable of plasma therapy or blood transfusions. Acepromazine should not be used to sedate the horse due to its hypotensive effects.

Vascular spasm

Vascular spasm and obstruction occur most commonly with suspensory breakdown injuries and with limb strangulation(wire wrapped around the limb). Heparin and warmth are usually not sufficient to prevent clotting and fibrosis of the lumen. The limb must be amputated or the animal euthanized. Limb amputations in larger animals are challenging and often lead to inhumane recovery periods. This may change in the future.

Key Takeaways

Large animals have large blood volumes and can tolerate more than 5 liters of blood loss without needing a transfusion. Just don't give them acepromazine.

Blood supply is essential for healing. A cold limb means it won't heal.

Resources

Wound Management: Wounds with Special Challenges, VCNA Vol.34(3), pp.511-538, 2018

Synovial involvement

Any wound over a joint or in the region of a tendon sheath should be evaluated for penetration of synovial structures. Remember the joint capsules extend beyond the bones of the joint and that the deep flexor tendon sheath runs on the palmar/plantar surfaces of the lower 1/3 of each cannon bone and down through the pastern region.

Synovial involvement can be confirmed by 1) visualizing or feeling smooth cartilage or 2) by trying (and failing) to distend the joint. A normal joint will pressurize. In other words, when you inject fluid, the joint eventually gets full – pressure builds up – and it is hard to inject more fluid.

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If a joint is damaged, fluid just leaks out. No pressure develops. To check joint integrity using this technique, the needle should be inserted through a cleaned area of intact skin. Do NOT put the needle through the wound or damaged tissues. If you can inject large volumes of sterile fluid and the joint does not become harder to inject (no pressure develops), it is open. Tendon sheaths can be harder to distend; wrap the unaffected part temporarily with vetwrap to make a smaller space to distend.

If synovial damage is suspected or verified, intravenous antibiotics and NSAIDs should be started immediately or as soon as a culture can be obtained if one is possible. The animal should be hospitalized.

Continued treatment usually entails a combination of regional antibiotic perfusion (horses) and systemic antibiotics. Arthroscopic lavage is used in horses to remove debris and provide high volume flush. In ruminants, the large amount of fibrin usually makes arthrotomy necessary.

Prognosis depends upon the duration of contamination, access to the joint, type of joint (high motion or low motion) and level of performance required.

Key Takeaways

Always think about where the joints and tendon sheaths are in relation to the wound. Evaluate their involvement early on to give your patient the best prognosis. Treatment is often successful if treated early. Waiting for lameness is not a good plan.

Resources

Equine Wounds over Synovial Structures, VCNA Vol.34(3), pp.575-590, 2018

Manual of Clinical Procedures in the Horse

Flexor tendon damage

The flexor tendons run on the palmar/plantar aspects of the limbs and are responsible for limb support. If flexor tendons are partially damaged, weight bearing can lead to complete tears. It is important to stabilize these injuries as soon as possible to minimize further damage.

Superficial flexor damage | Both superficial and deep damaged | Suspensory degeneration | Gastrocnemius rupture (bilateral)

- Fetlock sinking a little lower = superficial digital flexor tendon disruption
- Toe up = deep digital flexor tendon disruption
- Fetlock really sinking = suspensory ligament disruption
- Hock dropped = gastrocnemius /calcanean tendon disruption

These videos are related to degeneration vs injury but should give you the idea; we don't walk the injured ones!

Example of toe up indicating DDFT disruption

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Example of suspensory degeneration

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The limb should be casted or splinted with the heel elevated (ballet dancer position) for the flexor tendons. Kimsey leg saver splints are great for this when available and when they fit the patient.

Prognosis is guarded for performance.

In larger animals, it is really hard to recreate the calcanean tendon or stabilize the limb for healing and euthanasia is usually indicated.

Key Takeaways

If the wound involves the palmar or plantar aspect of the limb, check the limb conformation when weightbearing to see if tendon disruption has occurred. If you can feel a partial tear, stabilize the limb to prevent further tearing. The easiest way is to cast the limb with the toe pointed down (heel elevated).

Bone damage

Wounds leading to long bone fractures, joint dislocations, collateral ligament damage, nerve damage, and/or flexor tendon transection will lead to limb instability. Horses that cannot bear weight on a limb or that have limb angulation should be sedated, splinted and referred. See Emergency Orthopedics

Fractures of smaller bones

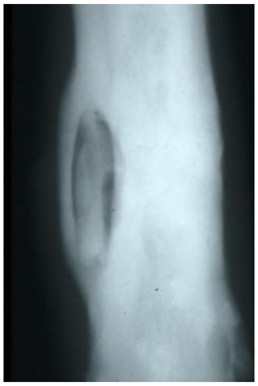
Direct damage to the smaller bones is possible. Fractures of the splint bones (metacarpus/metatarsus II and IV) and the fibula are relatively common with wounds. Radiographs are recommended, particularly in horses with significant lameness or wounds on the palmaro/plantarolateral or palmaro/plantaromedial aspects of the cannon bone.

Sequestration

Sequestra are pieces of dead bone that develop over 2-3 weeks and lead to persistent draining tracts.

A superficial layer of cortical bone can die off with wounding. This may be related to direct damage, contamination or a combination of factors. The dead bone detaches from the parent bone but is often trapped in the wound. These are seen as foreign bodies by the immune system. The immune system attempts to destroy the dead bone through lysosomal actions and, when that isn't successful, then tries to wall the dead bone off with additional bone formation (involucrum). Due to the dead fragment, the wound does not completely fill with granulation tissue.

Note: we consider this osteitis, NOT osteomyelitis. The infection, if present, is superficial.



To find sequestrum, it is often necessary to take multiple radiographs at slightly different angles to identify the slim bone fragment.

In the case in the image, the calf's limb was caught in a metal feeder. The dead bone (sequestrum) is surrounded by new bone (involucrum). The draining tract through the bone is the cloaca.

To prevent sequestrum formation, the wound should be kept moist and covered. The surface of the bone can be rasped to debride the top layer of contamination.

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If the wound is otherwise doing well, the skin may heal but with a persistent draining tract. In other situations, it is obvious that part of the wound is not being covered by pink granulation tissue. Sequestration should be suspected with the wound continues to drain after 2 weeks.

Radiographs are used to identify the location and size of the sequestrum. The optimum time to evaluate a wound for sequestration is 2-3 weeks after injury. Before that time, it is not radiographically apparent. After that time, it may be harder to remove as more bone is laid down over the top of the dead fragment.

Surgical removal is required. Occasionally this may be done standing; other cases may required general anesthesia. The process will set back the wound healing process but it should proceed more smoothly this time.

Foreign bodies and infected or damaged tendons and ligaments can also lead to poor granulation tissue coverage and draining tracts. These also require further surgery to remove the foreign bodies and/or debride structures.

Key Takeaways

If you can see the bone, sequestration is a risk. Clean the surface by rasping and keep the wound moist. If granulation tissue doesn't develop, it is likely dead/dying.

If the wound heals 90% of the way but never gets fully healed, take radiographs.

Taking radiographs at 2 weeks is optimum for sequestrum identification. Sequestra are typically visible by then and is easier to remove.

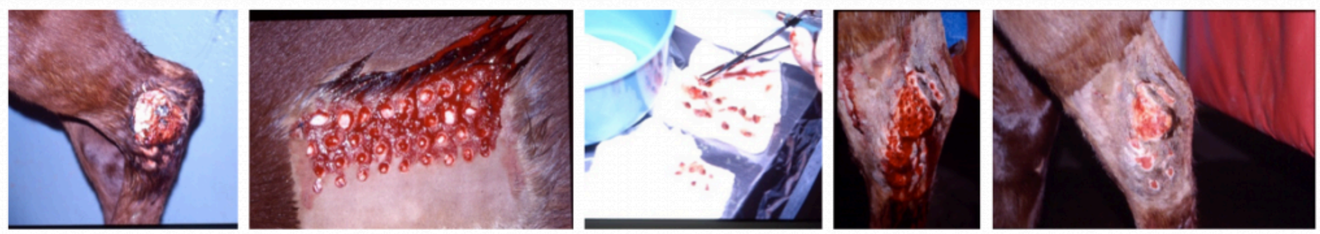
Resources

Wound Management: Wounds with Special Challenges, VCNA Vol.34(3), pp.511-538, 2018

Osseous sequestration in alpacas and llamas: 36 cases (1999–2010), JAVMA Vol.243(3), pp.430-6

Poor epithelialization

The horse's leg does not have much loose skin. A larger wound may not be able to completely epithelialize. If wounds stop contracting before healing is complete, a skin graft may be necessary. The most common forms of skin grafting are punch or pinch grafts, with donor skin being taken from the neck or ventral abdomen. Skin grafting does require strict immobilization to allow the skin plugs to attach and vascularize. Skin grafting in horses is meticulous and time consuming. It is best done in a hospital setting both for the surgery and the initial postoperative period.



The problem | The donor site (neck) | The grafts | Grafts in place | Final result

Proud flesh (exuberant granulation tissue)

Granulation tissue provides new blood supply with nutrients and oxygen. Once granulation tissue fills the wound, infection from the environment is very low risk. It protects as well as nourishes the tissues. Granulation typically starts to appear about day 4-5 after wounding.

However, due to the poor oxygenation levels in the lower limb, horses tend to develop exuberant proud flesh. In these horses, the new granulation tissue grows above the level of the wound, preventing epithelialization. The proud flesh must be removed so that the new skin cells can cover the surface.

Proud flesh removal can be done with a laser, sharp blade or safety razor. The tissue does not have nerve endings so the process is not painful if the skin margins are not cut accidentally. However, it will bleed profusely.

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After debridement of the proud flesh, a “bandaid” or short term wrap can be used to apply pressure to the surface. This should be removed after bleeding stops (or the following day) to minimize the risk of more granulation tissue. After removal, a light layer of corticosteroid ointment can be applied.

Owners can be taught to recognize the early signs of proud flesh and shown how to trim it back with a safety razor.

Proud flesh can be managed with a variety of products; however, most products also damage epithelial cells. Hydrocortisone applied weekly can control proud flesh with minimal effect on new epithelialization.

Once the wound has filled in with granulation tissue, bandaging will encourage the formation of proud flesh. At this stage it is usually preferable to leave the wound unbandaged unless the horse is repeatedly traumatizing the area.

Proud flesh can get colonized by bacteria (including Pseudomonas) but that doesn’t alter wound healing. The presence of the proud flesh interferes with healing but the bacteria on the surface do not cause issues unless you are attempting a skin graft.

WARNING- Proud flesh only occurs at/below the carpus and hock in horses. If it looks like proud flesh in other areas, it is more likely tumor or fungal infection.

Key Takeaways

Proud flesh interferes with healing. Epithelial cells don’t climb well so proud flesh needs to be shaved down to a flat wound surface. Apply hydrocortisone weekly and leave unbandaged

Eventually wounds stop contracting due to opposing forces. Skin grafts are helpful and the final result will not look normal.

Resources

Wound Management: Wounds with Special Challenges, VCNA Vol.34(3), pp.511-538, 2018

Wound Care in Horses, VCNA Vol.28(1), pp.83-100, 2012

Extensor tendon damage

The extensor tendons recover from complete transection without major issue. These injuries heal quickly with little residual deficits. Splinting the limb for 2-3 days is often all that is required. The damaged tendon does not need suturing. Performance should not be impacted.

(a)

Key Takeaways

Extensor tendon injuries mean the horse knuckles for 2-3 days. Splinting helps. After 2-3 days, the problem usually resolves. Good prognosis.

Wound bandaging

In most cases, we apply a half or full limb bandage, rather than a wound bandaid. With bandaids, swelling tends to develop above and below the bandage, creating traumatic areas at the edges of the bandage.

In early wounds (pregranulation tissue), **occlusive** bandages can be used to stimulate granulation tissue production. Once granulation tissue is present, the bandage should be non-occlusive.

The bandage layers are

- nonstick pad – Adaptic, Telfa
- padding- sheet cotton or premade bandages
- compressive layer- brown gauze, vetwrap
- tape (optional) to hold it in place
-

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Wrap Right,Horse & Rider,53(12), 40-43.- Great pics and what to avoid

Stall rest management

Horses aren't good at self-protection. If you provide them space, they will run, buck and kick if they choose. This could result in reinjury or further damage to a healing injury. Stall rest helps to control the activity and stress a horse puts on an injury.

Optimum healing requires controlled exercise. Often horses needing stall rest require hand-walking to slowly go back to work. There are a few tips to keep the horse happier and to help ease this process. Offer these to your clients to encourage compliance.

Stall rest suggestions

Provide natural light and fresh air

- Consider using outdoor stalls or pens the size of stalls. Natural light and fresh air can make a horse feel better.
- Use indoor stalls with windows to the outside or near a low traffic door left open

Keep the environment healthy

- Make sure the clean the bedding often
- Provide extra bedding, particularly for concrete floors and if the horse lies down
- Ensure good airflow to reduce the risk of respiratory problems
- Use fans, flysheets and repellents to limit insect annoyance

Feed for stall rest

- Eating is a great way to pass the time as long as the calories are appropriate
    - Adjust the diet to a lower calorie level if weight gain is not needed
    - Use a more mature (lower energy) grass hay as the backbone of the diet
    - Provide a ration balancer to ensure appropriate minerals and vitamins
    - Slow feed hay nets or feeders are great for making meals last longer
- Limit carbohydrates to decrease the restlessness associated with the sugar boost
    - Use fat calories instead; fat may also provide a calming effect

Provide company

- Have buddies stay inside too – switching companions can minimize the stress on the friends
- Add a stall mate – goats and chickens often work well
- Have the humans at the barn stop by and say hi whenever possible
- Hang a radio near the stall

Provide something to watch

- Place the horse in as stall near a wash stall or farrier area so there's always something to watch
- Keep the horse's needs in mind. Some prefer more activity while others prefer some down time.
- Placing the horse near a high traffic area can be a negative if the other horses are using the space to go outside

Provide something to do in the stall

- Make the horse work for a treat
    - Horse popsicles: freezing carrots or apples in an ice block
- Toys
    - stuffed animals, playground balls, traffic cones
- Unbreakable mirror

Maintain the current routine as much as possible (grooming etc)

- Regular activities are reassuring

Provide something to do outside

- handwalk or handgraze the horse if permitted (and get friends to help)
- pony the horse while riding another, as more exercise is permitted

Teach new skills

- Groundwork can challenge your horse's mind and let them learn something new.
    - Make sure to keep groundwork within reason of your horse's injury.
    - Teach them to ground tie, get them used to obstacles or work on walking showmanship.
- Add stretching exercises
    - Stall rest can be hard on joints and tendons
    - Massaging joints or stretching can loosen up your horse and help them feel good

Take a break

- Ask a friend to assist you or hire a caretaker
- Consider a rehabilitation barn

Monitor the horse

- Monitor manure for moisture, appetite and attitude
    - Stall rest can make horses more prone to stomach ulcers, while changes in activity make them more prone to colic.
- Consider using omeprazole

Transition to turnout carefully

- Horses will be excited on their first turnout and overexercise is likely, as are battles to reassert herd position

- Don't feed breakfast until they are outside
- Turnout with only 1-2 other horses at first
- Sedate with acepromazine
- Turnout during the heat of the day when everyone is moving slower
- Supervise turnout the first few days
- Turnout for short periods of time at the beginning
- Start in smaller area such as a small paddock
    - Round corners encourage running; the arena may not be the best bet
- Avoid lush grass paddocks to minimize the risk of laminitis from the abrupt change

- Recondition carefully -the horse will have lost muscle tone
    - Continue stretching
    - Avoid tight circles and repetitive exercises for the first month
    - Plan for 3 months of gradual return if stall rest lasted more than 3 weeks.

Horses can also be given anti-anxiety drugs. These drugs often have a low safety threshold so care is needed with original dosing. Overdosing can lead to anxiety. Reserpine is a human drug often used for horse sedation. The main side effect is diarrhea, which isn't common. Other products (B vitamins, magnesium sulfate, herbal combinations) can also help.

Boarding at a rehabilitation facility can make sure the horse isn't the only one on stall rest. These barns are used to restrictions and usually have plenty of company inside. Sometimes the new environment helps make the transition easier. The staff will be more familiar with rehabilitation care and can better follow treatment instructions.

Check in with your client. If they get too frustrated, they will just turn the horse out. There may be a middle ground between stall rest or total turnout that is safer.

After stall rest, plan for recheck radiographs and ultrasound to make sure the horse builds up work as fast as possible without causing reinjury.

From: Stall rest, how to make it easier, UMN extension

Key Takeaways

Stall rest if often required but is hard on man and beast. Explain why it is needed and work with your client to encourage compliance.

Puncture wounds

Puncture wounds usually heal quickly and can even be missed by the animal's caretaker unless complications develop. Complications include deep seated infections and foreign bodies. Foreign bodies will lead to persistent draining tracts and require surgical removal.

Infections can reach deeper tissues either primarily (direct injury) or secondarily (through extension as the infection builds). Infection in synovial structures can be hard to manage if diagnosis is delayed.

puncture wound into the fetlock joint

Puncture wounds can also lead to cellulitis – infection disseminated through the tissue planes.

Key Takeaways

Puncture wounds look innocuous and are often not. Train your clients to call you (or at least send pictures) regarding all wounds.

Bite wounds

Small ruminants and pot bellied pigs are often presented for bite wounds from dogs. Bite wounds are associated with ripping and tearing as well as oral bacteria. The ripping and tearing pulls skin away from the subcutis, creating potential for seromas and infection in the deadspace. The oral bacteria is usually a wide variety of many pathogenic organisms. Keeping the area clean and oxygenated helps minimize the need for heavy duty antibiotics. Closure is usually contraindicated due to the deadspace and bacterial population. The torso is generally affected and bandaging can help provide pressure to the area, minimizing seroma formation. Penrose drains may also help. Drainage is important even if means more holes.

Non healing wounds

Similar to abscesses, nonhealing wounds typically involve an underlying issue. These tend to appear in two different forms.

Incomplete granulation

If granulation tissue is not covering the wound and/or drainage is noted:

- foreign body – remnant from the original trauma or suture material from the repair
- lack of ventral drainage – a pocket or tract that is being forced to drain upwards
- **sequestrum** – fragment of bone serving as a foreign body
- damaged or decaying tissue – tendon fragments, etc
- flow of fluid (milk, synovial fluid, urine) – fluid flow acts to keep the pathway open

Granulation tissue is filling the wound except in one area

Evaluation includes ultrasonographical examination, wound probes and surgical exploration.

For most, treatment involves removing the foreign body and/or creating ventral drainage. En bloc resection of the entire tract may be performed if drainage is persistent but a source cannot be identified.

Incomplete epithelialization

If the granulation bed is complete but epithelialization has stalled, consider:

- motion – especially wounds over joints
- continued trauma

high motion area and no loose skin

If the limb wound has covered in granulation tissue but not skin, skin grafting is recommended. If the area is repeatedly traumatized, bandaging may be required (with concomitant proud flesh management).

Cellulitis

Cellulitis is disseminated infection under the skin – the bacteria grow in the tissue planes rather than in an abscess capsule.

The affected area becomes warm, swollen and painful. Animals will be febrile and have changes in white blood cell counts.

Therapy is systemic antibiotics and NSAIDs. Oral antibiotics are not always sufficient. Limbs are also bandaged to remove swelling and decrease pain.

If left swollen, limbs will develop problems with lymphatic and capillary flow. Many affected horses will be prone to limb edema with stall rest.

Client education article

Key Takeaways

If the limb is swollen, hot and painful, think cellulitis. Treat with antibiotics and firm wraps to push the fluid out of the limb.

Practice

Wounds level A

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Wounds level A

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Wounds level A

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Wounds level A

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Miscellaneous

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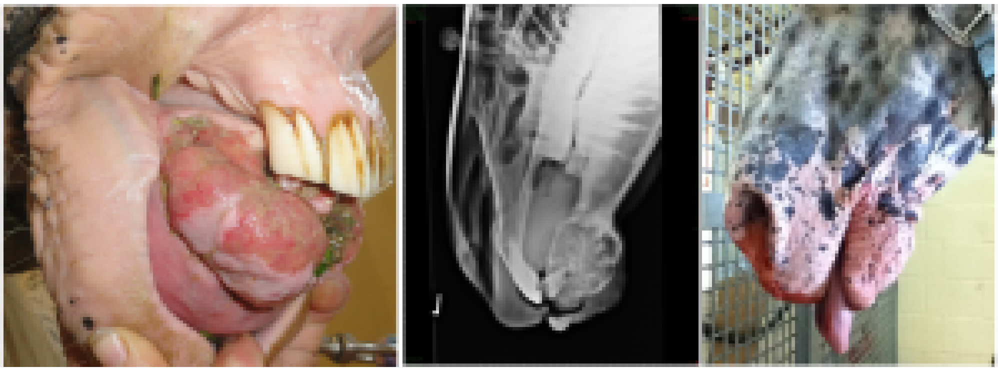
Equine Oral, Esophageal and Rectal disorders

Neoplasia

Squamous cell carcinoma is the most common oral tumor. Local bone destruction is often advanced before obvious clinical signs
develop. SCC is frequently associated with bone destruction and extension to lymph nodes. Excision and/or radiation therapy may be possible in some cases.

Dental tumors are usually benign and slow growing. Most respond to local excision.

It is possible to remove the entire rostral lower jaw (from the incisors to the interdental space) for ossifying fibromas and other tumors. This is a referral procedure. Horses can eat normally but tend to have the tongue exposed.



Resources

Equine mandibular growths, EVE (2015) 27 (1) 16-21

Odontogenic tumours in the horse, EVE 2008, Vol.20(12), pp.652-654

Salivary Gland Lacerations

Lacerations may heal completely, may lead to obstruction of the duct or may lead to fistula formation. Many injuries heal without complication if the are is kept clean and dry. Superglue may help to prevent leakage and allow healing.

Salivary fistula

Salivary fistula most often occurs secondary to direct injury to the parotid duct. Debridement and closure of the fistula can be successful. In resistant cases, the gland may be destroyed.

Salivary gland destruction
Inject 35-50 ml of 2% iodine or 10% formalin (best) into duct.. The distal aspect of the duct needs to be blocked so the formalin goes into gland instead of leaking out or going into the oral cavity. The injection can be repeated if required. The horse should be given NSAIDs pre and post injection.
Schmotzer WB, Hultgren BD, Huber MJ et al. Chemical involution of the equine parotid salivary gland. Vet Surg 20:128, 1991

Sialoliths

Salivary stones create a swelling in the parotid duct due to obstruction. Surgery involves an incision over the stone through the buccal mucosa The incision is left to heal by second intention.

Salivary gland neoplasia

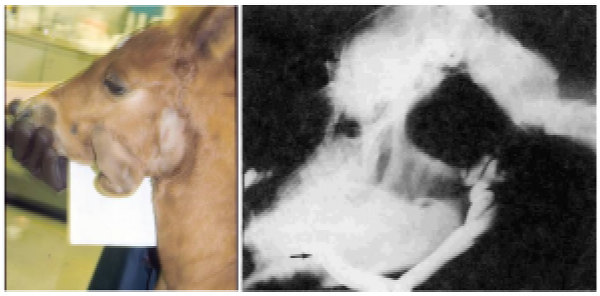
The most common tumor is parotid melanoma. These cannot be removed but can be present for years without clinical disease.

Cysts

Mucoceles, ranula, salivary cysts, and duct atresia are rare in horses. These are treated by surgical removal, drainage of the cyst into the oral cavity or gland destruction. Diagnosis is aided by electrolyte measurement – saliva had higher potassium and calcium levels than plasma.

Salivary duct atresia

This baby had no duct opening. The gland was destroyed with 10% formalin injection. Formalin is more effective with less inflammation than 2% iodine.



Resources

Sialolithiasis in equids, a report on 21 cases, EVE 2006, Vol.18(6), pp.333-336

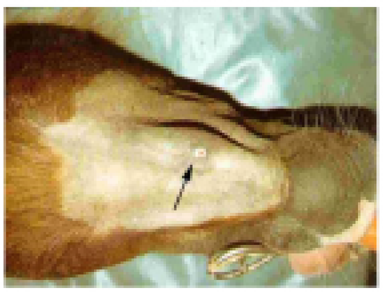
A review of five cases of parotid melanoma in the horse. EVE 2001 Vol 13(1), pp. 17-24.

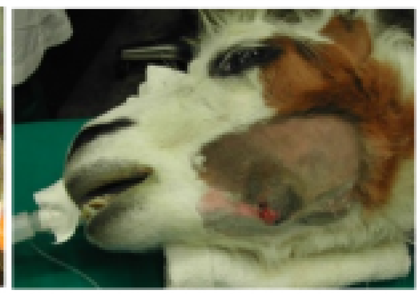
Dental surgery

Equine teeth are firmly packed together and develop issues readily. Miniature horses have regular sized teeth. Horses develop habits of chewing on things. In other countries, horses are fed silage and don't brush afterwards. Diseases lead to extra calcification and pain or to tooth loss.

The biggest thing we worry about is whether or not to remove a tooth. It may be diseased due apical infection, fractured (removal may not always be required) or in an abnormal position (malalignment). More and more, we are removing incisors to treat ETORH (equine odontoclastic tooth resorption and hypercementosis).

Clinical signs associated with dental disease include nasal discharge or fistula (maxillary teeth) or draining tracts (mandibular teeth). Horses may also have malodorous breath and quidding (abnormal chewing).





CT scans are ideal for diagnosing dental disorders. Radiographs are often confusing!

Tooth removal methods

Oral extraction

This is the best option if possible. Oral extraction carries the fewest complications. However, it takes patience and skill due to the tightly packed teeth. If the tooth enters the sinus (most do), it needs to be combined with sinus flush.

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Tooth repulsion

We used to remove teeth through repulsion. with the horse under general anesthesia, the tooth was "hammered" out from the root surface. The hammering loosened the tooth so it could be pushed or pulled out of the socket.

Root access was gained by trephination or sinusotomy. This method was very traumatic to adjacent structures; complication rates were close to 50%.

Trephine and dental punch

Intraoral tooth removal + repulsion

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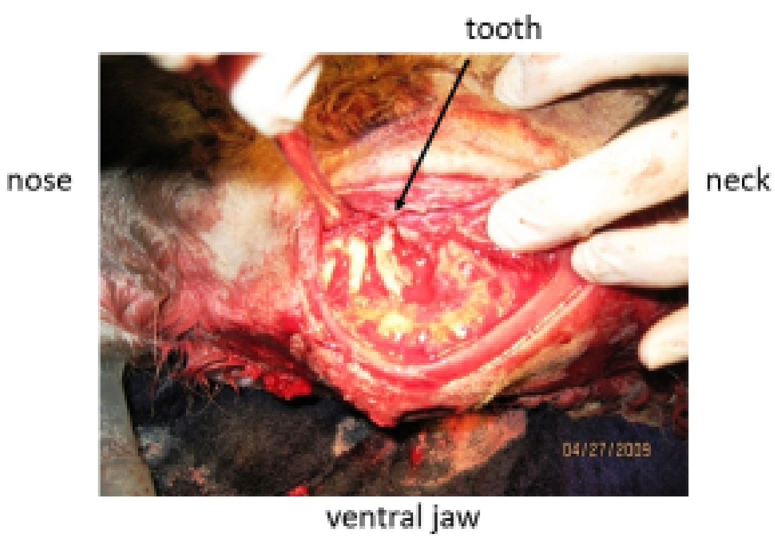
Buccotomy

Buccotomy is an alternative option for removal of cheek teeth. The tooth is approached through the side of the jaw. This method is commonly used in camelids due to the thinner, more easily fractured jaw. This approach requires specialized drill bits.



Lateral (buccotomy) approach to the abnormal tooth

Postoperative care

After tooth removal, the socket may be left open to fill in with granulation tissue. With this method, the socket should be irrigated daily to remove food material until healed. This can take awhile. Care is long and tedious; sometimes it doesn't heal and horses are left with a fistulous tract. Alternately, the socket can be filled with a temporary seal for 4-6 weeks in order to prevent food contamination of the area. Sealants include gauze packing, wax, polymethylmethacrylate (bone cement) and gutta percha. The seal should be seated so it occupies only the proximal 20% of socket. The rest fills in with granulation tissue. As the granulation tissue develops, it is supposed to push the sealant out of the socket. Occasionally manual removal is required. Finally, a permanent prosthesis can be used. Often polymethylmethacrylate is used as a permanent tooth replacement. This helps prevent overgrowth of the opposite tooth and subsequent mastication problems. However, some will create a chronic fistula as a foreign body. Without a placeholder, the adjacent teeth will drift into the socket and the opposing teeth will overgrow.

If the sinus was involved, sinus lavage is also necessary.

Complications

Complications with surgical repulsion include:

– damage to adjacent teeth
– removal of wrong tooth
– retained root fragments
– fistula formation
– wound healing problems
– overgrowth of opposing teeth
– requires frequent floating
– osteomyelitis
– fracture of jaw
– lack of resolution of problem

Alternative procedures

If surgical removal isn't indicated or isn't an option, management of the the sinusitis or infection may help. The sinus can be flushed through trephination and insertion of a catheter lavage system. Flushing through a 28-32Fr catheter once or twice daily can help clear the infection and may be less costly in some cases.

Endodontic treatment is possible but not commonly performed. “Root canals” can only be performed if the periodontal ligament is intact. With a root canal, the diseased pulp is removed and the cavity sealed. Periapical curettage may be sufficient with mandibular tooth infections. It is not recommended if the tooth is cracked below the gum line, an oral fistula is present, or the horse has a deep corner periodontal pocket.

Resources

Dental Disorders of Donkeys, VCNA 2019, Vol.35(3), pp.529-544

Equine Odontoclastic Tooth Resorption and Hypercementosis, EVE 2018, Vol.30(7), pp.386-391

Standing Equine Dental Surgery, VCNA 2014, Vol.30(1), pp.63-90

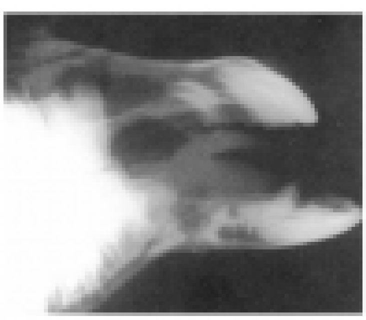
Manual of Clinical Procedures in the Horse

Jaw fractures

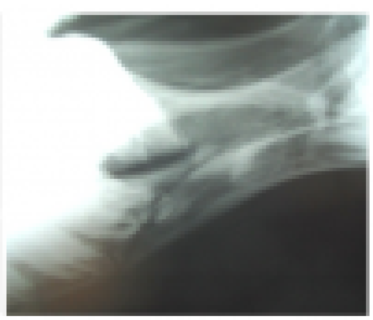
Rostral mandibular and incisive fractures are common in horses and are actually readily managed in the field, despite their apparent complexity and stress level to the owners. Due to the type of forces placed upon the jaw and the excellent vascularity of the region, fractures involving the incisor region and interdental space generally heal rapidly and well following wire fixation.

These fractures are generally due to trauma and can occur in any age group. The most commonly affected group seems to be young males that are biting something when they get startled. Alternatively, kick wounds are common causes of unilateral fractures. Incisive fractures may involve only the alveolar bone of a single tooth. Fractures of the horizontal ramus of the mandible are invariably open and most often bilateral. Affected horses may drool saliva mixed with blood, have a protruded tongue and possibly an obvious deviation to the jaw. Maxillary fractures may be associated with additional head trauma. Mandibular vertical ramus fractures are rare and generally due to direct trauma.

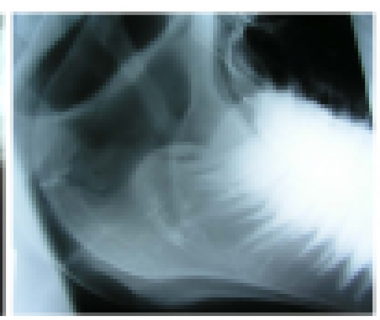
Oral examination is often more informative than radiographs; however radiographs are useful to identify tooth damage and fractures of the vertical ramus.



Interdental fracture



Fractured root



Fractured ramus

Several methods are employed to repair other types of jaw fractures, including plates, pins, and external fixateurs. However, due to the location of tooth roots, wire fixation is usually the preferred method for rostral fractures. Preoperative diagnostics should include a good oral examination to determine if any teeth have been damaged or if there is any risk of more caudal fractures. Radiographs are ideal but may not be necessary in many cases. Preoperative antibiotics are usually given and continued postoperatively. Anti-inflammatory drugs are helpful in speeding the animal’s return to a good appetite.

Incisive alveolar bone fractures

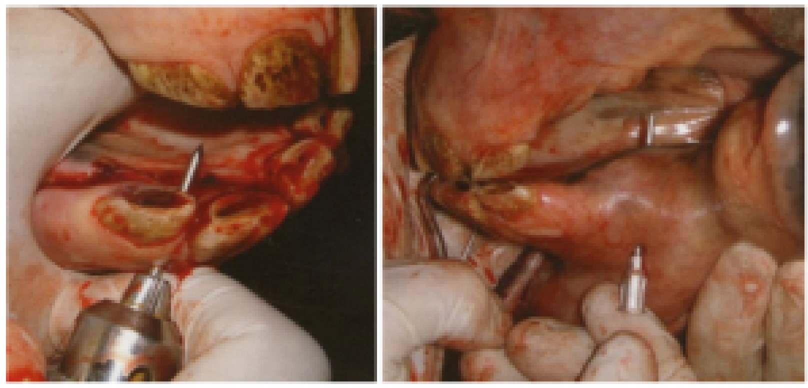
Occasionally just the labial plate of the alveolar bone is fractured, rather than the mandible. These may be replaced into the socket (adult teeth) or removed (deciduous teeth or damaged adult teeth). Stabilization is often not needed. Horses are sedated standing, usually with detomidine + butorphanol. Local block may be performed but often isn't necessary. Increasing amounts of direct pressure are applied to the teeth until the segment pops into position. Usually the segments are very stable when replaced. For removal, a local block may be helpful. Often the fragment is only held in place by a skin tag and the tag may be anesthetized prior to transaction or standing sedation may be sufficient.

Rostral mandibular bone fractures

18 gauge wire is used to secure the incisors to the molars or to each other using figure 8 patterns. Repair is usually done under injectable or inhalant general anesthesia. It helps to have the horses nasally intubated rather than orally intubated. A gag is used to keep the teeth separated. Local block of the mental nerve may be used in all ages.

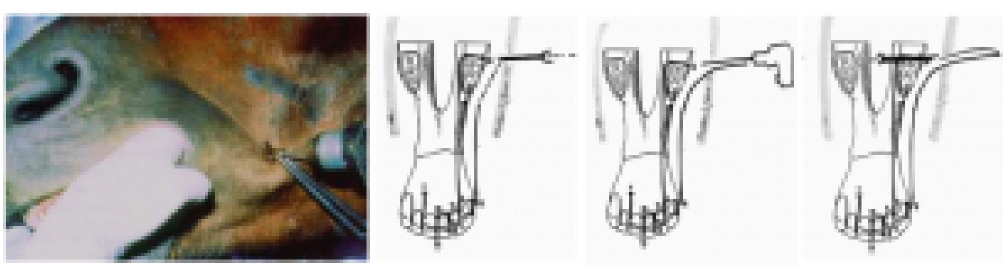
Meticulous debridement permits the best reduction. Good water pressure can be obtained using a water pik or a 20cc syringe with an 18 ga needle. Currettes are useful clean exposed bony surfaces.

Wires are passed through the bone rather than trying to fit them between the teeth. Rostral fractures may be stabilized by wiring across the incisor region (perpendicular to the fracture line is ideal). Additional wires may be necessary to prevent caudal migration of incisors. For interdental space fractures, the wires are usually secured between the first and second cheek teeth (306/307 and 406/407) and around 2-3 incisors in a woven pattern. It is possible to wire between the second and third cheek teeth if necessary. I have also wired to the bone in the interdental space for very rostral fractures or for added support.

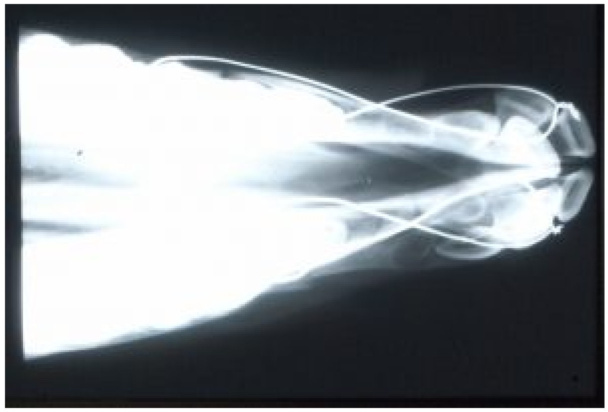


In foals, 14 ga needles can be inserted through the soft bone to create a hole for the 18ga wire (can be passed directly through the needles). In older horses, a drill (Black and Decker, etc) or handchuck is useful. Drill bits or pins are chosen to be slightly larger than the wire (2mm drill bits, 1/16″ pins). Holes are drilled between teeth, avoiding the roots. If drilling is difficult, redirection should occur to avoid the likely root.

In large animals, the cheeks cannot be retracted sufficiently to allow easy placement of wire between the first two molars so access is through a small incision in the cheek. A drill guide is used to protect the soft tissues. A 14 gauge needle can be used to help guide the wire. The most common problem with direct passage of the wire is lack of penetration of the oral gingival. Oral exploration can assist. When using the needle, it needs to placed so that it can be removed without disturbing the wire (eg placed from the opposite side of the bone from which the wire is inserted).



Once the wire is around the incisor teeth and the molar, twist the wire together in the interdental space. An option is to begin and end in the interdental space and twist the wire together at the end. I find this easier to tighten than when the wire is tied elsewhere. However, it is harder to protect the soft tissues from the knot. Another option is to create loops between each incisor and finish by threading the end of the wire back through the loops. Each loop is then tightened for additional stability. I have not found this degree of stability necessary in most cases. Plan on breaking at least one wire when tightening (have sufficient anesthetic capabilities to keep going). In unilateral fractures one wire may be sufficient. Most often wires are placed bilaterally.



If you are concerned about wire breakage (mouthy stallion, cribbers/windsuckers, etc) wires can be supported by dental grade methylmethacrylate. The methylmethacrylate can be used to cover the wires after placement or wires can be inserted into a methylmethacrylate brace during wire placement. A preformed brace may also be useful in comminuted fractures that tend to collapse when the wires are tightened. I have not found postoperative wire breakage to be a big concern if animals can be prevented from grazing, cribbing, etc until the bone is stronger.

Horses can survive with severe overbites or amputated lower jaws. In some instances, such as severe comminution, minimal vascular supply or nonhealing fractures, amputation may be a preferred option to repair.

Tooth root involvement

The roots of teeth involved in the fracture plane are at risk due to the open nature of the fractures and immediate contamination. However, root involvement does not mandate root infection. Generally I leave the teeth in place until proven infected. Good bony union is nice before attempting repulsion or removal of problem teeth.

Vertical ramus fractures

These fractures are well covered by musculature and are usually unilateral and relatively stable due to muscle coverage. It is possible to plate these fractures if necessary. The masseter muscle is elevated subperiosteally, exposing the bone. The bone does thin in a rostral direction, potentially making implants less stable in a rostral-caudal direction.

Maxillary fractures

These fractures tend to be comminuted and open to the nasal passages. The incisive bones as well as the palate may be involved. Repair involves wiring of the affected teeth as well as wire repair of the palatal fractures, if any. Wiring to a “retainer” device or brace can help support the jaw; straight wiring can collapse the jaw in comminuted fractures. Sequestration is more of a problem and repeat evaluation should be done to remove fragments not covered by mucosa or granulation tissue.

Postoperative care

Antibiotics may be continued for 4-5 days, until granulation tissue formation can occur. Phenylbutazone is used to keep horses comfortable while eating for the first few days. If possible, the wire area should be lavaged daily to prevent erosions from impacted food. Tap water can be used but there are healing advantages to flushing with dilute chlorhexidine solution (<0.12%) or dilute doxycycline solution (inhibits collagenase and enhances reattachment of the periodontal ligament). The wires themselves will create mucosal erosions if placed tight enough to enable rapid healing. The wires should be checked daily for breakage and removed early if broken. In most cases, wires can be removed at 6-8 weeks. The erosions in the mucosa will heal rapidly.

Complications

Prognosis is generally excellent. Small fragments may sequester and require removal. This is rarely the case with mandibular fractures. Lack of blood supply to the fracture fragment is a concern in severely traumatized fractures. These usually require removal vs repair. Creation of malocclusion is possible in youngstock. This has usually been in delayed repairs in which it was not possible to fully reposition the teeth. Leaving the wires on longer resulted in a braces effect that resolved the problem.

Figure 8 wiring steps
– drill through bone (between teeth roots) with pin chuck or electric drill
– use 14ga needle to place wire in hole
– figure 8 around incisors and molar on ipsilateral sides
To get wire around molars, it is necessary to make an incision through the cheek
– pass needle through cheek and through hole, thread wire from lingual surface out and then back in through same hole to buccal
surface of tooth
– wire ends up on oral cavity side only, but cannot retract cheek enough to get there without making a “window” first
– finish by repeating figure 8 around incisors (alternate spaces to original) and knot with original end
– twist together the two wires in the interdental space to tighten
– cover wire ends with vinyl polysiloxane or other compound
– remove after 4-8 weeks

Resources

Conservative Management of Unilateral Fractures of the Mandibular Rami in Horses, Vet Surg 2016, Vol.45(8), pp.1063-1065

Fracture repair techniques for the equine mandible and maxilla, EVE 2009 Vol.21(7), pp.352-357

Management of rostral mandibular fractures in the young horse, EVE 2008, Vol.20(2), pp.107-112

Miscellaneous oral cavity disorders

Cleft palate – very difficult to repair; feed by nasogastric tube until repair attempted. Purely soft palate lesions have a better prognosis than hard + soft palate lesions

Osteoarthropathy of temporohyoid joint occurs secondary to otitis media/interna. It can lead to skull fracture. Treatment involves removing part of the ceratohyoid bone to minimize pull on the area due to tongue motion.

Osteomyelitis – rare; poor prognosis

Brachygnathia – can put on "braces" but most likely inherited. Horses can do very well with untreated brachygnathia.

Retropharyngeal foreign body – can cause dysphagia. Localize with radiographs and ultrasound.

Lacerations – Most areas are high motion with heavy bacterial contamination but with good blood supply. Debride and lavage, appose deep tissues to close dead space, and place tension relieving sutures in skin.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=4387#h5p-195

Anatomy / Physiology

1. Passes to left of trachea at level of C4; accompanied by common carotid, vagosympathetic trunk, and recurrent laryngeal nerve; enters cardia at level of 14th rib
2. Proximal 2/3 = striated muscle, distal 1/3 = smooth muscle
3. Only abdominal portion has serosal covering
4. Moderate dilations are normal just distal to the cranial sphincter, in the distal cervical region, and in the thorax

Esophagotomy

Esophagotomy is used to remove foreign objects (particularly stomach tubes) and occasionally for choke. A longitudinal incision is made over the obstruction or in adjacent healthy esophagus. Primary closure is performed if healthy tissue; otherwise it is left to heal by second intention.

Esophagostomy

The esophagus is opened in the midcervical region. Esophagostomy is used for extraoral alimentation as an alternative to indwelling nasogastric tube. The tube is removed after 7-10 days -a stoma will be present that can be used for feeding. The stoma is allowed to heal by second intention when no longer needed.

Esophageal surgery complications

- Dehydration + hyponatremia, hypochloremia, and transient metabolic acidosis
- **Dehiscence** – difficult area for healing; can dehisce despite meticulous technique
- Laryngeal hemiplegia due to trauma to the recurrent laryngeal nerve at surgery or with inflammation
- Aspiration pneumonia
- Pleuritis
- Horner’s syndrome due to trauma to the sympathetic trunk
- Laminitis from high concentrate slurry diet
- Chronic choke

- Esophageal stricture

Esophageal obstruction

Esophageal Obstruction

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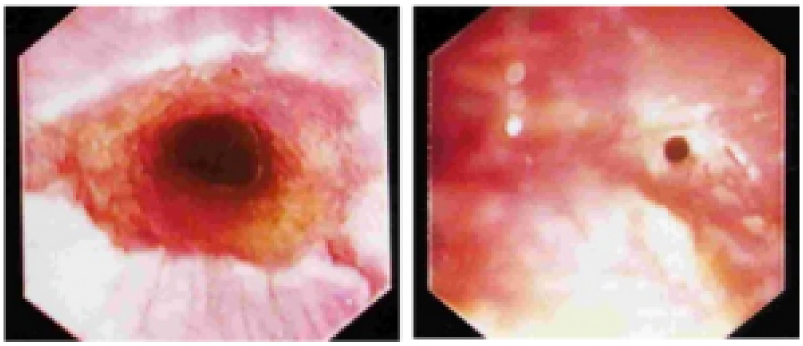
Esophageal foreign bodies

In Minnesota, fragments of stomach tube can cause esophageal or gastric foreign bodies. Typically this occurs in winter when tubes become cold and brittle. Sometimes the fragments can be removed endoscopically or via gastrotomy. If neither of those are an option, esophagotomy is possible. If esophagotomy is performed, a stomach tube should be placed to permit feeding. This can be placed through the incision. The slurry diet can predispose horses to laminitis (high concentrate, low fiber).

Esophageal stricture

Esophageal strictures may be congenital or occur secondary to surgery; however, most occur secondary to trauma from choke. If the choke leads to erosions in the mucosa, fibrosis may lead to stricture. This is particularly a problem with circumferential erosions. As the esophagus heals, it contracts in diameter for the first 15 days, becoming narrower and narrower. Between days 30 and 60, the lumen diameter actually increases. The risk of recurrrent choke is very high in the first 60 days. The diameter will not usually improve after 60 days.



Esophageal erosion and subsequent stricture

Acute cases may resolve with nonsurgical management. Horses are treated with antibiotics (choke can lead to aspiration pneumonia), soft feed, and NSAIDs. Bougeniage or balloon dilation has been helpful. Topical or systemic corticosteroids can be used to minimize scarring after infection is controlled. Surgery should be postponed until at least 60 days to allow full diameter to be achieved. Surgery is uncommon; referral is indicated.

Resources

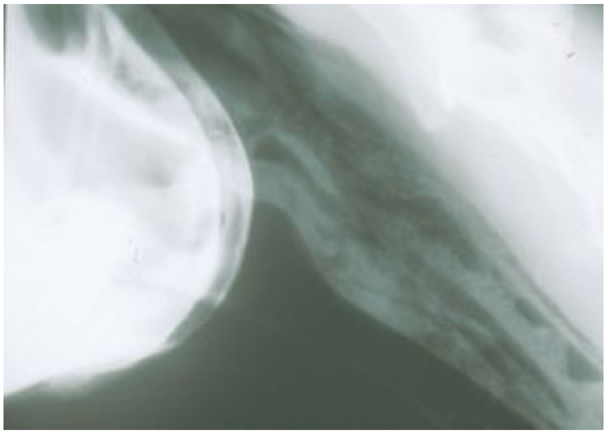
Oesophageal disorders in horses: Retrospective study of 39 cases, EVE 2018, Vol.30(2), pp.94-99

Conservative treatment of acquired oesophageal strictures by endoscopic-guided balloon dilation in two horses, EVE 2017, Vol.29(5), pp.259-265

Diagnosing disorders of the equine oesophagus, EVE 2015, Vol.27(6), pp.291-294

Esophageal perforation

Esophageal perforation can occur due to external trauma (kick) or internal trauma (esophageal foreign body). Clinical signs can include severe edema, **cellulitis**, emphysema, fever, and dyspnea.



The horse may need a tracheotomy due to swelling that compresses that trachea. The infection can descend into the mediastinal tissues; horses may develop pneumomediastinum and/or pneumothorax.

If the wound is acute (within 12h), it should be closed primarily if possible. If the wound is older than 12h or if it can't be closed,
ventral drainage is essential while the wound heals by second intention.

Horses should be treated with antibiotics, antiinflammatory drugs, and given tetanus toxoid. An indwelling feeding tube (through nostril or wound) is used for 10 days.

Resources

Treatment of cervical oesophageal rupture in horses, EVE 2013, Vol.25(9), pp.456-460

Management and complications associated with treatment of cervical oesophageal perforations in horses, EVE 2013 Vol.25(5), pp.247-255

Miscellaneous esophageal abnormalities

Traction (true) diverticula result from contraction of periesophageal fibrous scar tissue, often secondary to a wound or previous surgery. These are typically asymptomatic and will have a wide neck on barium swallow esophagram.

Pulsion (false) diverticula result from protrusion of mucosa and submucosa through a defect in the esophageal musculature. These may result from external trauma or fluctuation in intraluminal pressure and overstretch damage by impacted feedstuffs. These will have a spherical or flask-like on esophagram. Pulsion diverticula may enlarge over time and become evident as a large swelling in
the neck. These can lead to dysphagia or choke. Surgery is a referral procedure.

Esophageal fistula is usually secondary to previous surgery or trauma. These typically heal if ventral drainage is provided.

Intramural esophageal cysts are rare and likely congenital. They can be associated with dysphagia and regurgitation. A mass is identified in the neck. Surgery involves removal or marsupialization and cauterization.

Developmental abnormalities include tubular duplication and congenital esophageal dilatation.

Neoplasia is rare; usually it is SCC with a grave prognosis.

Megaesophagus is rare. Metoclopramide may be useful for secondary forms

Resources

Oesophageal disorders in horses: Retrospective study of 39 cases, EVE 2018, Vol.30(2), pp.94-99

Perirectal and rectal disorders

Perirectal abscesses are not common and may be secondary to trauma or lymph node disorders.

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Rectal atresia is considered heritable. Rectal tumors are common in gray horses (melanomas).

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General therapeutics

Antimicrobial therapy for GI diseases in horses, VCNA 2003, Vol.19(3), pp.645-663

Equine Colic

Introduction to equine colic pathophysiology

Anatomy review in video

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Physiology review

Pfizer gut video

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Small intestine

The main function of the small intestine is to move nutrients from the non-cellulose parts of the diet into the bloodstream. This part of the GIT works similarly to that of the dog with the restriction to a vegetarian diet.

Once foodstuffs such as grasses, corn, oats, barley and fats enter the small intestine, they are mixed with enzymes and buffers from profuse pancreatic secretions to start breaking down the food products into glucose, amino acids and lipids. The intestinal wall contracts rhythmically to mix the ingesta with the enzymes. The simpler components are absorbed through capillaries and lymphatics in the intestinal wall where they can be transported to other organs for use or storage. At the same time, the ingesta is moved from the duodenum, through the jejunum and into the ileum. Gradually more and more of the ingesta is exposed to the gut lining and can be absorbed if it hits the right receptors. The downstream (aboral) movement occurs through coordinated movements of the intestine, aka peristalsis. Most of the simple sugars and proteins are absorbed in the jejunum while fats are absorbed in the ileum. The ingesta will often be held and mixed in the ileum until the fat content is minimal.

During the process, the starches (including those from oats and corn as well as from hay) are not broken down but are being hydrated by active fluid secretion. The water exchange that occurs in the SI equals about 1.5x the total extracellular fluid volume of the animal over a 24 hour period. In all species, the SI is the main site of water absorption; in the horse, the large colon also does a decent job. Eventually the remaining components are moved into the cecum where microbial digestion will start.

One major difference from dogs is the type of motility patterns. Dogs eat set meals while horses graze continuously. This means there are different electrical and contractile patterns that result in continual activity with fewer periods of mass movement.

Cecum

The cecum is sometimes called the fermentation vat. Ingesta empties into the cecum via control by the ileocecal valve. Receptors in the ileum permit emptying after the fat content is properly lowered by nutrient absorption. Microbes in the cecum start the process of digesting cellulose. The cecal contents should always be liquefied, despite the fact that a large amount of water is absorbed here. Even though the cecum is a relatively small organ, the transit time averages 5 hours to allow proper mixing of contents with microbes and fluid. Afterwards, intestinal contents are moved into the right ventral colon.

Large colon

The equine large colon has been highly modified to allow cellulose digestion. It is very elongated to allow maximal exposure of the cellulose products to the microbes. Motility is largely mixing with propulsion slowed to keep the ingesta in the colon for long periods of time (transit time is 30-50h). This maximizes the nutrition that the horse can obtain from the hay diet. The microbes use the hay (and any leftover carbohydrates) for energy and produce volatile fatty acids that are absorbed by the colon wall and used by the horse. These fatty acids supply the major portion of the horse's daily energy requirements (and is why they do well on a strictly hay diet).

The colon also buffers ingesta coming from cecum and absorbs fluid from the ingesta. A pony resorbs approximately 30 liters of fluid/day from the colon. As with the small intestine, the colon (with its microbes) is designed to handle frequent eating and continuous flow of ingesta. If horses are fed only twice daily, they will have much more extensive fluid shifts into the ingesta and out of the colon, particularly if they are fed highly fermentable carbohydrates. Increasing carbohydrates entering the cecum and colon also means happy microbes – and more gas production.

Small colon

The small colon continues to remove water from the ingesta, forming fecal balls. The fecal balls can get drier and smaller with dehydration and impactions (more water is removed). It also continues some microbial digestion and buffering. Some retention also occurs (waiting on the defecation reflex).

Colic Pathophysiology

Colic refers to any type of abdominal pain or signs consistent with abdominal pain. While most cases are due to GI issues, other body systems (neuro, musculoskeletal, renal, respiratory) can cause signs of "colic". Colics can be divided into 4 main types

I. Strangulating obstructions

A twist or entrapment leads to obstruction along with a compromise to the vascular supply. The intestine is damaged or dead due to the strangulation of blood supply; obstruction occurs but is a secondary problem. Many conditions are often non-strangulating initially but rapidly lead to strangulating conditions due to swelling and fluid buildup (e.g. a loose entrapment becomes tight)

Examples : large colon volvulus, strangulating lipoma, epiploic foramen entrapment

Associated complications:

1. **Hypovolemic shock –**Fluid (SI & LI) and/or gas distension(LI) occurs proximally. Large volumes of sequestered fluid results in shock.
2. **Severe pain** due to traction on mesentery and distension of gut **–**pain increases rapidly until unrelenting and severe. Pain changes to depression if intestines become devitalized (pain often subsides).
3. Intestinal damage – venous occlusion leads to increased venous pressure and subsequent intestinal edema and net secretion of fluid. The occlusion also leads to decreased arterial inflow, resulting in intestinal necrosis. Necrosis starts with the mucosa as it is the most metabolically active section. See table below.
4. **RBC leakage –** Red blood cells leak out of altered capillaries, causing intramural hemorrhages and serosanguineous peritoneal fluid. Hemorrhages in mesentery can cause fibrosis, shortening of mesentery, and adhesions.
5. **Hypoproteinemia –** protein leaks out of bowel due to damage. This leads to a PCV /TPP mismatch : High PCV, low TPP. Compare this to blood loss with both low PCV and low TPP or dehydration with both values being high. The mismatch is hard to treat- if you give fluids to lower PCV and you severely lower the TPP. We usually give colloids first and then fluids.
6. **Endotoxemia**– ischemia causes progressive damage, starting with the metabolically active mucosa. Once this mucosal barrier is lost, endotoxin can leak across to the peritoneum and be absorbed into circulation. Horses may have a "toxic line" (darker line) around the teeth or have brick red mucous membranes.

7. Reperfusion injury may occur in the small intestine. The return of oxygen to previously ischemic area leads to formation of free radicals which cause further damage. Presently we have no effective means of preventing or treating reperfusion injury.
8. **Abdominal distension** if large intestinal lesion.
9. **Reflux** if small intestinal lesion.
10. **Death due to endotoxic and hypovolemic shock**

DAMAGE TIMELINE

Small intestine – Villi lost early on. Completely denuded by 3 hours

With time, the crypt cells will migrate to cover lost villi (within 12 hours), then rapid recovery occurs.

If ischemia continues for 4-5 hours, the loss of mucosa includes the crypts

By 6-7 hours of ischemia, degeneration has passed outward beyond muscle layers. This is bad news; recovery is very difficult as no mucosal cells remain. This section of the bowel needs to be removed surgically.

Large intestine -Complete ischemia induces cellular necrosis. Groups of 3-5 surface epithelial cells loosen and slough.

Cellular degeneration actually becomes irreversible before sloughing occurs. Irreversible mucosal damage occurs after 3-4 hours of complete ischemia

Sloughing of 97% of the surface epithelium and 50% of glandular epithelium is associated with death.

Strangulating lesions require surgery. General surgical complications include :

- Postoperative ileus (especially small intestinal lesions)
- Diarrhea
- Laminitis
- Adhesions
- Peritonitis
- Incisional infections
- Incisional hernias

II. Nonstrangulating obstructions

Simple obstructions may be **physical** (something in the way) or **functional** (not moving despite no physical obstruction, eg due to neurotransmitter issues or other problem). Intestinal distension occurs secondary to the obstruction or lack of motility. Gas, fluid and ingesta increase proximally to obstruction. This distension can compress intestinal veins and capillaries. Edema occurs due to increased capillary filtration. Distension pressures of 25cm H_20 for 120 minutes can cause jejunal damage with adhesions possible due to the damage. Motility initially increases proximal to obstruction. As distension increases, spasms develop causing intermittent pain. Prolonged distension leads to continuous pain due to stimulation of stretch receptors.

The specific pathology that results depends upon the site of the obstruction.

Examples : large colon impactions, **enterolithiasis**

Small intestinal obstruction

1. **Reflux** due to fluid buildup in the stomach. Horses do not vomit. If gastric decompression isn't performed via nasogastric intubation, the stomach will rupture.
2. **Electrolyte abnormalities and dehydration** due to increased secretions
3. **Tachycardia** due to dehydration
4. **Pain** due to intestinal distension and spasms. Pain gradually worsens.

Large intestinal obstruction

1. **Bloat** due to gas buildup.
2. **Dehydration** due to altered water resorption.
3. **Pain** due to intestinal distension and spasms. Pain is generally mild but gradually worsens.
4. **Impaction** due to buildup of ingesta and removal of water from the ingesta.

Cecal obstruction

1. **Bloat** due to gas buildup.
2. **Dehydration** due to altered water resorption.
3. **Pain** due to intestinal distension and spasms. Pain is generally mild but gradually worsens over several days.
4. **Impaction** due to buildup of ingesta and removal of water from the ingesta.

Small colon obstruction

1. **Pain** – more severe than large intestinal obstruction due to more rapid distension
2. **Reflux** is possible. Duodenal compression? Gastrocolic reflex?
3. No bloat.

Non-strangulating lesions carry a better prognosis than strangulating lesion due to less toxemia and fewer complications.

III. Inflammatory conditions

Intestinal inflammation causes hyperplasia and hypertrophy in smooth muscle. This may cause ileus due to alterations in neurotransmitter function. Infectious agents often lead to secretory response and may also damage the absorptive capabilities of the gut.

Inflammation in the small intestine often leads to **hypoproteinemia** due to leakage of protein (loss) and less absorption through the villi due to the greater diffusion distance between the nutrients and capillaries. Horses may have **weight loss and ventral edema.**

Inflammation in colon (colitis) leads to mucosal permeability and signs of endotoxemia, especially tachycardia, shock, changes in mucous membrane color, and fever. Ulcerations can cause **colic** signs.

Inflammation also alters ability of gut to protect self from intestinal contents. Overwhelming gut inflammation can lead to systemic inflammatory response syndrome (inflammation in other organs).

Examples : equine proliferative enteropathy (*Lawsonia*), right dorsal colitis, Salmonellosis

IV. Nonstrangulating infarctions

With nonstrangulating infarctions, the intestine is devitalized but no twist or entrapment is present. These conditions are less painful than those involving intestinal distension and entrapment until secondary distension develops. Toxemia leads to tachycardia and depression. These generally carry a very **poor prognosis!**

Examples : mesocolon tear, intestinal infarctions from *Streptococcus equi* infections or large strongyles (this may become a problem again with increasing anthelmintic resistance)

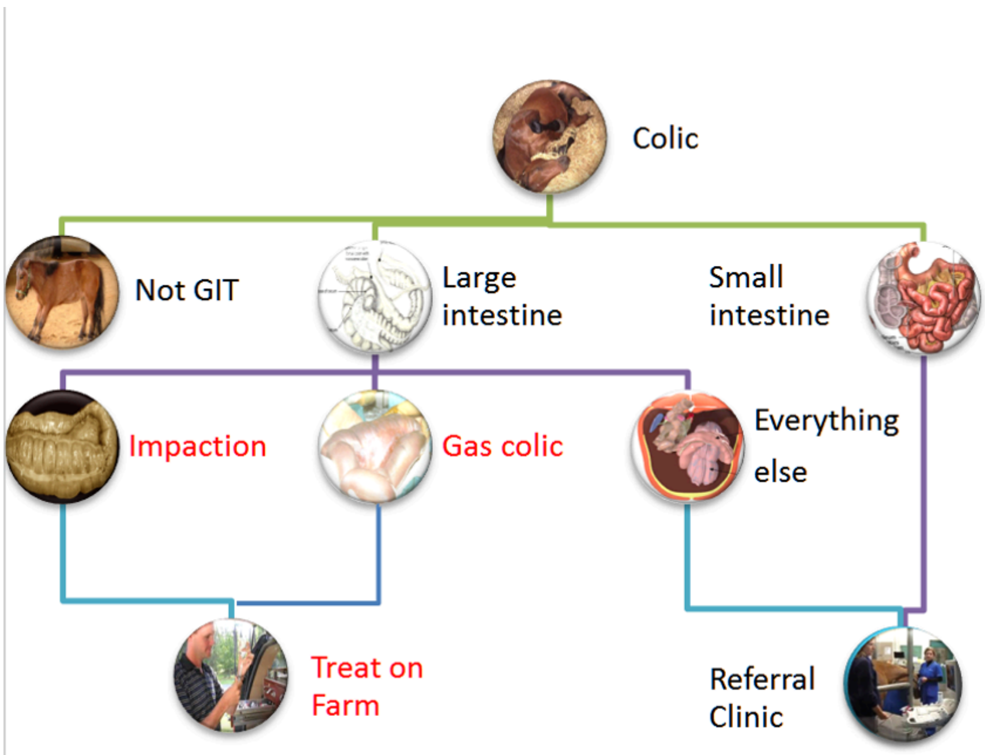
Resources

Lawsonia intracellularis and Equine Proliferative Enteropathy, 2014 VCNA

Nonsteroidal anti-inflammatory drug associated right dorsal colitis in the horse, 2015 EVE

The field colic - approach and management

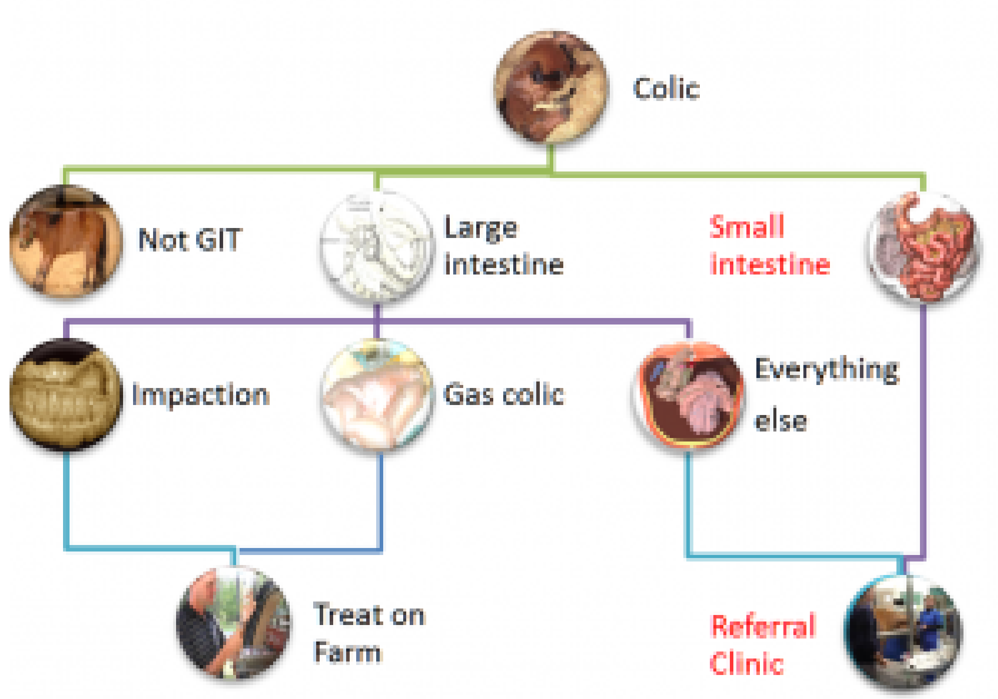
Two types of **colic** comprise 80% of the colics seen in the field. Gas and impaction colics are by far the most common and typically respond to one visit by the veterinarian. Luckily, treatment is similar enough that differentiating between them really isn't necessary. So if you can treat a gas colic, you can treat 80% of the colics you will encounter. So the only real challenge primarily involves identifying and managing the other 20%. Almost all of the other colics should be referred; it is reasonable to refer 100%* of the colics you see, including those gas and **impaction** colics.



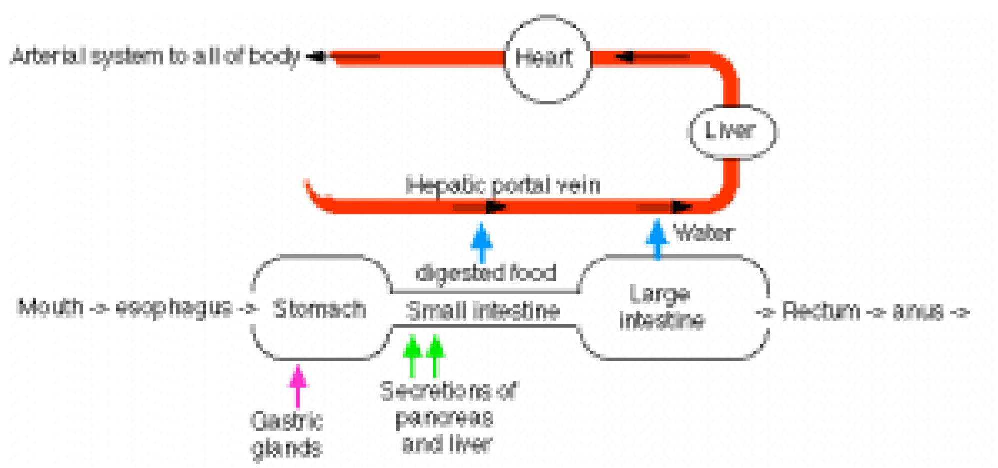
In my mind, this is a bit like the car that stops running. I can add gas or try jump starting the engine. I check the gas gauge and try the jumper cables. If the car has gas and the battery has a charge, it is time to call an expert. For field colics, I can treat impactions and gas colics. I look for those and then refer if they aren't seen.

*A colic that walks off the trailer pooping and comfortable likely had a "curative" trailer ride. Bouncing might be helpful with getting that gas knocked loose (a LA version of burping?). Everyone is happy. The colic that isn't better is the most stable it is going to be – ready for surgery or intensive medical management if needed. Waiting until it is obvious that things are bad significantly decreases prognosis!

Small intestinal colics



Horses with SI lesions should be referred to a hospital with 24 hour care, fluid set ups and surgical options. These horses typically need intensive care, surgery or both. Horses with SI lesions are sicker due to the large volume of secretions produced by the SI with the concomitant dehydration, reflux and electrolyte abnormalities.



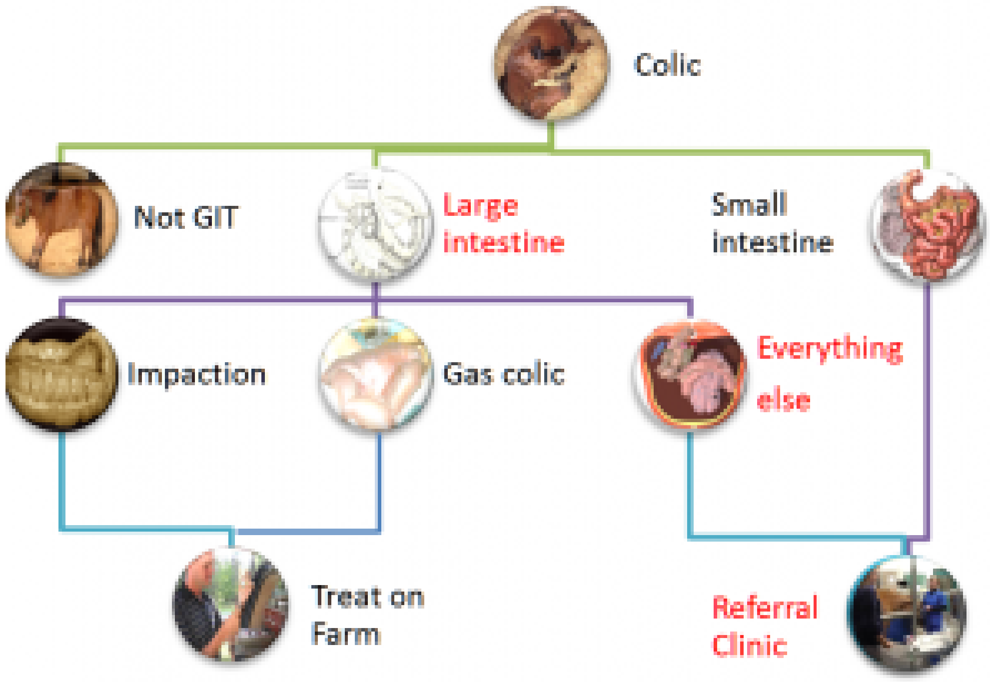
Most are refluxing or will be soon. This means they need careful attention to avoid stomach rupture and cannot drink or eat.

Small intestinal disorders may need referral for surgery, reflux management, intensive therapy and/or just for maintenance of hydration. SI lesions are identified chiefly by the presence of reflux and/or identification of distended SI on ultrasound or rectal.

Hints that the horse has a small intestinal lesion:

- Reflux
    - Due to small intestinal secretory activity, any type of small intestinal obstruction will eventually lead to reflux. As horses cannot vomit, the fluid buildup will lead to a gastric rupture if not removed via nasogastric intubation. Large quantities of reflux will also cause electrolyte and acid base changes. Oral fluids will not go anywhere, so IV fluids are required to manage hydration.
    - Small intestinal lesions can be differentiated from large intestinal lesions most readily if reflux is present. Very few large intestinal lesions will lead to reflux (nephrosplenic entrapments and small colon impactions can reflux). Small intestinal lesions do not generally cause bloat. If bloat is present, it is likely a large intestinal problem.
- Low protein
    - Small intestinal infiltration will lead to weight loss and low protein levels if it persists. Infiltrates increase the distance to the capillaries, making nutrient absorption less likely. Small intestinal inflammation can lead to loss of absorptive cells, also impairing nutrient absorption. When low protein leads to edema, it is definitely time for more intensive management. Steroids may be needed to control the inflammation and plasma may be needed to restore oncotic pressure.
- Metabolic derangements
    - Stomach and biliary secretions are lost in the reflux, leading to more severe changes in electrolyte and acid-base levels in horses with small intestinal lesions.

Other LI colics



LI colics that need intensive care or are not responding to field treatment should be referred. This includes those that have a low protein (eg Lawsonia or right dorsal colitis), weight loss, fever or diarrhea. Hints include more severe colic, abnormal rectal examinations, abnormal abdominal fluid or just lack of response to the normally effective treatment regimen. Many of these cases will need ongoing monitoring, more intensive treatment and/or surgery. Some displacements and sand colics can be managed in the field; most will benefit from hospitalization.

Cases that need surgery should be referred as early as possible. This may even mean referring in a case that is not yet surgical but isn't following the normal course of impactions and gas colics. Refer to the physiology/pathology section to notice how fast lesions become non-reversible.

Indications for surgery include

- poorly manageable pain
- serosanguinous or abnormal abdominocentesis
- lack of response to therapy
- a need for further evaluation

Cases that need more intensive therapy:

- Reflux, diarrhea, or low protein levels necessitate iv fluids or colloids
- Horses with fevers may indicate contagious disease, particularly Salmonellosis and/or Clostridial

infections

Not all clients will let you refer. Develop a mutual plan on when it will be time to stop.

Resources

Equine colic podcast

Management of colic in field, 2021 VCNA

Review of Packed Cell Volume and Total Protein for Use in Equine Practice, 2001 AAEP

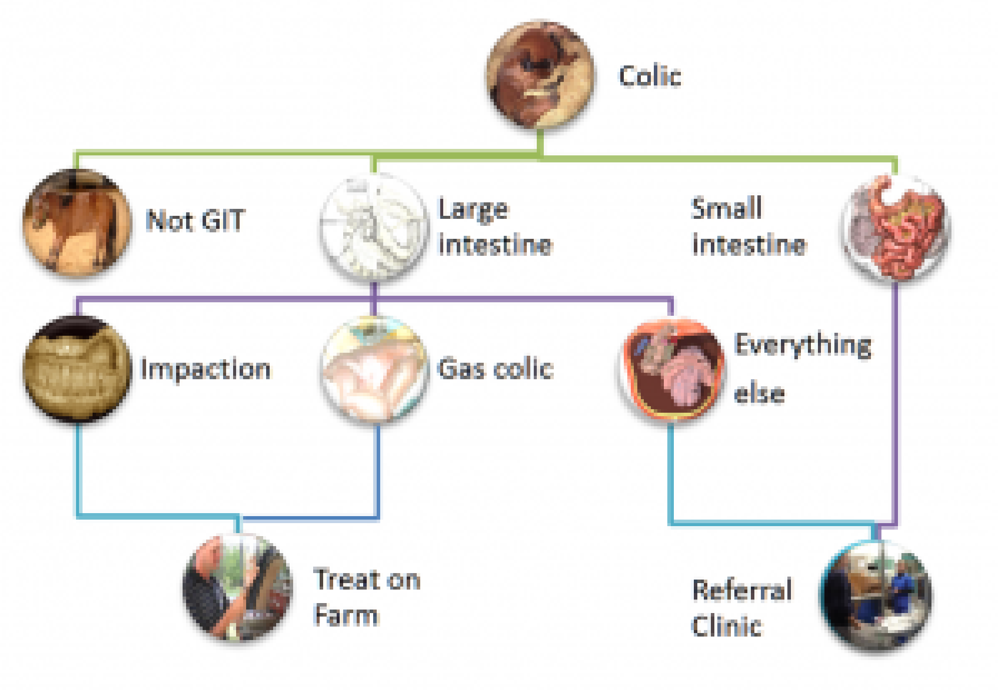
Evaluation of the colic in horses: decision for referral, 2014 VCNA

How to manage severe colic in the field, 2001 AAEP

How to manage the challenging colic when referral is not an option, 2016 FAEP

Field diagnostics

The goal of field diagnostics is to determine where on the flow chart this case is likely positioned. Not all diagnostics are required in most cases. Clinical signs, physical exam findings and nasogastric intubation to check for reflux are key.



While colic typically refers to signs of GI issues, it is important to remember that not all colics are due to GI lesions. Thoracic pain from pleuritis, foot pain from laminitis, muscle pain myopathies, ureteral stones, biliary stones and abnormal behavior from rabies are commonly first identified as "colic".

History

History can be helpful, particularly with recurrent colics. **Enterolithiasis** is associated with west coast living and is more likely if another horse on the farm has had an enterolith. Sand impactions are more common in certain areas of the country, particularly when horses are fed off the ground. Travel may increase the risk of impactions or pleuritis. Limited dental care may point toward impactions or fecoliths due to difficulty chewing. Large colon volvulus is more common in postpartum broodmares. Right dorsal colitis is associated with NSAID administration.

Signalment predilections also exist, particularly for Arabs, Friesians, broodmares, stallions, old horses, neonates and miniature horses.

Clinical Signs

Horses with colic will look at their side, kick at their belly, act agitated, lie down and/or roll. Many will be sweating due to pain. If they have been rolling, you may see hay or straw on their backs or in their manes. Many that have been rolling may have abrasions on their head or limbs. Another common clinical sign is frequently stretching out and passing small amounts of urine. Many owners will call thinking that their horse has a urinary tract infection. Mild cases may just not eat well. Horses should pass at 6-8 piles of manure per day. Limited (<3) manure piles or dry, small fecal balls can indicate poor motility.

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Physical examination

Physical examination findings can help determine the severity and type (medical vs surgical) of colic. Fever is rarely associated with surgical conditions. A normal to slightly elevated heart rate (40-60bpm) is more commonly associated with large intestinal or milder colics. Very high heart rates (80-100bpm) are associated with dehydration and shock. Small intestinal and surgical colics are more likely to have such high heart rates (and need fluid resuscitation). Elevated respiratory rates can be pain or indicate pleuritis, pneumonia or diaphragmatic hernias. Dehydration is evidenced by tacky mucous membranes and prolonged refill times as well as elevated heart rates. Toxic lines (red line next to teeth) suggest **endotoxemia**. Bloat generally indicates a large colon issue. Weight loss can be seen with some forms of chronic colic.

Sedation for diagnostics

Most horses will need sedation before nasogastric intubation or more invasive diagnostics. The goal is to sedate sufficiently to be safe but not so heavily or for such a long duration that the sedation interferes with monitoring or worsens the horse’s systemic status.

Xylazine is the first choice for most colics. It provides both sedation and pain relief for about 15 minutes. It can last 20-30 minutes when combined with butorphanol.

Detomidine or detomidine/butorphanol may be used if the horse needs to be transported to a referral center. The center should be notified as the combination can be strong enough to make a surgical horse look less in need of surgery.

Acepromazine should not be used due to its hypotensive effects.

Nasogastric intubation

Intubation is warranted in almost all colics. Passing a stomach tube can relieve fluid build up in the stomach. Since horses cannot vomit, this can be lifesaving. Without intubation, the stomach may rupture.

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Rectal palpation

Rectal palpation may be needed in cases of recurrent colic. It is risky to the person palpating (kick injury) and to the horse (rectal tears)

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Abdominal Ultrasound

Ultrasound is often used in the clinic for full evaluation of the abdomen but the FLASH technique has been developed for quick scans in the field.

Barton- The FLASH Technique

Lactate analysis

Portable lactate analyzers are making it much easier to measure and monitor lactate in colics. While most studies have been performed in referral institutions, a high lactate likely indicates a need for hospitalization and intensive therapy, along with a poorer prognosis

ISF Henderson. Diagnostic and prognostic use of L-lactate measurement in equine practice. Equine Vet Educ Sept 2013

Abdominal fluid analysis

Abdominocentesis can be used to help differentiate between surgical and non-surgical colics as well as prognosticate. The tap is performed at the most ventral area of the abdomen or where a fluid pocket is identified ultrasonographically.

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Normal abdominal fluid is straw-colored and clear (you should be able to read newspaper print through it), with reported reference ranges of: <2.0g/dL (measured biochemically) or <2.5g/dL (measured via refractometer) for total protein (TP), <5,000-10,000 total nucleated cells/uL (NCC), and a lactate level of <2.0mmol/L with a ratio of peritoneal to plasma fluid lactate of <1:1. Changes in TP concentration or increased number of NCC or erythrocytes will change the appearance of the fluid to cloudy, dark yellow, orange or red. Elevated lactate levels can also confirm the presence of ischemic bowel.

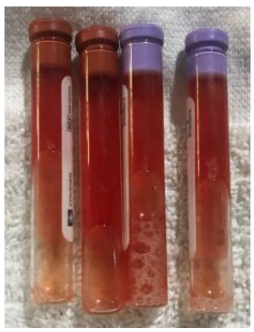
Key Takeaways

Abdominal fluid colors and differentials to consider

- Clear yellow –
    - normal fluid
    - normal fluid, abnormal belly
        - horses with bowel through a hernial ring (fluid is sequestered) or with a thickened bowel wall can have normal fluid
- Clear yellow orange – check protein levels
    - inflammatory bowel disease
- Cloudy yellow or yellow orange- increased cell counts
    - peritonitis
- Cloudy yellow-green –
    - bowel rupture
    - check for wbc cells + plant material or bacteria
- Reddish (serosanguinous)
    - dead bowel

- Bright Red
  - splenic tap or hemoabdomen

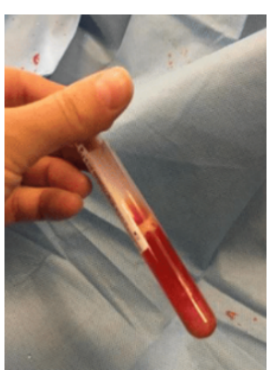
Non-strangulating obstruction: Most cases will have normal peritoneal fluid; however, in some cases the fluid can become slightly turbid with a NCC 5,000-15,000cells/uL and TP <2.5g/dL. Cytology may reveal an increase in segmented neutrophils.



Strangulating Obstruction: Exudative. Dark yellow to serosanguineous. Elevated NCC (values from 10,000-150,000 cells/uL), TP, and lactate levels (>2.8mmol/L). High number of RBC and if the sample is spun down in a centrifuge, it remains blood tinged indicating that it is not iatrogenic blood contamination. Often cytology shows 90-95% neutrophils with a high proportion of degenerative neutrophils and erythrophagia.

Infarction: Dark yellow to reddish brown. Elevated NCC (>150,000 cells/uL), TP, and lactate levels (>2.8mmol/L). These changes typically occur later in disease progression and have fewer RBCs than seen with strangulating obstructions.

Inflammatory (colitis/enteritis): Yellow to orange (rarely serosanguineous) with a very high total protein (>4.5g/dL) and normal to elevated nucleated cell count. Protein levels are high due to leakage through the damaged gut.



Septic Peritonitis: Exudative. Dark yellow, orange, serosanguineous, or white with an elevated TP and NCC (>150,000 cells/uL). Cytology shows increased percentage of degenerative neutrophils and there may be evidence of a single bacterial agent suggestive of primary peritonitis. (W*hat is the most common bacteria associated with primary peritonitis?*).

Notice in the first image the large number of WBC at the bottom of the tube. The second image is from the worst case of peritonitis I have seen.

GI Rupture: Exudative. Dark yellow to brown or green tinged; may also appear serosanguineous. Elevated NCC, TP, and neutrophil to monocyte ratio. Often find a mixed population of intra- and extracellular bacteria as well as plant material. The combination of bacteria and white blood cells differentiates it from enterocentesis (gut tap).

Horses with strangulating lesions or significant pathology may still have normal abdominal fluid!

Key Takeaways

- SI obstruction leads to reflux. LI obstruction leads to bloat. Usually.
- High heart rates mean dehydration and shock. Refer.
- Always pass a stomach tube. Reflux suggests a SI lesion. Refer
- Serosanguinous abdominal fluid often indicates dead bowel. Refer
- Rectals can be dangerous to both horse and veterinarian. Only do if safe and necessary. Palpable changes may include distension (gas or impaction) or displacement (spleen, guts).

Additional Resources

Management of colic in field, 2021 VCNA

http://eclinpath.com/atlas/cytology-2/equine-peritoneal-fluid/nggallery/page/1

Practical_Guide_To_Equine_Colic_Abdominocentesis

Peritoneal fluid analysis for the differentation of medical and surgical colic in horses

Manual of clinical procedures in the horse

Gas and impaction colics

The majority (80%) of colics are gas or impaction colics. They look very similar. They are treated very similarly and respond well to field treatment. Both have a good prognosis as long as the causative factors are managed.

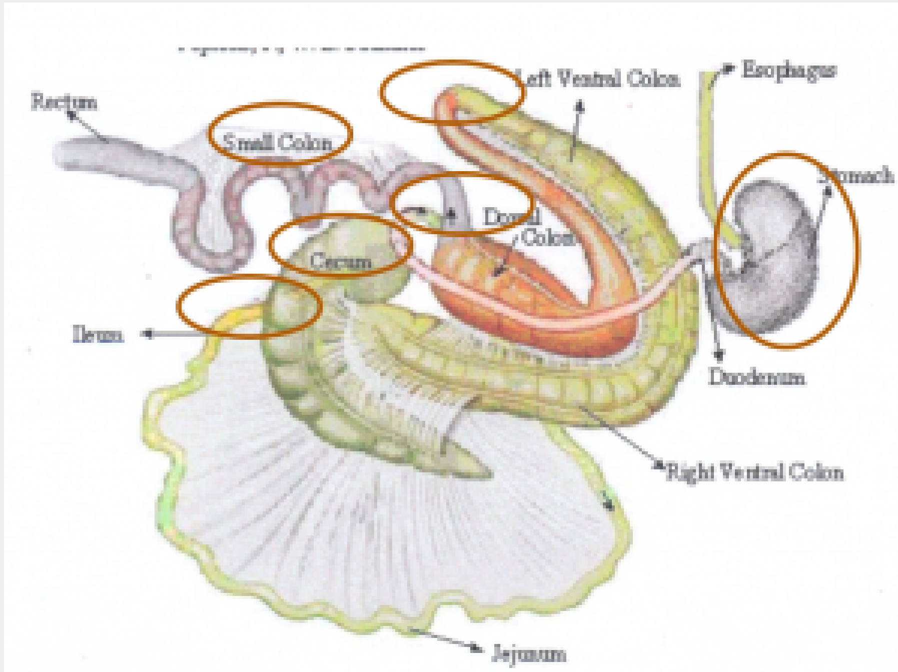
Impaction colics

Impactions may develop for 3 main reasons:

- Foodstuffs are not easily digestible. Ex: Poor mastication due to speedy eating, poor dentition, or poor quality feeds
- The gut isn't able to digest things well due to a change in motility or change in flora activity. Ex: atropine treatment for eye issues, pain or illness, exercise changes, feed changes
- The ingesta doesn't slide well due anatomical and physiological challenges (there are lots of these) or because the ingesta is dry, hard or sticky. Ex: dehydration, enterolith formation

Anatomical and physiological challenges

- Friesians have abnormal gastric motility
- Ileal break reflex slows emptying
- Pelvic flexure creates a hairpin turn with narrowing
- Cecum is blind-ended
- Small colon is narrowed
- Absorption of water from the small colon



Gas colics

Gas or tympanic colics develop when:

- Diet changes result increased gas production by the microbial flora. Ex: diets high in corn (fermentable), sudden feed changes
- Motility changes prevent farting and/or prevent more fermentation due to delayed transit times. Ex: pain, atropine, electrolyte abnormalities (endurance racing, hot weather).

Diagnostics

- Both gas and impaction colics lead to mild to moderate colic signs and decreased manure production. Heart rate is generally only mildly elevated (40-60bpm). Horses can become mildly dehydrated. Horses may look bloated with gas colics. Reflux is not generally seen.
- Differentiating between gas and impaction colics requires rectal palpation and even that may be inconclusive. However, both can be managed similarly so the challenge is only in differentiating field vs referral colics.

Treatment

1. Rehydrate/overhydrate

- Give fluids orally via nasogastric tube and/or iv. Oral is more effective! Generally give 4-8L (or 1 to 2 gal) total to 1000# horse.
- Gastric distension stimulates colonic activity through the gastrocolic reflex
- If you have difficulty passing the nasogastric tube into stomach due to esophageal sphincter tone, add 25-30 ml lidocaine

2. Provide pain relief

- Pain stimulates the flight response and shuts down motility
- NSAIDs such as flunixin meglumine are commonly used (remember – don't give banamine im due to the risk of clostridial myositis)
- Buscopan can be given once to help with intestinal spasms. This helps gas colics more than it helps impaction colics. Note : it will cause an elevated heart rate for 30 minutes!

3. Stimulate motility

- Walk horses to stimulate GI motility
- Grazing may also help (grass, not hay)

4. Prevent worsening

- Remove hay and grain (grazing, grass okay) until the horse poops

5. Consider laxatives –

- Magnesium sulfate (Epsom salts) are the primary laxative used to treat feed impactions. Horses should not be given more then 1g/kg/day (about 1 pound per day in 1000lb horse). This is administered orally via the NG tube in 4-6L of water. CAUTION: Horses with gastric ulcers can become very colicky after administration (as you can imagine, OUCH!) and indicates referral for gastroscopy.
- Dioctyl Sodium Sulfosuccinate (DSS) is a laxative but rarely used in the USA due to the potential of inducing a severe colitis.
- For a feed impaction, mineral oil can be used to help determine transit time but is really ineffective at breaking up the impaction. Mineral oil can help with gas colics.
- If sand : psyllium 0.5 g/kg PO BID or 1g/kg PO SID combined with 2L mineral oil
Psyllium and/or mineral oil can be given in place of oral water via nasogastric tube
Or could give ½ gallon water and ½ gallon oil

6. Monitor response to treatment

- Signs of pain, defection, rectal palpation if indicated and safe

- Most impaction and gas colic will resolve with just one visit. Refer if severe, not manageable, or not responding within 12-24h! That typically means they are in the other 20% of colic types

Resources

- Management of colic in field, 2021 VCNA
- Clinical features, diagnoses, and treatment of 120 cases of large colon impaction, 2014 BMC Vet Res
- Facts and myths about medical treatment of colic, 2017 FAEP
- Medical management of large colon impactions in horses, 2015 EVE
- Sand impactions ppt

Indications for surgery

The decision for surgery can be challenging. It often involves multiple factors and trends over time, in addition to the client goals and willingness. If surgery is indicated and not an option, euthanasia is probably indicated.

1. Persistent pain, even after appropriate analgesics.
2. Rapid physiologic deterioration
3. Persistent reflux + pain
4. Lack of manure and GI sounds despite rehydration
5. Abnormal rectal combined with lack of response to treatment
6. **Serosanguinous** abdominocentesis
7. **Enterolith** identified

Peek inside colic surgery

prep time- colic surgery is generally performed with the horse in dorsal recumbency

Colic exploration –youtube video–

Resources

Exploratory Celiotomy in the Horse Secondary to Acute Colic: A Review of Indications and Success Rates.Topics in Companion Animal Medicine Volume 34, March 2019, Pages 1-9- even has algorithms!

Stabilization of the Colic

Stabilizing and prepping a horse for referral is essential to ensure that the horse arrives safely and as quickly as possible. Horses with a longer distance to the referral hospital (an hour or longer) will require more extensive stabilization prior to traveling.

Fluid Therapy

Assess the horse for signs of dehydration and endotoxic, distributive or **hypovolemic** shock. For mildly dehydrated horses, oral fluids may be sufficient by providing 4-8L water via an NG tube. Remember, horses with reflux or small intestinal lesions should never be administered oral fluids.

IV fluids

- Isotonic crystalloids: Lactated Ringer‘s solution (LRS), 0.9% NaCl, PlasmaLyte, Normosol, etc. Rate of administration: In the dehydrated shocky horse, rapid/bolus administration is required. Ten to 15 L bolus would be appropriate in a horse >5% dehydrated (10–25 mL/kg).
    - % dehydration x BodyWeight (kg)= liters. This is usually more than you think it is!
- Hypertonic crystalloids: These hyperosmolar solutions provide rapid but short-lived plasma volume expansion in the shocky horse. Most clinicians have 7.2% NaCl available to them. The dose is 2 to 4 mL/kg which translates to ~1 to 2 L in an average adult horse.
    - The horses must receive isotonic fluids as follow-up therapy (10L of isotonic fluid for every 1L of hypertonic). This can happen at the referral center.

Analgesics

- Banamine 1.1mg/kg IV Q12h. Banamine should never be administered IM as it can lead to a deadly clostridial myositis.
- Xylazine: 0.2-0.4mg/kg IV or IM PRN. Xylazine has a short duration of action and should never be given alone if you plan to perform a rectal palpation as horses are prone to kicking without warning, and should be combined with butorphanol. Xylazine is a good option to use in mild colics as the horse will likely start to show colic signs again before you leave the farm.

- Detomidine: 0.01–0.02 mg/kg IV or IM PRN. Detomidine has a longer duration of action and horses are less likely to kick without warning.
- Butorphanol: 0.02 mg/kg IV or IM PRN. Butorphanol provides excellent analgesia particularly in combination with α-2 agonists.
- Ketamine 0.22 mg/kg IV or IM. This is a sub-anesthetic dose of ketamine and has been shown to provide short term analgesia in the colic patient. Typically used in combination with an alpha2-agonist.
- For patients with a longer distance to the referral hospital, you can administer detomidine with an opioid both IV and IM to allow for an extended duration of analgesia. You can also administer ketamine in combination with detomidine for more effective analgesia.
- Acepromazine should not be administered to the colic patient. Acepromazine does not possess an analgesic effect. Its alpha1-adrenergic antagonist activity produces vasodilation, which typically decreases arterial blood pressure 15-20 mmHg in normal awake horses. The negative effect is greater when acepromazine administration is combined with hypovolemic or endotoxic shock and/or the cardiovascular depression of inhalant anesthetics.

Nasogastric Intubation

For any horse with small intestinal distention or refluxing, you should transport the horse with the NG tube in place. Keep the tube uncapped and tape it to the halter so that the NG tube curves downward. This prevent gastric contents from getting into the horse's eye or on their skin.

Transportation

Do not tie a colic horse's head in the trailer. If the horse is painful and goes down, this can lead to significant injury to the horse's head and/or neck. Also, advise against owners or trainers against riding in the back of the trailer with the horse. It is illegal and they can get severally injured if the horse goes down and they are trapped between the horse and the trailer walls.

Other supplies

Ensure the clients have appropriate directions and any insurance paperwork, as well as copies of any drugs or therapies administered on the farm prior to shipping.

Key Takeaways

Give sedatives for trailering (detomidine may be necessary)

Give hypertonic saline if the horse is shocky (better than waiting on 20L of LRS etc)

Place and secure a nasogastric tube if any suggestion of SI lesion

Give good directions and alert the referral center about your findings and treatment

Resources

Analgesics in the colicking horse

Surgical Complications and Post-Operative Care

General post-operative colic complications include :

- Postoperative ileus (reflux)
    - Risk Factors: Small intestinal lesions, torsions
    - Prevention: Early referral, minimize tissue handling during surgery, post-operative analgesics and anti-inflammatories such as Banamine and lidocaine CRI. Additional prokinetics such as metoclopramide, erythromycin and neostigmine have been used with variable efficacy across studies. Early feeding is considered beneficial but has to be balanced with trauma to any enterotomy incision.
- Diarrhea
    - Risk Factors: Large colon lesions (volvulus, sand **impactions**, **enteroliths**), small colon lesions, Salmonellosis
    - Prevention: One study showed administration of Biosponge for three days reduced the risk of post-op diarrhea in horses undergoing large colon colic surgeries
- **Endotoxemia** / SIRS
    - Risk Factors: Strangulating lesions
    - These horses can often be very sick after surgery and require intensive care and management
    - Prevention: Early referral, aggressive treatment with antibiotics, polymyxin B and plasma
- Laminitis
    - Risk Factors: Strangulating lesions, endotoxemia, SIRS
    - Prevention: Early referral, antimicrobial therapy, anti-endotoxin drugs (polymyxin-B, plasma), ice boots (variable evidence for the efficacy of ice boots), heparin.
- Adhesions
    - Risk Factors: Being a horse, small intestinal surgeries, resection and anastomosis
    - Prevention: Several techniques have been proposed with variable efficacy including: peritoneal lavage, 1% high molecular sodium carboxymethylcellulose (belly jelly), hyaluronate/SCMC sprays or membranes
- Incisional infections
    - Risk Factors: Clean contaminated surgeries, environmental contamination
    - Prevention: Aseptic surgical techniques, adherence to appropriate antimicrobial therapy pre- and post-op, placement of a stent bandage over the incision during recovery

- Incisional hernias
  - Risk Factors: Incisional infections, repeat laparotomy
  - Prevention: Belly bandage or hernia belt may be beneficial. Restrict “bouncing” for the first 60 days after surgery.
- Continued or recurrent pain
  - Risk factors : ongoing damage, adhesions, ileus
  - Treatment : nasogastric intubation to relieve fluid, treatment for ileus; repeat laparotomy

Post-Operative colic complications

Prognosis:

This is highly dependent on the type of colic, severity of disease, and post-operative complications. Most studies have combined large and small intestinal lesions together when estimating prognosis and survival rates.

For horses allowed to recover from anesthesia, short term survival rate for small intestinal surgeries has been reported to by 68% to 100%.

76%-86% of horses discharged from the hospital returned to training after one year and 65-84% achieved the same or better performance.

Age is not associated with an increased risk of post-operative complications. Horses with concurrent diseases such as PPID may have an increased risk of infection or delayed healing.

Suggested Reading:

Fifty Years of Colic Surgery

Non-complicated Post-Operative Care:

In non-complicated colic surgeries (often large colon displacements or impactions), horses will be maintained on intravenous antibiotics and analgesics for 72 hours. During this time, if there is no signs of post-operative colic or reflux, they will be slowly re-fed and monitored for colic signs.

Average regimen after discharge

- **First 30 days:** Stall rest with hand walking the first 30 days after surgery. Hand walking, 10 minutes per walk, and hand grazing if grass is available, is recommended 3 to 4 times daily.
- **30 to 60 days:** Round pen or small paddock self-exercise is permissible from day 30 to day 60 after surgery if the incision is healing well. If a round pen or small paddock is not available, increase the time hand walking.
  - Malone keeps them stall rested for 60 days. We typically close with Vicryl which loses

strength about day 28. Since the body wall takes 60 days to regain strength, she worries that they will overexercise if turned out.

- **60 to 90 days:** Gradually return to normal activity from day 60 to day 90 after surgery. If postoperative complications occurred, especially in the incision, additional rest is recommended.

Preventing colic

Risk factors

Most preventable risk factors are management related:

- Change in diet is frequently reported as a risk factor- increased risk with change in concentrate or hay, generally within 2 weeks
- Increased risk with feeding concentrates – concentrates > 2.5kg/day or oats >2.7 kg/day, +/- feeding corn
- Increased risk with 1)feeding coastal grass hay, 2) feeding round bale hay, 3) no pasture access or 4) decreased pasture access
- Increased risk if stabled more than 50% of the time
- Increased risk if no or decreased water access
- Increased risk if change in housing or stabling

Horses were at decreased risk of colic if the owner was the sole care giver.

Minimize the risk of colic

Ensure fresh water always available.

- Add water trough heater to prevent water from freezing in winter.
- Increase water consumption by giving electrolytes during periods of weather change.
- Ensure horses have water available with each meal
- Warm the water – they tend to drink more

Feed easily digestible feedstuffs
Pasture > hay > no hay
Good dental care
Make changes gradually
Monitor closely within 2 weeks of any change in management, feeding or illness
Owners take care of horses vs barn managers or trainers
Provide postoperative pain relief
Use atropine only as needed (eg in eye cases)

Bran mashes are often used when horses may be at risk of developing an impaction and/or recovering from one.

Bran is mixed with hot water to create a fiber rich laxative. Mineral oil may be added to the mix. However, these are high in phosphorus and low in calcium so are not recommended as a continual diet!

Hospital cases

Certain hospitalized cases are particularly prone to impaction colic.

Horses hospitalized for orthopedic issues but NOT on NSAIDs are prone to pelvic flexure impactions. This is likely related to changes in exercise, management and diet.

These two groups are prone to cecal impactions which can be very challenging and often life threatening:

- Horses with eye issues being treated with atropine and flunixin meglumine
- Horses hospitalized for orthopedic issues on NSAIDs

These are likely related to the decreases in motility associated with stall rest, pain induced sympathetic tone and atropine treatment. The NSAIDs control the early pain associated with impactions, meaning the conditions can be very advanced before detected.

Cases at risk should be kept well hydrated and monitored closely for adequate manure production.

Resources

Risk factors for acute abdominal pain (colic) in the adult horse: A scoping review of risk factors, and a systematic review of the effect of management-related changes, 2019 PlosOne

Nutritional management of recurrent colic and colonic impactions, 2016 EVE

Differences in gastrointestinal lesions in different horse types, 2017 BMJ Vet Rec

Practice

Level A

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https://open.lib.umn.edu/largeanimalsurgery/?p=1986#h5p-147

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https://open.lib.umn.edu/largeanimalsurgery/?p=1986#h5p-203

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=1986#h5p-205

Try these cases:

- Gulp
- Beans
- LI cases
- Challenge cases

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Level B

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https://open.lib.umn.edu/largeanimalsurgery/?p=1986#h5p-206

Try these cases

- Bridle Party
- On the fence

Equine Colic Types

Gastric lesions

Gastric ulceration – see medicine

Gastric impactions

Gastric **impactions** are associated with non-nutritious feeds, irregular feeding, dental disease, defective gastric secretion, gastric atony, Senecio jacobae, persimmon seeds,mesquite beans, and pyloric stenosis. Friesians are predisposed.

Clinical signs include **bruxism**, anorexia, dysphagia, mild colic, and loss of condition

Treatment options include lavage via nasogastric tube – diet coke can help breakdown the fiber mat; external massage via celiotomy; injection of fluids via large bore needle or stab incision at celiotomy; and gastrotomy.

Gastric rupture can occur secondary to grain overload, gastritis, impaction, nasogastric feeding, feeding lawn clippings, proximal enteritis and gastric endoscopy in foals. It is invariably fatal.

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Small intestinal lesions

Predispositions to disease

The long jejunal mesentery allows movement; this means the jejunum can twist upon self or herniate through other spaces (inguinal rings, mesenteric rents, etc)

Horses can live without approximately 50% of SI; if >50% removed, they often have inadequate digestion of nutrients. Horses with >50% of the SI damaged are usually euthanized at surgery

Small intestinal disorders are characterized by a combination of:

I. C**olic (pain) or depression (illness)**

Pain is observed if there is intestinal distension, mesenteric traction, and/or inflammation.

Depression is seen if the horse has peritonitis, enteritis, and/or dead intestine.

2. **Reflux** (fluid build up in stomach)

If a small intestinal obstruction is present, the horse will reflux eventually. How fast this happens depends on how far downstream the obstruction is and how dehydrated the horse is.

It is possible to have functional obstructions – no physical obstruction exists but ingesta doesn't move downstream due to motility disorders. These will also reflux.

Rare large intestine disorders can lead to reflux.

3. **Hypovolemic and/ or endotoxic shock**

Signs include tachycardia, weak pulses and prolonged CRT. Severe tachycardia is usually due to shock and the need to move the blood back to the heart as fast as possible vs due to pain.

Horses are very sensitive to low levels of endotoxin! When toxic, they can also develop toxic (darker) lines around the teeth or purplish mucous membranes.

4. **Significant electrolyte abnormalities**

These are due to secretory and absorption function of the small intestine.

Secretions are usually increased if an obstruction is present– the body tries to hydrate it and break it down. These secretions carry high levels of electrolytes. If the secretions can't move downstream, they can't be reabsorbed.

Re-absorption can be hampered if the intestinal wall is swollen or contains inflammatory cells. These changes increase the distance to the capillaries and lymphatics, interfering with absorption of nutrients.

5. Minimal abdominal distension or bloat (unless foals)

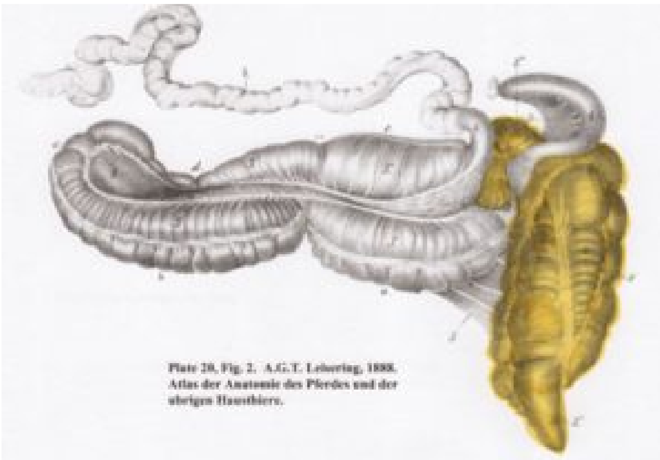
The small intestine is covered by the rib cage so small intestinal distension is usually not noticeable externally

6. **Abnormal small intestine on ultrasound** (thickened wall, distension)

Small intestine is generally not visible ultrasonographically in healthy, fed horses. You can see small intestine in horses that are off feed but it should be flaccid in the inguinal area. Distended small intestine on ultrasound is never normal.

7. **Distended small intestine on rectal palpation**

Cecal lesions



Predispositions to disease

The cecum is a blind ended sack with a single entry and exit portal. As it is a branch off of the rest of the intestines, motility disorders can lead to impactions.

Tapeworms live at the ileocecal junction and can cause motility issues and intussusceptions.

Cecal disorders are characterized by :

1. **Low grade pain**

Distension can take awhile

2. **Difficult diagnoses**

Gas distension is palpable rectally with tight vertical bands but may resemble other forms of gas colic. It will usually respond well to pain relief, antispasmodic agents, mineral oil and exercise.

Impactions will cause the cecum to sink and to be less palpable. Impactions are generally not identifiable until advanced.

Cecal impactions develop most commonly in horses that are hospitalized and on NSAID therapy. Due to chronic pain, horses with orthopedic issues or eye lesions are predisposed. The presence of NSAIDs means early signs of colic may be missed.

Due to the increased risk of rupture with cecal impactions, these horses should be referred.

3. Minimal response to laxatives

Most substances bypass the cecal contents and move from the ileum, straight thru the cecum into the colon. Surgery is often necessary to empty the cecum.

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Cecal tympany is difficult to differentiate from large colon tympany (check for a ping on the right) but should also respond to the same therapy.

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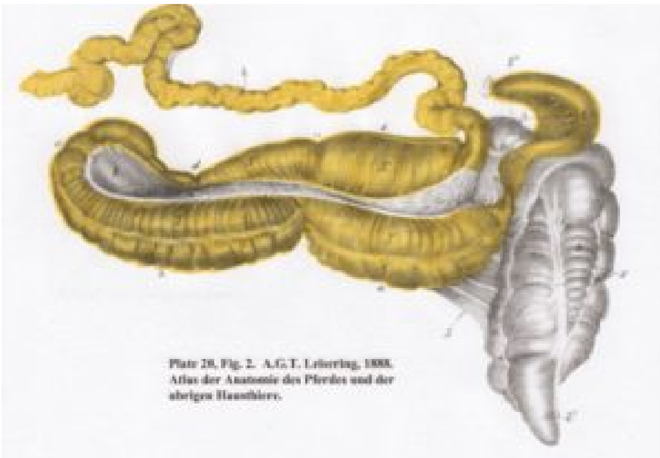
Large colon lesions



Predispositions to disease

Minimal fixation allows movement – colonic torsions and displacements are common

Gas production during microbial digestion may cause colic (gas distension; displacement)

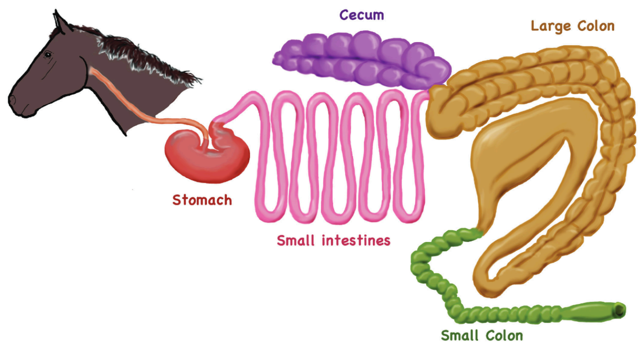
Hairpin turns and changes in diameter create sites prone to impaction

Large intestinal disorders are characterized by:

1. **Gas distension** : microbes keep producing it even if physical obstruction
2. **Mild-severe colic** : depends upon amount of gas distension
3. **Bloat** : can see rib cage and flank distension
4. **Decreased fecal production**

Two types of large colon disorders can reflux: nephrosplenic entrapments and small colon impactions. We believe the colon lesions are pinching the duodenum shut, creating a secondary SI obstruction.

Small colon lesions



Predispositions to disease

-smaller diameter than colon = site of obstruction of stones and fecoliths

-mesentery (and vascular supply) can tear off with extensive rectal prolapse ; this means the bowel dies

Small colon disorders characterized by :

1. **mild signs of pain –** usually simple obstruction; younger horses can seem pretty painful
2. **slow deterioration** in condition

Even with vascular compromise, initial transient signs of severe abdominal pain -> depression and less severe pain

3. associated with greater risk of Salmonellosis

Arabs, minis, and ponies are predisposed to small colon lesions (better able to maintain hydration by removing water from ingesta?)

Poor area for healing

- high mural collagenase
- poor blood supply
- high bacterial counts
- firm formed manure passes by

Impaction pathophysiology

Common sites of impaction (intestinal blockage due to feed material) include the pelvic flexure, the ileum, the cecum, the small colon and the stomach. Ascarid impactions are typically in the jejunum.

Gastric impactions

Gastric impactions in horses, a review. The Horse, 2011

> She added that the condition is caused by a variety of factors including the consumption of certain feeds that swell after ingestion, dental problems that diminish the horse's ability to chew feed properly, inadequate water supply, excessively rapid eating, and pathophysiological disturbances (changes in the horse's normal mechanical, physical, and biochemical functions).

Ascarid impactions

Ascarid impactions can occur after deworming when the dead and dying worms create an obstruction.

Signalment	• 4-24mo old
Clinical signs	• Unthrifty • Mild-moderate colic • Reflux
Diagnosis	• Worms in reflux • Ultrasound- worms may be visible • Signs of intestinal blockage
Complications	• Peritonitis • Adhesions • Intestinal rupture
Treatment	• Surgery with enterotomy
Risk factors	• Deworming with an effective agent in an infected foal (large die off)
Prognosis	• Poor
Prevention	• Deworm with less effective product first (strongid, 1/2 dose fenbendazole • Treat with mineral oil at time of deworming

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Ileal impactions and ileal hypertrophy

Ileal impactions occur most often with Bermuda grass hay and parasite issues.

Signalment	• Arabs, mares for ileal impactions • >5 yo for ileal hypertrophy
Clinical signs	Ileal impaction • worsening colic • reflux Ileal hypertrophy • recurrent colic • partial anorexia • weight loss
Diagnosis	• Rectal: SI distension, early on – doughy tubular mass • Transrectal ultrasound: SI distension • Differentials: strangulating lesions, PDJ
Complications	• Gastric rupture • **Hypovolemic shock**
Treatment	• Iv fluids with analgesics • Intraoperative massage, lubrication
Risk factors	• SE USA • feeding low quality Bermuda grass hay • Sept-Nov • tapeworms
Prognosis	• Good. Reimpaction is rare
Prevention	• Avoid Bermuda grass hay • Deworm for tapeworms

video

Resources

Pelvic flexure impactions

Large colon impactions (intestinal blockage by food material) are very common and generally occur at the pelvic flexure due to the narrowed turn

Signalment	• All ages and breeds. Show horses?
Clinical signs	• Mild colic, slow onset • Decreased manure production • Small dry feces +/- mucus covered
Diagnosis	• History, response to therapy • Rectal palpation – doughy mass near pelvis • Differentials – gas colic, colon displacement
Complications	• Eventually the impaction can damage the local blood supply. This leads to necrosis and bowel rupture
Treatment	• See field colics. • Improve motility, control pain, soften the impaction, prevent worsening • Surgery if not responsive
Risk factors	• Sudden feed changes, management changes, exercise changes • Motility disorders, other illness, atropine or anesthesia • Following surgery and not on analgesics • Inadequate mastication • Poor dentition • Poor feed quality • Reduced water intake

Prognosis	• Good
Prevention	• Minimize management and feed changes • Ensure good water intake • Feed off the ground to minimize sand intake • Good dental care • Parasite control • Owner involved in animal care

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Cecal impactions

Signalment	• Especially Arabs, Appaloosas and Morgans • Especially >15 yo
Clinical signs	• Mild colic, slow onset • Decreased manure production- may be the only sign due to the NSAIDs masking pain • Anorexia, depression
Diagnosis	• Rectal palpation – doughy mass to right of midline
Complications	• Cecal rupture, recurrence if treated
Treatment	• Challenging – laxatives bypass the cecum. Surgery may be required.
Risk factors	• Eye conditions being treated with atropine • Hospitalized horses treated with NSAIDs • Sandy environment • Tapeworms
Prognosis	• Grave
Prevention	• Monitor animals on atropine and hospitalized animals closely

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Enterolithiasis

Signalment	• Especially 5-15 yo • Arabs, Morgans, Saddlebreds, donkeys, miniature horses • Mares
Clinical signs	• Intermittent mild colic • Pain after exercise • Can -> acute severe pain
Diagnosis	• Rectal palpation on a hill (so transverse colon floats back) • Radiographs • Differentials – gas colics, impactions
Complications	• Intestinal rupture • Diarrhea, fever postop
Treatment	• Surgery
Risk factors	• Another horse on the property has enteroliths • Life in California, Indiana, Florida • Water with high levels of Mg • Eating alfalfa • Limited pasture access • Confinement >50% of the day
Prognosis	• Good – may recur
Prevention	• Feed grass hay • Feed 1 c vinegar per day • Avoid bran mashes

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youtube video

Sand impactions

Signalment	• All ages and breeds
Clinical signs	• Mild colic, slow onset • Intermittent diarrhea • Weight loss
Diagnosis	• Sand test – put feces in a plastic bag or rectal sleeve and let stand – does sand settle out • Auscultate ventral abdomen for “ocean” sounds • Radiographs
Complications	• Mucosal erosion • Secondary large colon torsion
Treatment	• Psyllium + mineral oil • Psyllium + magnesium sulfate • Surgery
Risk factors	• High sand content in soil • Eating off the ground or short/nonexistent pastures • Insufficient roughage
Prognosis	• Fair to good
Prevention	• Food off ground or use mats to catch grain • Long term psyllium is likely ineffective • Ensure eating sufficient fiber

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Small colon impactions

Signalment	• Arabs, minis, and ponies predisposed to small colon lesions (better able to maintain hydration by removing water from ingesta?) • Broodmares in the third trimester • >15 yo
Clinical signs	• Mild colic, slow onset -> significant pain • Decreased manure production • May reflux (compression of duodenum?) • Fever (if Salmonellosis) • Anorexia
Diagnosis	• Rectal palpation – doughy tube instead of fecal balls
Complications	• Colon rupture due to mural necrosis • Associated with greater risk of Salmonellosis and diarrhea
Treatment	• Oral and iv fluids • Enemas and laxatives • Surgical decompression (enema)
Risk factors	• Dehydration and other factors as for colon impactions • Parasites
Prognosis	• Good
Prevention	• As for colon impactions- ensure good water intake, good forage, good dental care

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Meconium impactions

Signalment	• foals, especially males?
Clinical signs	• mild colic within 24 hours of birth • becomes more severe with accompanying tympany
Diagnosis	• Digital rectal • Radiology +barium enema • Differentials – congenital lesions, ruptured bladder
Complications	• Patent urachus • FPT
Treatment	• Enemas • Analgesics • Oral laxatives
Risk factors	• Delayed colostrum
Prognosis	• Good
Prevention	• Early colostrum

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Perirectal abscesses can lead to obstipation due to pain

Displacement pathophysiology

The microbes in the colon produce gas and create a balloon-like response. Since the colon is not adhered to the body, it is free to float up and down. Sometimes it floats out of position. Many simple displacements will self correct.

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Nephrosplenic entrapment (left dorsal displacement)

Signalment	• Deep chested breeds
Clinical signs	• Mild to severe colic, depending upon the amount of distension; slowly progressive • Good response to analgesics • Reflux is relatively common due to compression of the duodenum
Diagnosis	• Rectal palpation – colon identified in the nephrosplenic space; spleen deviated axially • Ultrasound – kidney not visible on left • GGT increased • Differentials – gas colic, impactions, other displacements
Complications	• Secondary impaction and gas buildup • Secondary colon torsion • Colon rupture
Treatment	• Treat as for gas colic – withhold feed 48-72 hours; may self correct if not stuck • Phenylephrine to shrink spleen (2-8mg, up to 20 mg Neosynephrine (two 10mg ampules, dilute to 60 ml); jog to loosen ◦ NOT in horses over 15 yo – risk of large vessel rupture and fatal hemorrhage • Roll under GA (lots of work) • Surgery
Risk factors	• Diet change, other as with gas colic
Prognosis	• Good; may recur
Prevention	• Laparoscopic obliteration of the nephrosplenic space • Colopexy

Since this type of colic can be treated in the field, it is useful to be able to identify it.

Nephrosplenic entrapment, J Jewell, NEEMSC

Right dorsal displacement

If the colon displaces to the right, it may not get stuck. Some of these will fix themselves and others will need surgery. Trocarization may help if the colon has a ping and if surgery isn't an option as there is a risk of peritonitis.

Signalment	• Deep chested breeds
Clinical signs	• Mild to severe colic, depending upon the amount of distension; slowly progressive • Good response to analgesics
Diagnosis	• Rectal palpation – gas distended colon which lies horizontally in front of the pelvic canal with a tight horizontal band. Unable to palpate the pelvic flexure. • Right flank distension • GGT increased • Differentials – gas colic, impactions, other displacements
Complications	• Secondary impaction and gas buildup • Secondary colon torsion • Colon rupture
Treatment	• Treat as for gas colic – withhold feed 48-72 hours; may self correct if not stuck • Fluids and antispasmodics • Surgery
Risk factors	• Diet change, other as with gas colic
Prognosis	• Good; may recur
Prevention	• Colopexy or colon removal

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The use of phenylephrine in the treatment of nephrosplenic entrapment of the large colon in horses, Equine vet. Educ. (2020) 32 (11) 568-570

Lindegaard et al: Nephrosplenic entrapment of the large colon in 142 horses. EVJ 43(Suppl 39):63-68, 2011

Torsions and entrapments (hernias)

Both the small and large intestines can twist. The large colon tends to twist more often, likely related to changes in gas levels and motility. Intestines can also slide through small holes (hernias, mesenteric rents). Often they can't slide back out (particularly in small holes) and become distended and swollen, leading to even more severe entrapments and devitalization.

Large colon volvulus

Signalment	• Deep chested breeds • Broodmares, especially late gestation and postpartum
Clinical signs	• Rapidly increasing severe pain • Abdominal distension (bloat) • Shock • Occasionally bradycardia (vagal tone?) • Toxic signs
Diagnosis	• Rectal palpation – severe gas distension • Ultrasound -thickened colon wall >9mm and edema around vessels • Differential- uterine artery rupture
Complications	• Endotoxemia • Hypoproteinemia • Diarrhea (mucosa sloughs) • Salmonellosis • DIC • laminitis • fatal hemorrhage
Treatment	• Surgery • To stabilize -give hypertonic saline; trocarize if needed to decompress; wean foal
Risk factors	• Changes in space (parturition)
Prognosis	• Fair to grave, depending upon amount of damage • Can recur- up to 15% in broodmares; 80% if had two episodes
Prevention	• Don’t let the mare carry another pregnancy (can do embryo flush) • Colon removal or colopexy

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These horses do require surgery and intense medical therapy. The colon may be viable enough to just be untwisted and left in the horse. Much of the colon can be removed if needed. This isn't always possible due to the location of the twist.

Small intestinal volvulus

Signalment	• especially 2-4mo; < 3 years
Clinical signs	• Moderate to severe colic • Depression in foals
Diagnosis	• Distended SI on rectal exam or ultrasound • Marked abdominal distension in foals • Abdominocentesis
Complications	• Peritonitis • Adhesions • Intestinal rupture • **Hypovolemic shock**
Treatment	• Surgery
Risk factors	• Inguinal hernia • Mesodiverticular band • Meckel's diverticulum • Mesenteric rents • Fixation by umbilical remnants
Prognosis	• Fair; foal are more prone to adhesions
Prevention	• none

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Up to 50% of the small intestine can removed if needed due to damage. These horses are more prone to postoperative ileus and adhesions.

Hernias

Inguinal hernias

Signalment	• foals, stallions; especially Standardbreds, Tennessee Walking Horses and Saddlebreds
Clinical signs	• foals – no pain; scrotal swelling with palpable loops SI • stallions – colic; enlarged scrotal neck, testicle cold and firm
Diagnosis	• Scrotal changes • Ultrasound of scrotum • Rectal examination of inguinal rings
Complications	• rare in foals; resolves on own 3-6mo • older foals: secondary volvulus • stallions – intestinal strangulation, testicular damage, adhesions
Treatment	• foals – daily reduction and monitoring • stallions – generally need surgery with unilateral castration to close ring
Risk factors	• breeds • breeding
Prognosis	• Fair to good
Prevention	• none

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Epiploic foramen entrapments

Related to cribbing. Often have a normal belly tap despite dead bowel.

Inflammation related colics

Erosions and ulcerations can lead to significant pain. NSAIDs are a common cause of GI ulceration in horses.

Duodenal ulcers

Duodenal ulceration is identified in foals and in adults.

Signalment	• foals, yearlings
Clinical signs	• fever • mild-moderate **colic** • mild obtundation • diarrhea
Diagnosis	• duodenoscopy • contrast radiographs
Complications	• Secondary gastric ulcers and reflux esophagitis • duodenal perforation • duodenal stricture and SI obstruction • ascending cholangitis, hepatitis, pancreatitis • death
Treatment	• Supportive care – aggressive medical management • parenteral nutrition • may need surgical bypass
Risk factors	• illness
Prognosis	• Guarded
Prevention	• quick attention to sick foals

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Right dorsal colitis

Right dorsal colitis can cause severe pain and is often associated with performance horses on NSAIDs.

Signalment	• performance horses
Clinical signs	• acute severe or recurrent pain • depression • weight loss • diarrhea • fever • hypoproteinemia, hypoalbuminemia, hypocalcemia, anemia • ventral edema, limb edema
Diagnosis	• ultrasound • fecal occult blood • surgery
Complications	• other forms of NSAID toxicity
Treatment	• discontinue NSAIDs • supportive care – fluids, colloids • consider misoprostol, sucralfate • surgery – colon resection • dietary adjustments
Risk factors	• NSAID use
Prognosis	• Guarded
Prevention	• avoid NSAID overuse

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Inflammatory bowel disease

Inflammatory bowel disease can lead to weight loss and multiple conditions related to poor nutrition.

Signalment	• ?
Clinical signs	• Progressive weight loss • Poor appetite • Diarrhea • Dermatitis • Peripheral edema • Anemia, hypoproteinemia
Diagnosis	• intestinal biopsy • rectal mucosal biopsy • glucose or d-xylose absorption tests • ultrasound – intestinal thickening • gluten-dependent antibodies?
Complications	• often fatal
Treatment	• aggressive treatment often unsuccessful • highly digestible well balanced feeds • dexamethasone • avoid dietary antigens • metronidazole • hydroxyurea • surgical removal if focal
Risk factors	• ?
Prognosis	• Good
Prevention	• none

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Proliferative enteropathy

Proliferative enteropathy generally affects juveniles and is a growing concern.

Signalment	• 2-13 mo, especially 4-7mo; more often Aug-Jan
Clinical signs	• Severe hypoproteinemia • Chronic weight loss • Intermittent colic • Diarrhea • Lethargy • Stunted growth • Ventral edema • Occasional fever
Diagnosis	• Ultrasound – thickened SI • Profound hypoproteinemia (TPP <3 g/dl; albumin <1.5g/dl) • Fecal PCR or rectal swab PCR (may not always be shedding) • Serology – exposure • Detection of bacteria in crypt epithelial cells • Differentials : renal disease, colitis, parasites, Salmonella, Clostridial infection
Complications	• Secondary to hypoproteinemia
Treatment	• Supportive care – plasma, prednisone • Antibiotics- oxytetracycline iv, doxycycline or minocycline po; treat 2-4 weeks
Risk factors	• FPT • overcrowding • weaning • transportation • other illness
Prognosis	• Good

Prevention	• Avoid overcrowding • Avoid contamination of feed and water (fecal-oral transmission) • Separate sick animals • Ensure good colostral intake • Minimize stress to youngstock • Monitor farm for outbreaks • Off label use of swine vaccine?

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Infarctions and intussusceptions

Infarctions

Infarctions are the rarest form of colic but are often life threatening as the damage may be multifocal, severe and/or not resectable.

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Intussusceptions

Intussusceptions typically occur with motility disorders (diarrhea, parasites) and with changes in the intestinal wall (neoplasia or granulomas). Brown Swiss are predisposed to intussusceptions.

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Motility disorders

Hormonal (stress, pregnancy), drugs (most sedatives) and electrolyte changes can alter motility, leading to colic.

Postoperative ileus and exertional ileus

Signalment	• recent abdominal surgery or intense exercise
Clinical signs	• colic • tachycardia • shock • reflux
Diagnosis	• reflux • distended SI • lack of manure
Complications	• gastric rupture • **hypovolemic shock**
Treatment	• nasogastric intubation • motility stimulants • iv fluids • time • lower body temp if overheated
Risk factors	• surgery • endurance racing • performance in hot, humid weather
Prognosis	• Guarded for POI; treatment can be prolonged and expensive • good for exertional ileus
Prevention	• lidocaine iv for POI • proper conditioning, avoid overheating for exertional ileus

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Proximal duodenitis jejunitis

Inflammation can also lead to ileus. Proximal enteritis is a syndrome characterized by inflammation and edema in the proximal SI, leading to excessive fluid and electrolyte secretion. Both Salmonella and Clostridium have been implicated in proximal enteritis.

Signalment	• >1.5 years
Clinical signs	• Moderate to severe colic • Large amount of reflux, often orange brown with fetid odor • Fever • Dehydration • Injected mucous membranes • Shock • Tachypnea • Depression (less painful)

Diagnosis	• Rectal palpation – moderate SI distension
	• Differentials -other causes of ileus, strangulating lipoma
	    ◦ Compared to a physical obstruction, PDJ is more likely to be associated with fever, leukocytosis, less pain, more depression
	    ◦ Abdominocentesis tends to have a mild increase in WBCs and protein; it should not be serosanguinous

Complications	• Laminitis • Adhesions • Gastric rupture • Myocarditis • Hypovolemic shock • Death
Treatment	• Refer for medical management (supportive care, motility stimulants) or surgical decompression
Risk factors	• Weakly associated with high grain diets
Prognosis	• Guarded; treatment can be prolonged and expensive
Prevention	• None known

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Age group and colics

Neonates

Foals are commonly affected by meconium impactions. These typically respond quickly to enemas. Lethal white foals, on the other hand, have defects in the myenteric ganglion and are not treatable. Other congenital anomalies tend to be found in neonates.

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Juveniles

Young horses are more prone to

- ascarid impactions
- SI volvulus
- intussusception
- proliferative enteropathy
- foreign bodies
- duodenal ulceration
- cecal tympany
- herniation

Differentials include enteritis and uroperitoneum

Seniors

Horses over 15 yo are more prone to

- Strangulating lipomas
- Neoplasia

- Cecal impactions
- Small colon impactions

Colic by breed, sex and job

Breeds

Friesians are prone to gastric **impactions** and megaesophagus

Saddlebreds, Tennessee walking horses, Morgans and Standardbreds are prone to inguinal hernias

Miniature horses and ponies are prone to small colon impactions, fecoliths and enteroliths

Easy keepers (Quarterhorses, Arabs, Saddlebreds are prone to strangulating lipomas

Deep chested breeds (Warmbloods) are prone to colon displacements and torsions

Thoroughbreds and ponies are prone to intussusceptions

Thoroughbreds and taller horses are prone to epiploic foramen entrapments

Arabs, Appaloosas and Morgans are prone to cecal impactions

Arabs are prone to ileal impactions (and to **colic** in general)

Arabs, Saddlebreds, Morgans, donkeys and miniature horses are prone to **enteroliths**

Paints are associated with the gene for myenteric aganglionosis (lethal whites)

Sex

Stallions are prone to inguinal hernias, particularly with live covers.

Other types of colic have been associated with sex (male, female, gelding) as well

Job and location

Broodmares are prone to large colon volvuluses, cecal tympany, small colon impactions and mesocolon tears. Differentials include uterine torsions, uterine tear, uterine artery rupture and impending parturition.

Performance horses may be more prone to right dorsal colitis and gastric ulcers

Horses in California, Indiana and Florida or more prone to enteroliths

Horses in the SE are more prone to proximal enteritis and ileal impactions

Behavior

Horses that crib are prone to epiploic foramen entrapments

Practice

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FA GI Topics

Hardware disease, bloat, DA surgery and more

Ruminant Anatomy and Physiology review

Introduction

Ruminants and camelids are 2:20-6:06 – anatomy

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More about digestion

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Digestion in ruminants

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How does a rumen work?

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Mammalian digestive tracts slide show

Digestive physiology of herbivores – one of my favorite physiology websites

Bovine GI Surgical Disorders

Cattle get a few GI disorders relatively often and the rest are rare. The common disorders include:

- abomasal displacement
    - The abomasum should be just to right of midline on the ventral abdomen. However, it does have microbes and can fill up with gas. When it does, it can float out of position. It typically floats up to the left in postpartum dairy cattle. It can float to the right.
- abomasal volvulus
    - When the abomasum floats to the right, it has more freedom of movement and can also twist, creating an abomasal volvulus
- abomasal ulcers
    - Ulcers are not a surgical lesion but often accompany abomasal displacements and can make things trickier.
- hardware disease
    - Officially known as traumatic reticuloperitonitis, something sharp pokes out of the reticulum, leaking reticulum juice and creating an abscess and adhesions. Since cattle are not discriminate eaters, this happens relatively often
- cecal dilatation/torsion
    - This one isn't as common but is common enough to be an important differential. Generally this occurs due to poor motility. The cecum becomes gas distended. It can twist but that isn't common
- bloat
    - bloat can be either free gas or frothy bloat
    - free gas bloat occurs when the animal can't eructate (obstruction, nerve issues)
    - frothy bloat are adjusting to a dietary change (growing calves)
- intestinal obstruction
    - this one is fairly generic and includes hemorrhagic bowel syndrome, adhesions, tumors, torsions and other intestinal accidents. Atresias are also found in all parts of the intestinal tract with the colon being the most common. Intestinal surgery is challenging to perform in the field.
- peritonitis/peritoneal abscesses
    - cattle wall things off well. Because of this, they can live through bowel leaks that would kill most other animals

Many of these (LDAs, abomasal ulcers, cecal dilation, hardware disease) occur in the postpartum cow and more than one can be present in the same animal.

Because gas is involved in many of these, "pings" are often useful diagnostic aids. Ultrasound is also useful to identify abscesses and peritonitis.

Most GI surgeries are performed in the standing animal but there are options to perform surgery in the recumbent cow without general anesthesia. Because of the rumen, exploration from underneath or from the left is difficult. The abomasum is best accessed ventrally but the best exploration access is from the right. This means it is important to decide on the likely issue and the optimum surgery approach (right side, left side, from underneath).

Forestomach disorders and surgery

Impactions

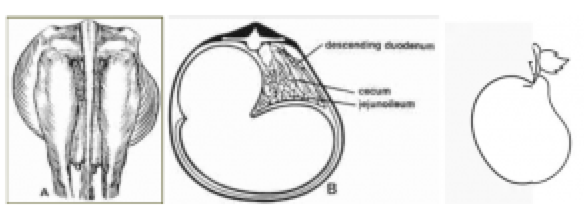
Bovine forestomach disorders include free gas bloat, frothy bloat, hardware disease, rumenitis/rumen acidosis, vagal indigestion, foreign bodies, grain overload/toxin ingestion, and omasal impaction. Surgery can be useful for bloat, hardware disease, foreign bodies, and grain overload/toxin ingestion. In cases of vagal indigestion, surgery can be useful to verify that there is nothing treatable (leading to euthanasia or culling).

Bloat

Free gas bloat occurs when eructation is prevented. This can occur with high levels of gas production, esophageal obstruction or motility dysfunction. Extra gas accumulates due to more gas production with a change in diet, excessive fermentable feedstuffs or lack of eructation. A stomach tube can be placed into the rumen via the esophagus or red rumen trocar can be inserted into the rumen via a skin incision in the flank. The trocar will lead to rumen fluid leakage and some level of peritonitis.

Frothy bloat most commonly occurs due to ingestion of legumes (alfalfa, beans). Stomach tubing will not relieve a frothy bloat. The animal should be treated with a product designed to destabilize the froth (eg poloxalene).

Bloat is diagnosed by an “apple” appearance on the left side and a “pear” appearance on the right due to the distension of both the dorsal and ventral sacs of the rumen.



A ping will be present on the left, including with percussion on the transverse processes of the vertebrae. The distension can be palpated per rectum. Cattle may show signs of dyspnea due to pressure on the diaphragm. Death may occur if the bloat is not treated.

Differentials include esophageal obstruction or other cause of poor eructation.

Calves often develop recurrent bloat as they adjust to a more adult diet. It can take awhile for the rumen flora to adjust. A rumenostomy can be performed to allow gas to escape as needed until the problem resolves. These will close over eventually.

Grain overload/toxins

Rumenotomy can also be useful to remove the grain or toxins if the ingestion is identified early enough. As most of the ingest needs to be removed in these cases, transfaunation (providing rumen juice from a healthy cow) is recommended.

Omasal impactions

Omasal impactions rarely need direct treatment and are usually secondary to another issue. Treat the inciting cause and rehydrate the animal.

Rumenotomies and rumenostomies

'Otomy' refers to a temporary hole while an 'ostomy' is a permanent opening. In cattle, most all holes eventually close, so an 'ostomy' is open for awhile but not usually permanently. ["ectomy" refers to cutting something off]

Rumenotomy is indicated for vagal indigestion, **hardware disease**, rumen acidosis and some forms of choke. Rumenotomy allows exploration of the rumen, reticulum and parts of the omasum.

Rumenostomy is performed in growing calves with chronic bloat and in any age ruminant to provide nutritional support. Rumenostomies can be performed instead of rumen trocarization for improved results. Rumenostomies are also performed for feed trials to enable direct feeding and/or sampling. Finally, a rumenostomy can be placed in an adult cow to provide easy access to microflora (rumen donor). Rumenostomies typically have smaller openings designed to close over time (calves) or are kept open with a rumen cannula sized to fit the cow and the need (feeding, fauna donor).

Microbial production of gas (physiology review)

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Hardware disease

Cows eat all sorts of stuff. Any foreign bodies usually end up in the reticulum. This includes nails, wire, ropes, etc. The sharp objects can be pushed through the reticular wall, creating a hole in the reticulum that leaks ingesta. The reticulum and heart are separated only by the diaphragm. A nail or similar object will often puncture the diaphragm and sometimes the pericardial sac. Cows with **hardware disease** may have peritonitis, abscesses from consolidated peritonitis, pleuritis, and/or pericarditis.

Signalment

Traumatic reticuloperitonitis secondary to hardware is more common in the postpartum period, often related to the straining of parturition. As the cow strains, the metal is pushed out of the reticulum.

Clinical Signs

- Anorexia
- Fever (although they can also be normothermic)
- Dramatic decrease in milk production
- Signs of abdominal pain: **bruxism**, grunting, hunched stance with abducted elbows

Clinical presentation

- Distended rumen
- Lifts up when pressure is applied at the xyphoid using a board or the hand pressure test
- Does not scootch with withers pinch

Diagnosis

Clinical and laboratory findings in 503 cattle with traumatic reticuloperitonitis
Ueli Braun1* , Sonja Warislohner1, Paul Torgerson2, Karl Nuss1 and Christian Gerspach1**Background**: The

study evaluated the results of clinical examination and haematological and serum biochemical analyses in 503 cattle with traumatic reticuloperitonitis (TRP).
Results: The most common clinical findings were abnormal demeanour and general condition (87%), decreased rumen motility (72%), poorly digested faeces (57%), decreased rumen fill (49%), fever (43%) and tachycardia (26%). In 58% of the cattle, at least one of three tests for reticular foreign bodies (pinching of the withers, pressure on the xiphoid and percussion of the abdominal wall) was positive, and in 42% all three tests were negative. The most common haematological findings were decreased haematocrit in 45% of cattle and leukocytosis in 42%. An increase in the concentration of fibrinogen in 69% of cattle and total protein in 64% were the main biochemical findings. The glutaraldehyde test time was decreased with coagulation occurring within 6 min in 75% of cattle.
Conclusions: In many cases, a diagnosis of TRP is not possible based on individual clinical or laboratory findings because even the most common abnormalities are not seen in all cattle with TRP.

Confirmation is more easily performed with ultrasonography rather than radiographs. Diagnosis on ultrasound is based on signs of peritonitis/pleuritis, abscess formation or other related changes. Sometimes the foreign object can be seen but it depends on how much gas is around it.

Ruptured abomasal ulcers and liver abscesses can present similarly.

Exploratory surgery is often used as a diagnostic test. The reticulum can be palpated from either the right or left side. A right flank exploratory is best if you don't know the cause of the cow's issues. If hardware disease is high on the list, a left flank approach provides an option for treatment as well as diagnosis.

Prognosis is guarded due to the challenges in effective treatment. Prognosis is grave if the object has penetrated the diaphragm.

Treatment

- Conservative – treat medically with antibiotics and rest; allow the infection to wall off. Add a magnet if she doesn't have one to stabilize the wire. However, in some cases, the magnet may not move into the reticulum. Transfaunate.
- Surgery – Rumenotomy to remove the object and/or drain the abscess. It is important to not make things worse. Start with an exploratory, leaving the reticular area to last. Do not explore after contamination is encountered or rumenotomy performed. Tacking the rumen up or using a rumen board or shroud is needed to minimize the risk of peritonitis from leaking rumen contents. Abscesses must be cranial to be worth draining (an ventral abscess won't drain up into the rumen; drainage of an abscess on the medial aspect risks damaging the vagal nerve.) Ensure one magnet and transfaunate.
    - See How to – Rumenotomy
- Cull – not a bad idea for some cows

Prevention

As much foreign material should be kept out of feed troughs as possible. Cows may be pretreated with a magnet to catch metallic objects as they move into the reticulum.

Videos

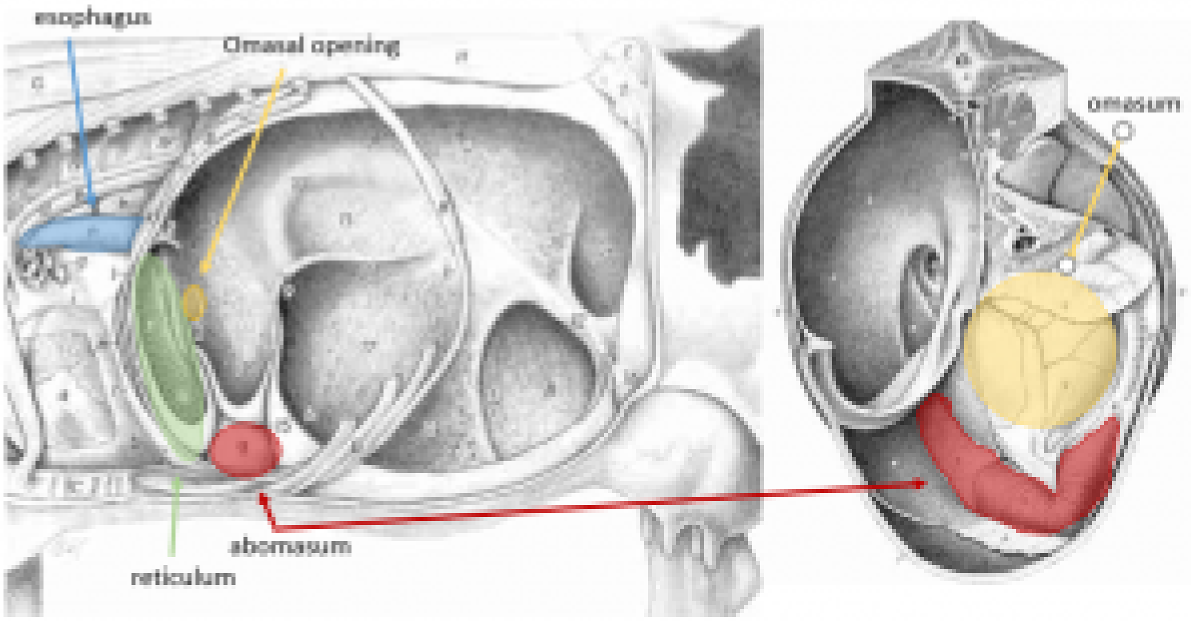
Youtube video

Indications

Rumenotomy is indicated for vagal indigestion, **hardware disease**, rumen acidosis and some forms of choke. Rumenotomy allows exploration of the rumen, reticulum and parts of the omasum.

Relevant anatomy

The rumen is a large fermentation vat. The layers should be gas (dorsal), recent fiber, older fiber and fluid (ventral). The reticulum is sac off the dorsal aspect. The esophagus empties into the rumen from the dorsal cranial wall while the reticulum empties into the omasum on the medial wall just above the pillar separating the rumen and reticulum. The omasum and abomasum are often palpable through the rumen wall.



Preoperative management

Food restrictions: If possible the cow should be held off feed for 24 hours prior to rumenotomy.

NSAIDs/analgesics: Recommended preoperatively. Flunixin meglumine 1.1-2.2 mg/kg iv is standard.

Antibiotics:Recommended. If milking, ceftiofur 2.2 mg/kg im is standard. In beef or non-lactating cattle, other options do exist. Pencillin is often effective; however, remember that the label dose of procaine penicillin is ineffective!

Other: If possible, plan on rumen transfaunation.

Local blocks: A line block, inverted L or paravertebral are all reasonable options.

Position/preparation: See How to- Standing GI Surgery

Surgery Supplies- Additional

- Extra sleeves and gloves
- Additional laceration or surgery pack is ideal
- Sterile saline for lavage
- Rumen board – optional
- Wound drape – optional
- 2 suture on a cutting needle for securing rumen
- 2-0 or 0 absorbable suture for closing rumenotomy
- Wet-dry vac -optional

Surgery Supplies – Standard

- Standard surgery pack
- Sterile sleeves for internal palpation
- Scalpel blade and handle
- 2 or 3 absorbable suture material for muscle closure
- 3+ nonabsorbable suture material for skin closure

Surgical procedure

Tacking sutures

After exploratory, the rumen is tacked to the body wall to hold it in position. This will minimize the work needed to hold it up and decrease the risk of peritoneal contamination. To tack:

- insert the needle (attached to #2 suture) through the skin away from the incision into the abdominal cavity
- grab a large bite of rumen away from the proposed rumen incision
- drive the needle back through the skin near the original insertion and tie

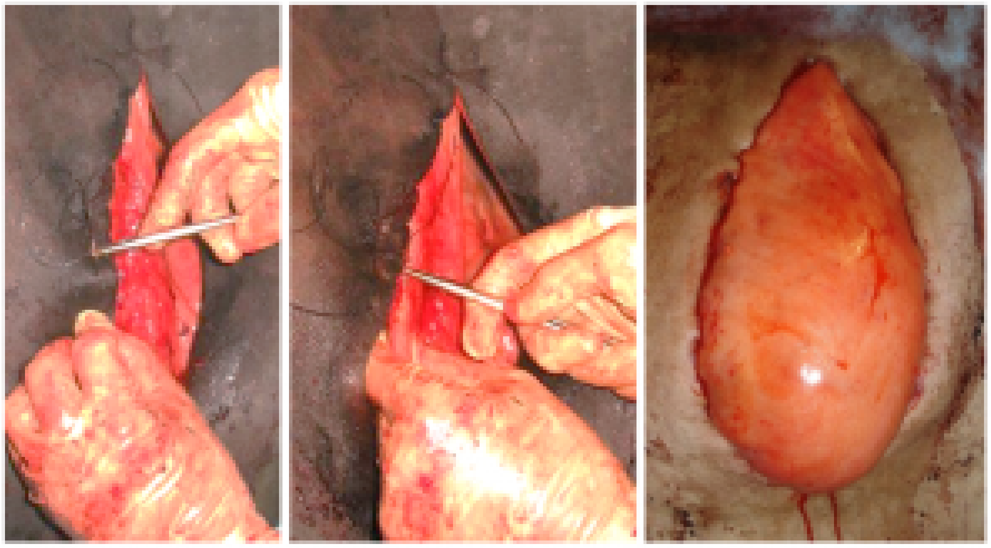
Repeat until the rumen is held in position by the tacking sutures.

Rumen exteriorized and temporarily tacked to skin

Contamination management

It is important to control contamination. This can be via use of a rumen board, rumen protector or by creating a water tight seal by use of an **inverting** suture pattern. The latter is the most effective.

To create a water tight seal, secure the rumen to the skin using a continuous Cushing pattern of 2 suture on a cutting needle. When completed accurately, no suture should be visible. Any gaps should be closed with a mattress suture, especially at the ventral aspect. NOTE that the rumen should be poofed out a bit. However, too much poof leads to a poor match with the skin and more gaps.



Rumen attached to skin using a Cushing pattern to create a water tight seal

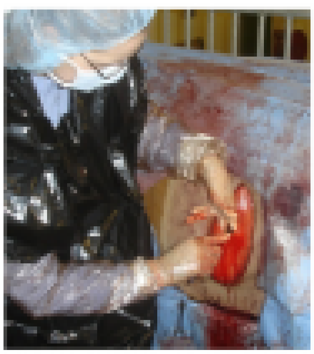
To minimize contamination, separate rumenotomy instruments (scalpel, saline, gauzes, needle holders, suture, scissors) from closure instruments. Cover closure instruments to keep sterile and move them away from the area.

Consider adding protective gear to minimize lingering smells. Garbage bags are good protection. At this stage, the procedure is not a sterile one.

garbage bags make great rumenotomy gowns

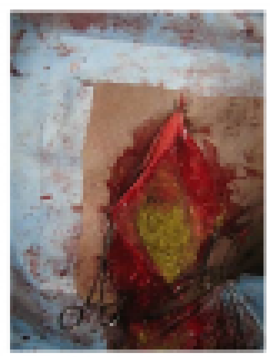
Rumenotomy

Incise the rumen. Remove ingesta along the path to the reticulum for hardware (or all of it if the animal has rumen acidosis). A wound protector can minimize trauma to the rumen surface. Another option would be to tack the rumen open or temporarily suture it open to minimize exposure to the serosal surface.



Barrier protection for surgeon, incising rumen

Wound shape: circle goes in rumen



Rumen tacked open

Explore the reticulum, esophageal opening and omasal opening. If the reticulum does not move, investigate the adhered area for penetrating foreign bodies. Palpate through the wall for any abscesses that need drainage. Hardware should be removed as should any extra magnets. One magnet should be left or placed. Rumen transfaunation is easiest at this stage.

If an abscess is identified, it can be drained into the rumen through the *area adhered.* Any incision that extends beyond that area will leak ingesta into the peritoneum. Note: Pus does not drain up hill well. And if you lose a scalpel blade, you have to find it. Tie it to your wrist before taking it into the rumen.

If contamination occurs or peritonitis identified, DO NOT lavage the abdomen. Cows can wall off infection if localized.

Rumen closure

The rumen drapes or shields are removed and the rumen surface cleaned. The rumenotomy incision is closed in two layers with an inverting pattern uppermost. After the first layer is closed and the rumen surface cleaned, the garbage bags are removed from the surgeons, gloves changed and the clean instruments used for the second layer. After two layer closure, the rumen is slowly released from the body wall so that it can be cleaned well prior to return to the abdominal cavity.

Body wall closure

Follow the guidelines for standing GI surgery. By this point, the drape may no longer be helpful.

Postoperative care

- Continue NSAIDs and antibiotics for at least 3 days
- Provide new rumen flora if possible
- Monitor for infection

Complications

- Lack of improvement
- Peritonitis
- Incisional infection

Videos

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=3260#oembed-1

Youtube video 2

Youtube video 3

Resources

How to - Rumenostomy

Indications

Rumenostomy is performed in growing calves with chronic bloat and in any age ruminant to provide nutritional support. Rumenostomies can be performed instead of rumen trocarization for improved results. Rumenostomies are also performed for feed trials to enable direct feeding and/or sampling. Finally, a rumenostomy can be placed in an adult cow to provide easy access to microflora (rumen donor). Rumenostomies typically have smaller openings designed to close over time (calves) or are kept open with a rumen cannula sized to fit the need.

Relevant anatomy

The rumen is located on the left side of the abdomen. A rumenostomy is centered in the left paralumbar fossa.

Preoperative management

Food restrictions:

Surgery is harder with a full rumen. Animals should be held off feed for 24 hours if not urgent. Bloating calves are NOT typically held off feed as the procedure may be needed on an emergency basis.

NSAIDs/analgesics:

Animals should be given flunixin meglumine or other NSAID prior to surgery

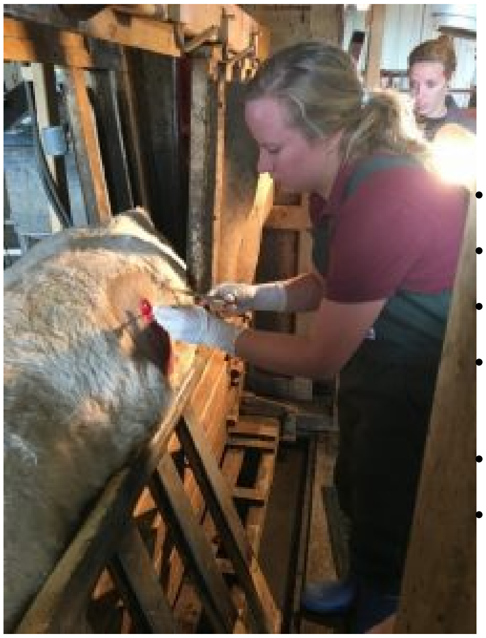
Antibiotics:

Procaine penicillin G is typically given preoperatively

Local blocks:

Line block, inverted L or paravertebral block with lidocaine

Position/preparation:



Standing and restrained. Larger animals can be restrained in chutes or headgates; younger animals are often restrained by people.

Surgery Supplies:

- Standard pack
- Scalpel blade and handle
- 2-0 to 0 absorbable, taper needle for the inner layer
- 2-0 to 0 nonabsorbable or absorbable, cutting needle for the outer layer
- Cannula (optional); soaking in hot water
- Syringe case, 0 suture, umbilical tape (optional)

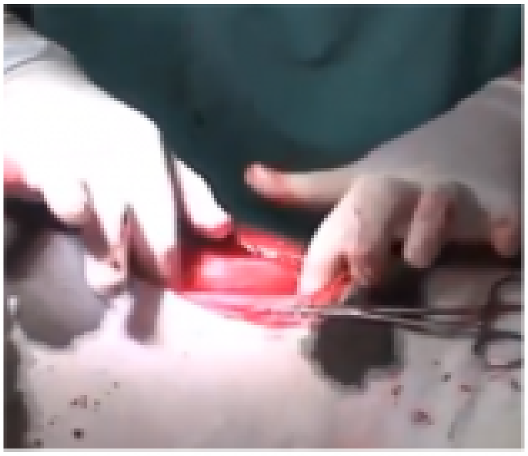
Surgical procedure

After the area is clipped, prepped and blocked, a circular incision is made in the center of the flank through the skin. In a standard rumenostomy, this is the diameter of two ribs. If a cannula is being inserted, this is the inner diameter of the cannula. The circle of skin is removed. A circle of external abdominal oblique muscle is removed.

Remove circle of skin

and of external abdominal oblique

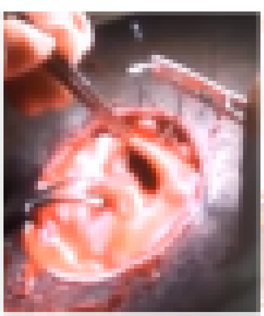
The internal abdominal oblique and transversus muscles are separated along their fibers to grid the opening. This creates a natural valve effect that minimizes rumen fluid leakage.

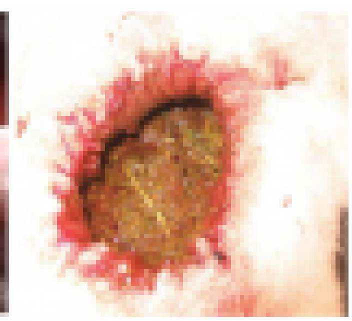


The rumen is grasped with allis tissue forceps and pulled gently out the incision until is “poofed out” and is filling the the hole. Some exteriorization is needed to minimize tension on the suture line. Excessive exteriorization creates folds and areas that can necrose under a cannula.

The rumen is secured to the external abdominal oblique with an **inverting pattern** using 2-0 or 0 absorbable suture (taper needle). This pattern (blue lines in image) is placed as far from the center of the circle as possible to avoid interference with the final layer. This pattern creates a water tight seal that protects the abdominal cavity from contamination.

A circle of rumen is removed stepwise. One quarter of the arc is incised. The cut edge of the rumen is sutured to the cut skin edge in a continuous **appositional pattern** using the 2-0 or 0 suture (cutting needle).

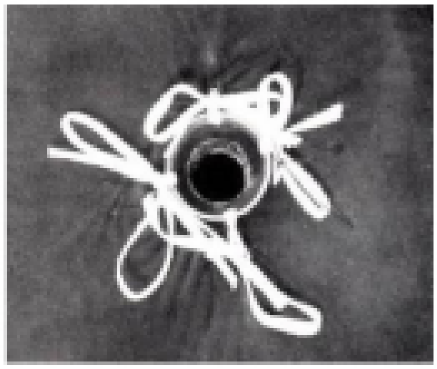




After the first quarter is incised, another quarter is transected and sutured. At this stage, the continuous pattern should be knotted to prevent a **purse string** effect. The suture is not cut free but is simply tied in place and then continued in use. The third quarter is transected and sutured. This is continued until a full circle of rumen wall is removed and the remaining rumen secured to the skin.

If a cannula is being placed, it is inserted at this time. Having it soaking in hot water helps the pliability. It should fit snugly. A temporary cannula can be constructed out of a syringe case for cases of bloat. The case is secured to loops of suture using umbilical tape. The cap can be put back on the case to minimize fluid leakage; bloat will blow the cap off and the gas can escape. Both can keep the site open, potentially longer than needed.

Cannula being inserted



Syringe case can be capped

Postoperative care

- NSAIDs are continued for 2-3 days, antibiotics for 5 days
- The flank is coated with vaseline and cleaned as needed to minimize scalding from the rumen juices.
- Nonabsorbable sutures are removed at 10-14 days
- Without a cannula, the rumenostomy site will gradually shrink and eventually close in most situations. If sized appropriately, the bloat should be resolved by the time it closes.
- 

Complications

Peritonitis- animals may have a fever and be off feed. Some cattle can wall off the infection.

Incisional infection- part of the suture line may need to be opened to allow drainage.

Skin scald – can be treated with cleaning, zinc oxide and vaseline

Lack of closure – with constant manipulation from cleaning or continued cannulation, the site will stay open. It can be closed if needed. Closure involves resecting the fistula and should be done by an experienced surgeon.

Videos

This videos were taken as part of a teaching laboratory; calves are in lateral recumbency rather than standing.

youtube video 1

Gridding close up

youtube video 2

Resources

Abomasal displacement

Right displaced abomasum

These can occur in any animal with an abomasum. Rare in small ruminants. Beef and dairy cows are at equal risk.

Left displaced abomasum

Classically these occur in the early (first 4-8 weeks) postpartum dairy cow.

Pathogenesis

- Decreased abomasal motility or increased gas production can lead to gas build up within the abomasum which allows for dorsal movement of the abomasum.
- During gestation, the uterus pushes up on the rumen. After parturition, there is more room in the abdomen and less rumen fill, increasing the risk of an LDA. Further, post-partum cows have an increased risk of:
    - atony due to hypocalcemia, diet change, or other diseases
    - gas production due to altered fermentation.

Risk Factors

- Man-made disease!
- Feed increased concentrates and decreased fiber – don't have fibrous mat in the rumen as thick as normal
- Increased grinding of feed – increases VFA production but decreases speed of turnover which increases gas production
- Decrease rumen fill (post-partum)
- Concurrent diseases post-partum – coliform enteritis, mastitis, milk fever, metritis, retained placenta.

Clinical findings

- scant loose feces

- left sided ping on a line from tuber coxae to elbow, centered on 12th ICS
- sunken left PLF (paralumbar fossa)
    - rumen usually pushes the left body wall out. With an LDA, the abomasum pushes the rumen toward the center line
- Concurrent diseases (see above): ketosis, hypocalcemia and abomasal ulcers
- Sequestration of fluid within the abomasum and concurrent anorexia:
    - dehydration
    - metabolic alkalosis
    - hyponatremia, hypochloremia, and hypokalemia
    - paradoxical aciduria (*Challenge: What is the pathogenesis behind this? Review here*)
    - Metabolic Profile and Inflammatory Responses in Dairy Cows with LDA
- Ping location can help differentiate from other GI disorders. An RDA cannot be easily differentiated from an abomasal volvulus or duodenal obstruction. As an abomasal volvulus requires emergency surgery, never let the sun set on a right sided ping!

Treatment options

- Fluid therapy – hypertonic saline and oral water after surgery; avoid LRS (more alkalinizing)
- Surgical options
    - Roll and toggle or tack
    - Right sided **omentopexy** and/or antropexy (pyloropexy)
    - Left side abomasopexy (long tack)
    - Right sided abomasopexy (long tack)
    - Right paramedian abomasopexy
    - Laparoscopic abomasopexy

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=1548#oembed-1

Roll and toggle

Cow is put on her back with casting ropes and/or sedation (acepromazine, xylazine and/or butorphanol). When she is on her back, the abomasum should float into its normal position. After the abomasum is identified by pinging, two toggles can be placed in the abomasum. Quick work is needed to identify the abomasum before the gas leaves. Potential complications include not being able to find the abomasum and toggling the pylorus. Other risks include tacking other structures, tacking the abomasum in the wrong position and problems associated with dorsal recumbency. If the cow is not doing well 2 days postoperatively, the toggle should be cut loose. If she recovers, the toggle should be cut free in 2-3 weeks to prevent fistula formation.

Toggle at 12:30-15:30min

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=1548#oembed-4

This is a tack suture vs a toggle but you can see the general procedure:

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=1548#oembed-2

This one has lots of details : MSU roll and toggle

This one has videographer challenges: Roll and toggle

Right sided omentopexy

This procedure is done standing with a local block. An incision is made in the right paralumbar fossa and the abomasum identified through palpation of the far side of the abdomen. The abomasum is decompressed using 10 gauge needle attached to tubing. Once it is deflated, the surgeon reaches underneath the viscera and pulls it over to the right side. This can be a scoop after lifting the viscera or a pull on the omentum. Once it is pulled to the right side, the omentum just caudal to the pylorus is used for the pexy. There are many versions of omentopexy. Commonly, horizontal mattress sutures are used to attach the omentum to the muscles on the cranial aspect of the incision. If desired, part of the antrum (slipped mucosa) can also be attached to the cranial incision.

Complications include breakdown of the pexy, particularly in very fat cows or pregnant cows. If adhesions are present, the abomasum often cannot be brought to the right side.

Youtube video

Left sided abomasopexy

This procedure is done standing with a local block. An incision is made in the left paralumbar fossa and the abomasum identified as a gas distended structure in the incisional area. A short run of ford interlocking sutures are preplaced in the greater curvature. These will create your pexy through adhesion formation. A needle is placed on each end of the suture and these ends run out the ventral body wall to the right of midline, just behind the xiphoid.

An assistant is generally needed to grab the needles as they exit the body wall. The abomasum is deflated and the sutures pulled tight. This will pull the abomasum to its normal position. After checking to make sure no structures are stuck between the abomasum and the body wall, the sutures are tied to each other, creating the pexy.

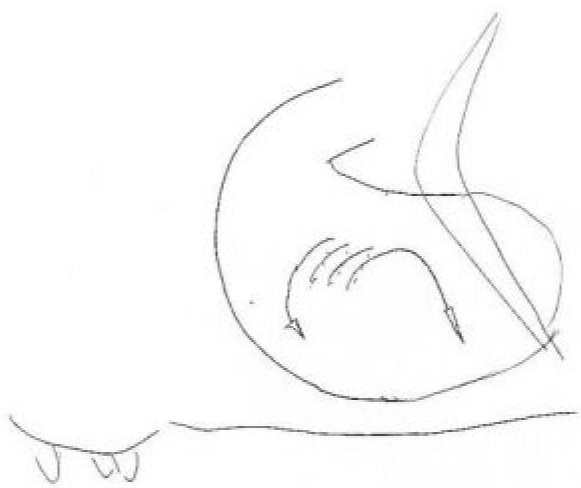
Complications include entrapment of viscera, breakdown of the adhesion and abomasal fistula formation. Can be useful if adhesions.

Cannot be done for an RDA or abomasal volvulus.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=1548#oembed-3

Right sided long tack

A right flank abomasopexy is performed similarly to a left sided long tack. Generally, this is only possible with an RDA. The structures are stretched and exposed enough with RDAs; not enough abomasum is exposed with most LDAs



Right paramedian abomasopexy

This procedure is done with the cow in dorsal recumbency as for the toggle procedure. A 4″ incision is made 4″ caudal to the xiphoid and 4″ to the right of midline, avoiding the milk veins. Once the peritoneal cavity is entered, the abomasum is identified. It should have returned to its normal position and can be identified via the mucosal slip. The pexy is performed by incorporating the abomasum into the closure of the internal rectus sheath using a continuous pattern. The pexy should extend for ~ 6 bites and finish ~4″ from the reticuloabomasal fold.

Complications include problems with recumbency (worsening pneumonia) and with standing up. Cows with nervous ketosis, musculoskeletal issues and pneumonia should not be put into dorsal recumbency.

Should not be used with an abomasal volvulus or anything that might be a volvulus.

Youtube video

Laparoscopic abomasopexy

This is basically a visualized toggle procedure and generally requires casting the cow.

Key Takeaways

LDAs are most common in dairy cattle that have recently (within 6 weeks) calved. RDAs can occur in all large ruminants.

There is no definitive best approach for correcting a displaced abomasum. Factors to be considered include health of the cow, availability of a surgeon and other help, facilities, LDA vs right sided displacement/torsion, and cow value.

Procedures include both direct and indirect tacking of the abomasum to its normal position or into a position on the right that prevents future movement.

Resources

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=1548#oembed-5

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=1548#oembed-6

Comparison of omentopexy versus pyloro-omentopexy for treatment of left abomasal displacement in dairy cows: 87 cases (2001–2005), JAVMA 2017;251:1182–1187- A more recent discussion of options

A study of 54 cases of left displacement of the abomasum: February to July 2005, Irish Vet Journal **60**, Article number: 605 (2007)- nice overview with case details

Abomasal volvulus

An RDA can progress to a volvulus. Generally the abomasum flips up (forming an RDA) and then rotates toward the tail (counterclockwise as viewed from the right side). This compresses the abomasum so no fluid can leave either via the pylorus or to the omasum. Vessels can also be compressed, leading to ischemic necrosis. Occasionally, the omasum is involved in the twist. The torsed abomasum can contain gallons of fluid. Affected cows can become very shocky and can die from cardiovascular collapse. The distension can lead to problems with abomasal contraction even if the volvulus is corrected.

Signalment

Any ruminant

Clinical signs

ADR (ain't doin' right), acute and severe drop in milk production, anorexia

- A right sided ping is generally present, extending from the paralumbar fossa cranially for at least one rib space. If the abomasum contains enough fluid, it may not ping at all since a ping requires a gas-fluid interface.
- The cow may be lying down. Colic signs are NOT typically seen.
- Dehydration can be severe. Dehydration will lead to an elevated heart rate.

Treatment

Emergency surgery is required. Preoperative antibiotics and NSAIDs are needed.

A right sided standing approach is indicated. The amount of fluid in the abomasum makes a ventral approach challenging for both cow and surgeon. The fluid will press on the diaphragm, impairing oxygenation. It is close to impossible to drain the fluid with the cow on her back so detorsing the abomasum is very challenging when the surgeon has to bend over to manipulate the abomasum. Remember: "a pint is a pound the world around"- that abomasum is HEAVY.

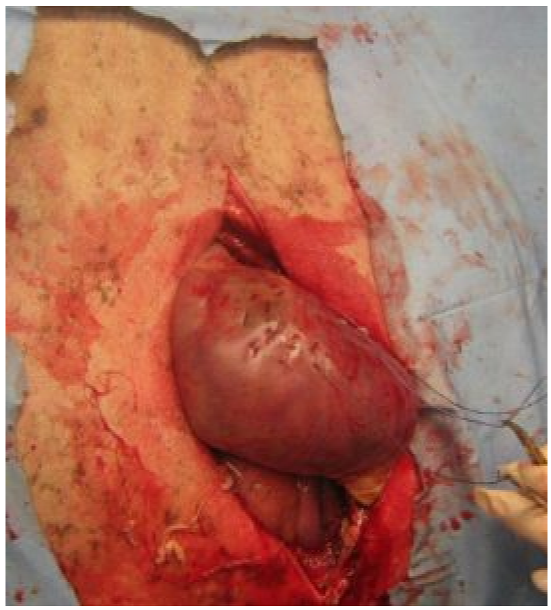
The abomasum is typically visible as soon as the flank is incised.

Differentiating an RDA from an abomasal torsion:

RDA	Place hand on the far side (axial) aspect of the abomasum. It can run easily to the ventral abdomen	Omental sling is in place
Abomasal torsion	Hand runs into a twist	Omental sling pulled out of position

If it is an RDA, decompress and pexy. If it is a torsion, the torsion is corrected by pushing the abomasum up and forward in a clockwise manner. This requires draining the fluid first.

A doubled **purse string suture*** is placed in the visible body of the abomasum. A vertical incision is made in the center of the purse strings and a stomach tube quickly inserted into the abomasum. The fluid will drain rapidly.



*I place two purse strings as I never make the first one with a wide enough diameter and end up cutting it to get the tube in place

Once the fluid is drained, the tube is removed and the pursestring sutures pulled tight. The exposed suture is oversewn with an **inverting** pattern to minimize adhesions. The abomasum is now repositioned and a pexy performed.

If the abomasum is gangrenous or will not hold suture (the purse string sutures pull out), the cow should be euthanized.

Postoperative care

These cows generally require fluid and electrolytes. Antibiotics and NSAIDs should be continued for at least three days.

Complications

Many cows never regain abomasal motility (too much stretch? nerve damage?). They eat for a day or two and pass the manure that is currently in the GI tract. However, once the abomasum fills up, the cows stop eating. Abdominal distension develops and no more manure is passed. The cow should be euthanized.

Other complications include shock, peritonitis and incisional infections.

How to - Right flank omentopexy/antropexy

Indications

Stabilization of the abomasum is indicated with any DA surgery and is generally performed any time a right flank exploratory is performed (prophylactic tack). Right flank **omentopexy** is one option. Omentopexy combined with a tack of the antrum (often called pyloropexy) is a modification that may be stronger.

Relevant anatomy

The abomasum is normally located on the ventral abdomen, typically just to the right of midline. It often shifts horizontally across the midline during late gestation. When gas filled, the abomasum can displace to either the left or the right sides of the abdomen and float up. The pylorus will stay more ventral while the body of the abomasum floats more freely upward.

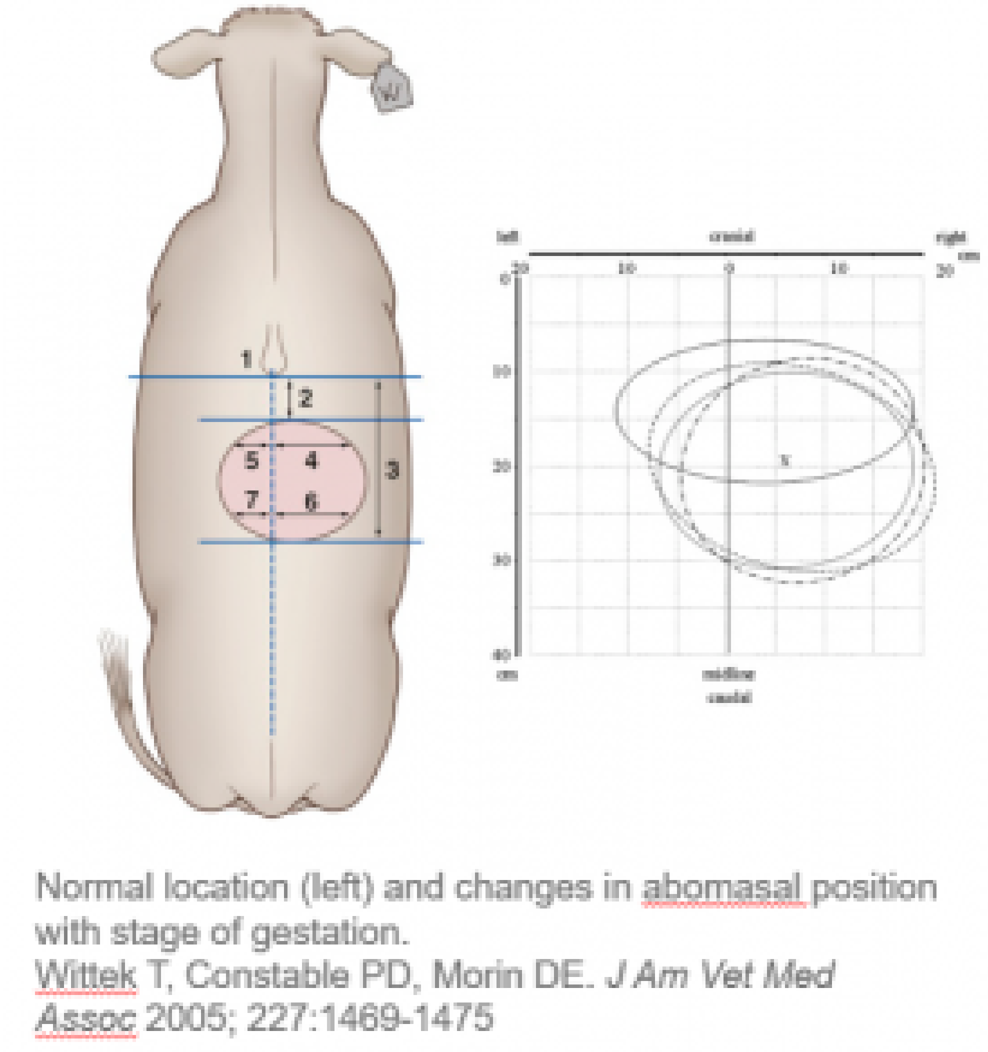


Fig 1. Normal position of the abomasum and changes with gestation.

The abomasal antrum is exposed while the pylorus and proximal duodenum are encased in omentum. The "sows ear" is not necessarily close to the antrum.

Fig 2. Abomasal antrum and sow's ear

The greater curvature of the abomasum is encased within the omental bursa – a potential space formed by the greater and lesser omentum (omental leaves). The greater omentum has two layers. The superficial layer connects the descending duodenum, abomasum and the left longitudinal groove of the rumen. The deep layer connects the duodenum, abomasum and the right longitudinal groove of the rumen. This creates the "sling" and the omental bursa between the layers. The lesser omentum connects the abomasum, liver and ascending duodenum.

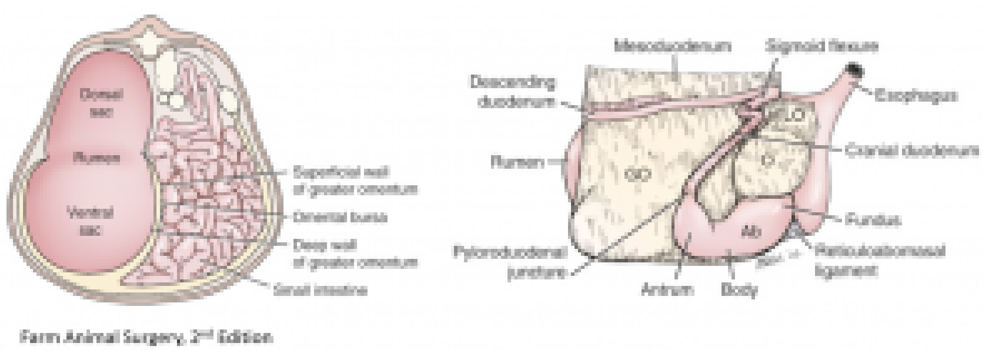


Fig 3. Note how the angle between the duodenum and the abomasum is ~ 45 degrees. This is important to remember when pulling up the abomasum

The flank musculature is comprised of the external abdominal oblique, internal abdominal oblique and transversus abdominus muscle.

Fig 4. Flank musculature shown as grided

Preoperative management

Food restrictions: NA

NSAIDs/analgesics: Recommended preoperatively. Flunixin meglumine 1.1-2.2 mg/kg iv is standard.

Antibiotics: Recommended. As cows can wall off infection, there can be surprises inside. If milking, ceftiofur 2.2 mg/kg im is standard. In beef or non-lactating cattle, other options do exist. Remember: the label dose of procaine penicillin is ineffective!

Local blocks: A line block, inverted L or paravertebral are all reasonable options.

Position/preparation: See How to- Standing GI Surgery

Surgery Supplies – Additional

- 2 chromic gut, 2 vicryl, 2 nylon or similar for the pexy
- DA simplex – long flexible tubing attached to a 10ga needle for viscus decompression
- 0 vicryl or similar for the abomasotomy with abomasal volvulus
- Large bore stomach tube – for abomasal volvulus

Surgery Supplies- Standard

- Standard surgery pack
- Sterile sleeves for internal palpation
- Scalpel blade and handle
- 2 or 3 absorbable suture material for muscle closure
- 3+ nonabsorbable suture material for skin closure

Surgical procedure

Follow the guidelines for Standing GI surgery. , How to – Abdominal Exploratory

To replace a left displaced abomasum

Identify the top part of the abomasum or as high as you can reach. Take the DA simplex (tubing with 10 ga needle attached) into the abdomen, protecting th needle by having it in your palm or folded backwards. When you reach the abomasum, tunnel the needle through the wall of the DA for a few mm and then direct it perpendicularly into the lumen. Push down to encourage as much gas as possible to escape. Remove the simplex and drop it on the floor or hand to a nonsterile assistant (contaminated).

Reach under the sling and grab the pylorus OR grab the omentum that is in the cranioventral aspect of the omentum and gradually pull on that at a 45 degree angle (see Fig 3) to pull the abomasum over to the left side. This may take some wiggling or manipulation inside the cow. If the omentum starts to tear (much more likely in very fat cows), stop and try to find the pylorus to pull the abomasum over directly. NOTE: Pulling vertically pulls on the rumen and pulling horizontally pulls on the liver. Neither will help reposition the abomasum. Pull at an angle.

If it is not moving check for

- excessive gas – repalpate craniodorsally and repeat the gas removal if necessary
- adhesions – previous pexy or ulcer – palpate along the ventral body wall. If present, close and move to plan B
- torn omentum – attempt to grab the pylorus itself

To replace a right displaced abomasum

Identify the gas distended viscus and verify displaced vs twisted. Run your hand down the medial aspect. If you hand can follow the medial aspect down to the ventral abdomen, it is just displaced. A twist will stop your hand midway down. A twist is also usually accompanied by displacement of the omental sling. If you have a twist, see below.

Decompress the abomasum using the tunneling technique + direct stab. Once the gas is relieved, dispose of the simplex and grab the pylorus. The abomasum has flipped up in a counterclockwise manner as viewed from the rear. Push down the body of the abomasum while pulling up on the pylorus. f you move too slowly, the gas will redevelop and you will need to repeat the decompression.

To correct an abomasal volvulus

With a volvulus, the abomasum has moved into the RDA position (flipped up) and then twisted counterclockwise as viewed from the right side of the cow. You need to twist it clockwise into RDA position and then flip it down. However, it is usually full of fluid. Untwisting can be challenging until you remove the fluid.

Cover both arms with sterile sleeves and overgloves, set up gastrotomy instruments (needle holders, suture scissors, suture, blade) and move the clean instruments aside. Preplace two **purse string** sutures of 0 vicryl in the exposed abomasal body – one with a center diameter of 4 cm and one encircling that with a slightly larger central diameter. Leave the ends of each purse string long. Create a stab incision in the center, big enough for your large bore stomach tube. Quickly insert the stomach tube, passing it into the ventral aspect of the abomasum. Abomasal fluid will start to siphon off. Adjust the tube as needed to remove as much fluid as possible. Remember, as you pull the tube out, the tube is contaminated. Remove the tube fully and tighten the purse string sutures. Clean the surface and remove the overgloves and sleeves. Use the suture in the last purse string or an additional strand to cover the knots with an **inverting** pattern.

Reposition the abomasum by pushing it forward and then down (or pull on the pylorus clockwise and then correct the RDA).

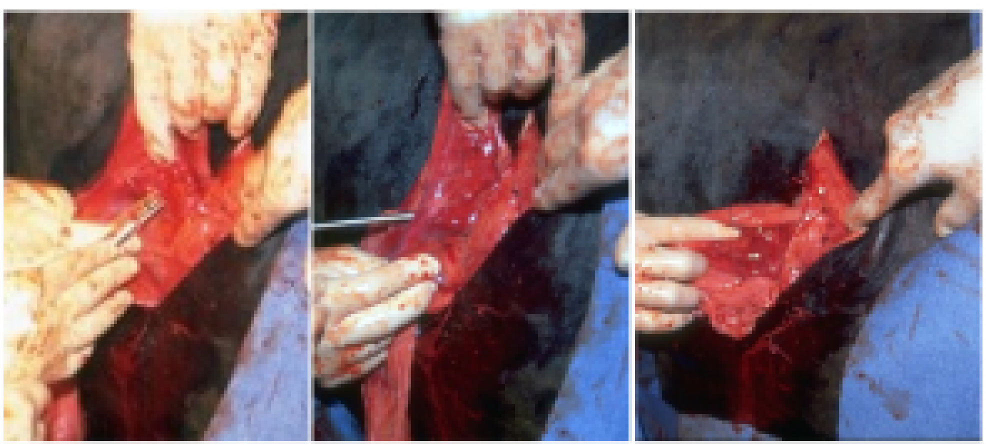
Omentopexy

Prior to closure, palpate the abomasal wall for ulcers and perform the omentopexy. There are several viable methods. This is one of them:

Pull the abomasum up (or extend the incision down) so that the abomasal antrum is visible (Fig 1). Clamp the omentum dorsal to the antrum to the dorsal aspect of the incision to hold it in place. The pylorus should not be elevated more than necessary or it puts the cow at risk of duodenal torsion.

Place 2 horizontal mattress sutures across the cranial incisional musculature and the omentum + 1 horizontal mattress across the musculature and the antrum.

- *Omentopexy bites*: Starting on the external abdominal oblique using 2 suture material, insert the needle 1 cm caudal to the cut edge, through the internal abdominal oblique, through the transversus, through the omentum (the part that is just caudal to the pylorus or duodenum) from cranial to caudal, back through the omentum from caudal to cranial, back through the transverus, back through the internal abdominal oblique and back through the external abdominal oblique. Tighten up the suture so the omentum is tightly against the body wall. Tie. Repeat for 1-2 more sutures.



Needle moving cranial to caudal through omentum | Needle moving caudal to cranial back through omentum | Omentopexy completed

- *Antropexy bite*: Using the same process, insert the needle through the musculature, through the slipped wall (mucosa not included) of the abomasal antrum, back through the slipped wall of the abomasal antrum and back through the musculature. With an RDA, you may be able to get 2 horizontal mattress sutures in the antrum instead of just one.

Closure is as described in How to- Standing GI Surgery. If the internal abdominal oblique muscle slid away during the pexy, you cannot use it for closure. Attach the caudal aspect to whichever layer you prefer. One wound, one scar applies anyway. In 10 days, you can't tell the difference.

Postoperative care

- Suture removal in 10-14 days.
- Monitor the cow for any signs of infection or peritonitis.
- Consider rumen transfaunation if available.
- If abomasotomy is performed to drain fluid, continue antibiotics for 5 days and NSAIDs for 3-5 days.

Complications

- Incisional dehiscence (rare)
- Incisional infection (common)
- Peritonitis

Abomasal volvulus

- Abomasal necrosis – if a portion of the abomasum is purple or if the purse string sutures pull out, the abomasum is devitalized. Quit.
- Abomasal atony – in some cases the abomasal wall is so stretched, it never works again. Cull.
- Unable to detorse – sometimes the omasum and/or reticulum are involved and detorsion is very challenging. Refer or quit.

Videos

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=3208#oembed-1

Youtube videos (age restricted)

Video 1

Video 2

Video 3

Resources

Farm Animal Surgery (Second Edition), 2017

Wittek T et al. Ultrasonographic assessment of change in abomasal position during the last three months of gestation and first three months of lactation in Holstein-Friesian cows. *J Am Vet Med Assoc* 2005; 227:1469-1475

How to - Right paramedian abomasopexy

Indications

Stabilization of the abomasum is indicated with any DA surgery. Right paramedian abomasopexy is one option. This is a direct tack of the abomasum in its normal location. This method can be performed in cows that cannot stand due to trauma or milk fever.

Relevant anatomy

The abomasum is normally located on the ventral abdomen, typically just to the right of midline. It often shifts horizontally across the midline during late gestation. When gas filled, the abomasum can displace to either the left or the right sides of the abdomen and float up. The pylorus will stay more ventral while the body of the abomasum floats more freely upward.

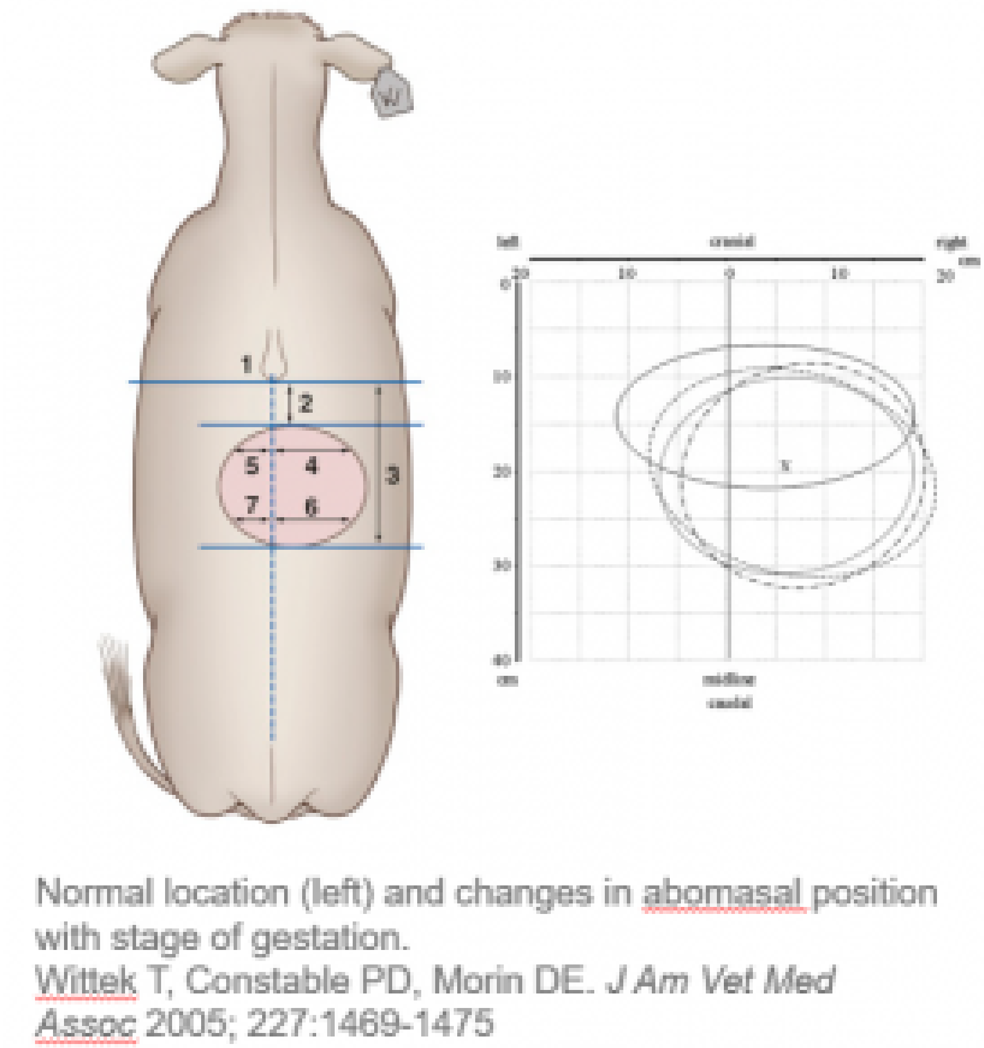
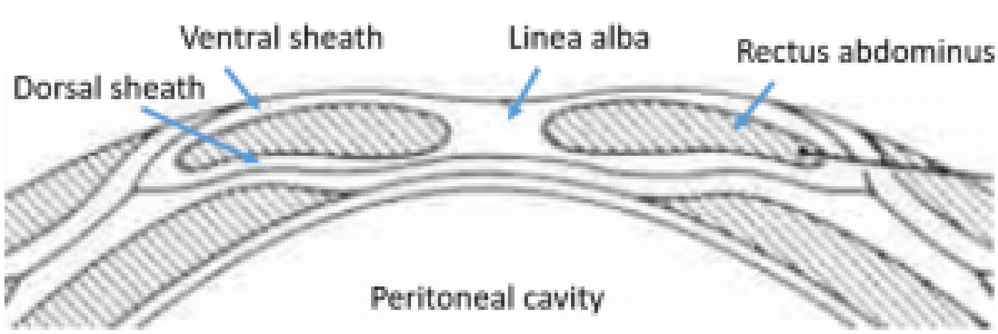


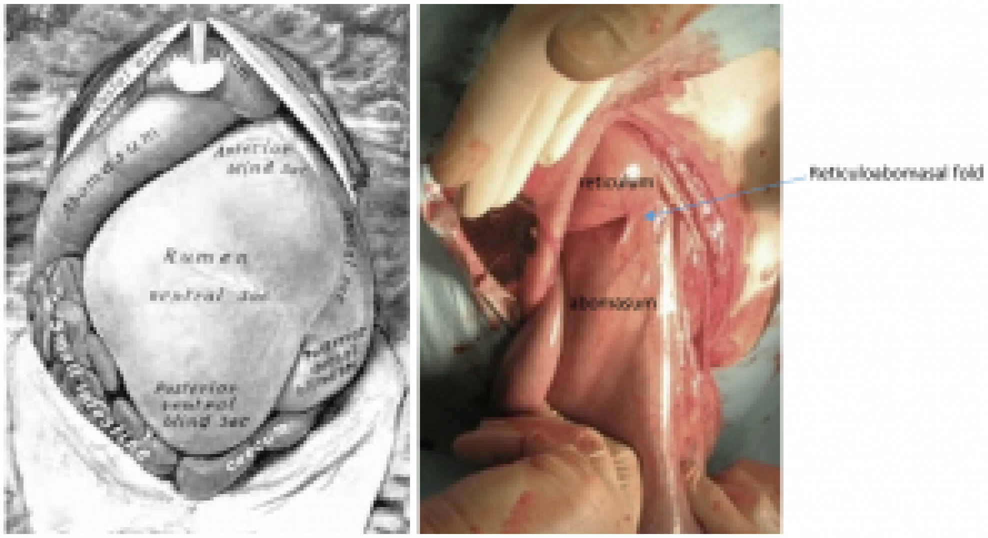
Fig 1. Normal position of the abomasum and changes with gestation.

The ventral abdominal wall is comprised of the continuation of the flank muscles; however these turn into fascia. Midline is the linea alba. Off midline is the rectus abdominus muscle encased between the dorsal and ventral rectus sheaths. The ventral rectus sheath is the strength layer.



Ventral body wall

Exploratory options are limited from this approach due to the massive rumen. The abomasum should sit between the reticulum and rumen.



The abomasum is identifiable by the noticeable mucosal slip as the wall is palpated. The reticulum has a honeycomb texture and is connected to the abomasum by a ligament (reticuloabomasal fold).

Omentum attaches to the greater and lesser curvatures of the abomasum. In this area, the omentum contains minimal fat and is best identified by the vascular arborization evident where it attaches to the abomasum.

Preoperative management

Food restrictions: Cows with a displaced abomasum are generally off feed already (poor appetite).

NSAIDs/analgesics: Recommended preoperatively. Flunixin meglumine 1.1-2.2 mg/kg iv is standard.

Antibiotics: Recommended. As cows can wall off infection, there can be surprises inside. If milking, ceftiofur 2.2 mg/kg im is standard. In beef or non-lactating cattle, other options do exist. Remember: the label dose of procaine penicillin is ineffective!

Local blocks: U block (line block in a U shape) or line block

Position/preparation: The animal is positioned in dorsal recumbency. This typically involves sedation (20 mg xylazine or similar) and casting ropes. The gutter makes a decent trough to help hold the patient in dorsal; bales can also help to support her in that position.

Surgery Supplies – Additional

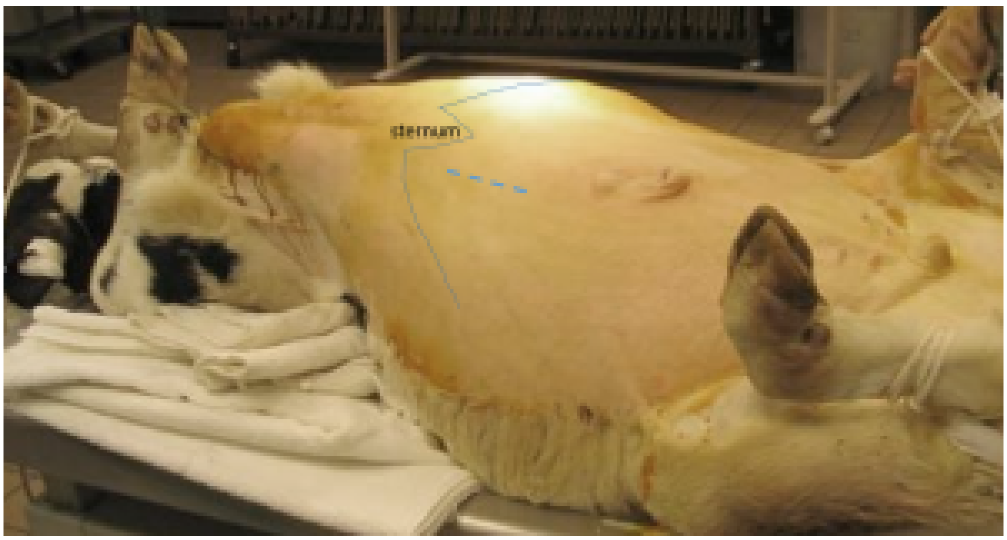
- 2 PDS or nylon for the pexy and the ventral sheath
- 0 chromic gut or similar for the muscle closure
- 3 vetafil or similar for skin closure

Surgery Supplies- Standard

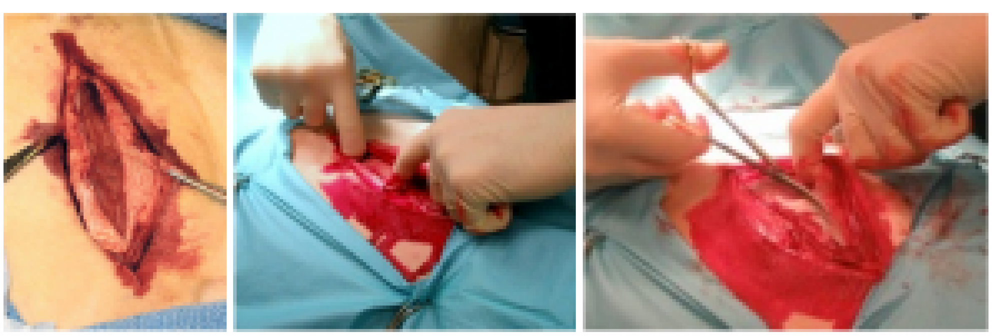
- Standard surgery pack
- Sterile sleeves for internal palpation
- Scalpel blade and handle

Surgical procedure

- In an adult cow, a 6-8″ incision is made approximately 4″ to the right of midline and approximately 4″ caudal to the xiphoid. This is the normal location of the abomasum. In smaller animals, adjust the distances for relative body size. If the milk vein is in the intended site, make the incision closer to midline.



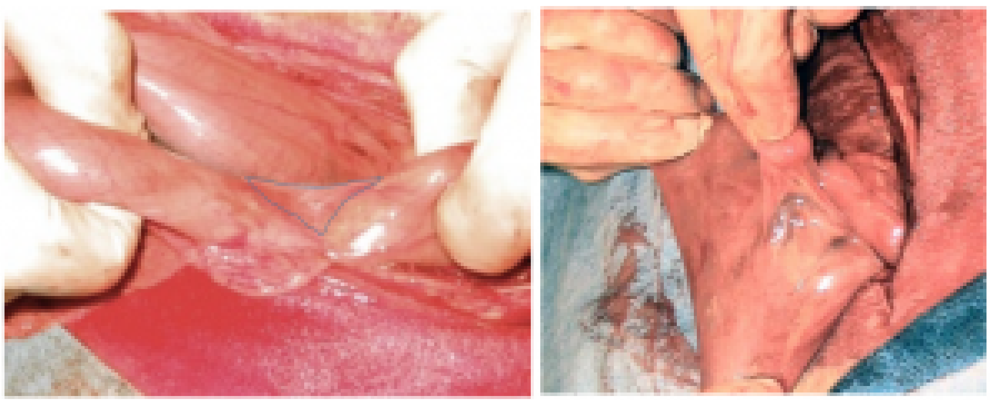
  - The incision is made through skin, external sheath, rectus abdominus, internal sheath and peritoneum
  - Blunt dissection should be performed through the rectus abdominus (less bleeding)



Incise dorsal sheath sharply   Separate rectus fibers   Incise ventral sheath and peritoneum sharply

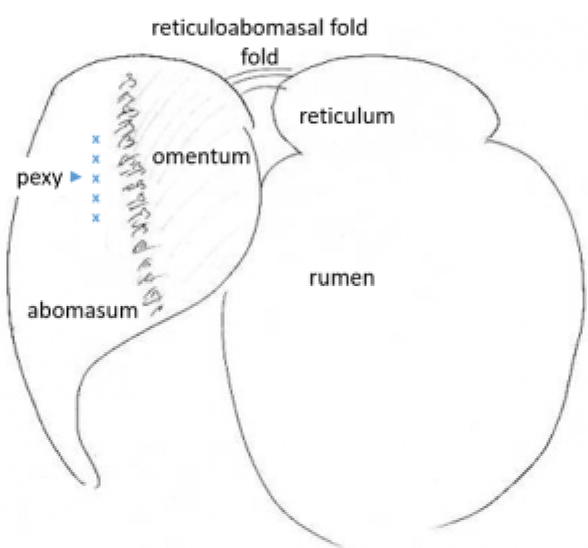
  - Any vessels encountered should be ligated; bleeding is typically minimal during surgery but that can change dramatically when the cow returns to her feet.

- If indicated, exploration can be performed. Sterile sleeves help minimize contamination. Exploration is needed if the abomasum is not immediately visible. The abomasum usually floats to its normal position. If it does not, adhesions are likely – either from abomasal rupture, peritonitis or previous abomasal tack.
- If the abomasum is in its normal position, the pexy can be performed. The objective is to incorporate the wall of the abomasum in the closure of the dorsal rectus sheath.
    - Identify the cranial aspect of the abomasum by locating the reticuloabomasal fold. This ensures the pexy is not near the pylorus.
    - Identify the attachment of the greater omentum. The omentum should be avoided in the pexy. The pexy should directly incorporate the greater curvature of the abomasum.

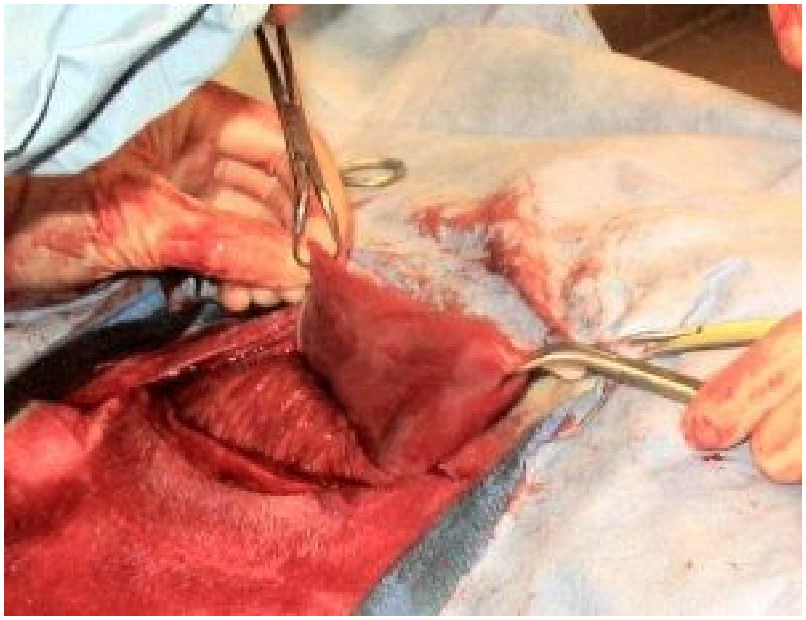


Palpate the reticuloabomasal fold (visualization is not required). Identify the omentum.

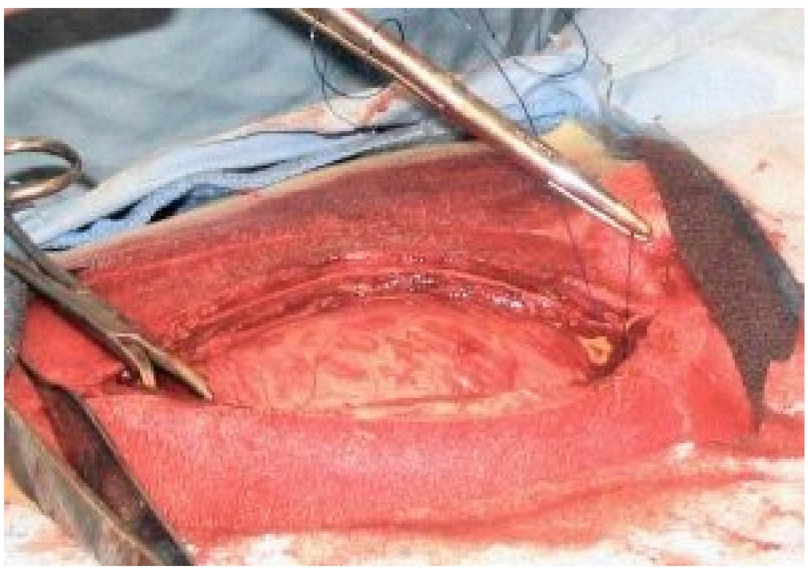
- The pylorus does not need to be exteriorized or visualized in most cases.
- Exteriorize 6-8″ of abomasum using wet towels to grasp and lift it out of the incision ~2″. Identify the pexy site. This should start about 3″ caudal to the reticuloabomasal fold and abaxial (lateral) to the omental attachment.



- Slip the mucosa away and place a towel clamp at either end of the exposed abomasum. This will allow you to move the abomasum in and out of the abdomen as needed.



- Start the pexy by placing a suture (#2 PDS or nylon) across the caudal aspect of the dorsal sheath. Secure the bite with a knot. There is no need to include the abomasum in this bite.



- Close the dorsal sheath using a simple continuous pattern. Incorporate a bite of abomasum in each pass, making sure the mucosa is not included in the closure (slipped away).

    - After 6-8 bites, close only the ventral sheath. Stop including the abomasum.
- Close the muscle using 0 gut, simple continuous pattern.
- Close the external sheath using 2 PDS or nylon, simple continuous pattern. Do NOT include muscle. When it tears loose, your closure is now loose too.
- Close the skin using 3 Vetafil, Ford Interlocking pattern.
- Return the cow to sternal recumbancy/standing.

Postoperative care

- Suture removal in 10-14 days.
- Monitor the cow for any signs of infection or peritonitis.
- Consider rumen transfaunation if available.

Complications

- Poor oxygenation (maximum surgery time ~ 1 hour)- Pa02 drops from 86% standing to 65% at 15 min and 61% at 30 min
- Incisional dehiscence (rare)
- Incisional infection (uncommon) or hernia (rare)
- Subcutaneous hemorrhage (uncommon) – apply a tight belly band for 24-48 hours
- Peritonitis
- Abomasal fistula (if suture went into lumen)
- Recurrence (generally due to suture breakage)

Videos

youtube video 1

youtube video 2

Resources

Abomasal ulcers

Abomasal ulcers may bleed or perforate. Surgery is not advisable when a cow has a bleeding ulcer. However, ulcers are commonly associated with abomasal displacement so surgery may be unavoidable.

A cow with a ruptured abomasal ulcer may show signs similar to **hardware disease** initially. Ruptured ulcers lead to localized peritonitis. Cattle are really good at walling off infections. In fact, they may go on to look perfectly normal. When you encounter an adhesion at surgery, LEAVE IT ALONE unless the cow will not survive without you breaking it down. You are likely going to open up an abscess. Similarly, we don't flush the abdominal cavity in ruminants with peritonitis. All you are doing is dispersing the infection so the cow has to wall off multiple areas.

If the cow has a displaced abomasum along with an ulcer, the ulcer and resultant peritonitis may keep it from floating as high as it normally would. If you have low ping, worry about a ruptured ulcer!

At surgery, if the omental bursa is gas distended, assume you have a ruptured abomasal ulcer on the lesser curvature. Due to the omental leaves, the gas is trapped in the bursa.

When an ulcer is suspected, avoid tugging on the abomasum more than necessary. A right paramedian approach is recommended, as this will provide the best exposure to the abomasum and avoid extra manipulation. However, if the cow is anemic, the dorsal recumbency can be dangerous. If you are working from a right flank approach, do not pull the abomasum up any higher than necessary. Tack it lower than you usually would and let her recover.

Note: midlactation cattle with signs of abomasal ulceration should be checked for lymphosarcoma

Abomasal impaction

Impactions are not common but may be seen with changes in feedstuff, after abomasal volvulus and with pyloric lymphosarcoma. Cattle with lymphosarcoma or with impaction after volvulus should be culled.

abomasum affected with lymphosarcoma – thickened wall and ulcers

Abomasotomy is performed for abomasal impactions due to a change in feedstuff. It is performed with the animal sedated in left lateral recumbency.

If the animal has rumen distension, a rumenotomy should be performed first to empty the rumen. Otherwise, the rumen distension may lead to significant ventilation issues.

Resources

- Right flank laparotomy and abomasotomy for removal of a phytobezoar in a standing cow. CVJ 51(7):761-3

Small Intestinal diseases

The Bottom Line

In the field, if you see a cow with signs of colic, or you can palpate small intestinal distention on rectal then proceed with an abdominal exploratory. Abdominal exploratory is an excellent diagnostic test. Identification of a lesion allows better decision making. If treatment is an option then referral is recommended, although the decision is often euthanasia. Remember you cannot visualize all parts of the bovine gastrointestinal tract and cannot follow it from duodenum to rectum! However, if you can't visualize it, you can't readily fix it either.

General Considerations

Causes of small intestinal gastrointestinal obstruction include luminal obstruction (both intraluminal such as blood clots and extraluminal such as adhesions), intussusception (more common in Brown Swiss), volvulus (more common in young cattle) and strangulation (eg from an adhesion, entrapment in a hernia).

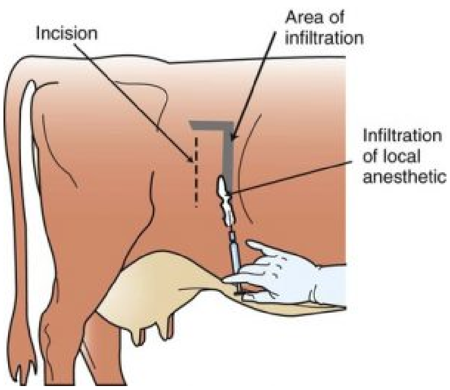
Cattle have a short mesentery. Since mesenteric traction is very painful, exteriorizing the small intestine may lead to the cow lying down during a standing procedure. Be cautious of this when exteriorizing the small intestine during exploratory. Lidocaine can be injected into the mesentery if needed.

Pain- Cattle do not show colic signs in most gastrointestinal disorders. If you see a cow kicking at her belly or acting uncomfortable, it generally indicates a need for abdominal exploratory.

Rectal Palpation: Depending on where the obstruction is, you may or may not feel distended loops of small intestine. It is very difficult to differentiate between causes of small intestinal obstruction on palpation alone. If you do feel small intestinal distension, an exploratory is warranted.

Ping: Right Paralumbar Fossa. Depending on the extent of SI involvement, cattle may have abdominal distention in the right paralumbar fossa (right sided apple).

Clinical Pathology: With lesions leading to outflow obstruction and sequestration of fluid in the abomasum and rumen you will see a hypokalemic, hypochloremic metabolic alkalosis with elevated rumen chloride levels. Additional electrolyte abnormalities include hyponatremia, hypocalcemia. Chronic cases can result in a paradoxical aciduria (poor prognosis). If the cow has ischemic necrosis and peritonitis then they will shift to a metabolic acidosis with a relative hyperkalemia and CBC will have an inflammatory leukogram with left shift (poor prognosis). In the field, we often do not do blood work but have clinical signs of dehydration and shock (cold ears or extremities). Knowledge of the suspected electrolyte and metabolic abnormalities allows for prompt stabilization or accurate assessment of prognosis.



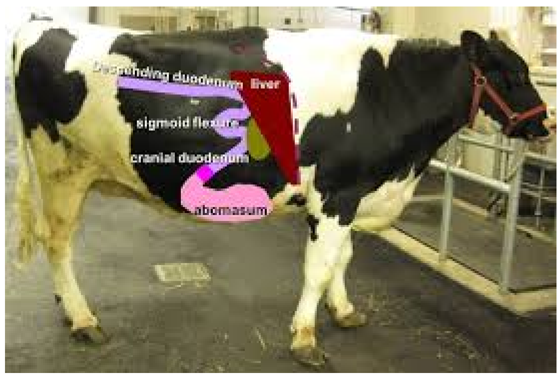
Surgical Approach: Right paralumbar fossa for surgical exploratory and visualization of the SI (best approach for most parts of the GI tract). Standing surgery using good surgical technique, local anesthesia and/or epidurals, and injectable analgesics (Banamine, butorphanol, and/or xylazine) provides a safer alternative to general anesthesia. In referral centers, we may opt to do general anesthesia in cases where there is a high risk for the cow to go down, but remember, laying a cow down for general anesthesia presents a very high risk due to regurgitation, pressure on their lungs from bloat, and myopathies.

Enterotomy: Can use a standing right paralumbar approach for this procedure. Exteriorize the portion of the small intestine and determine if the intestine is viable. If it is, make your incision on the antimesenteric side and remove the foreign body or blood clot. Close the enterotomy site with a two-layer closure using a simple continuous followed by a Lembert or Cushings to provide a water tight seal.

Resection and Anastomosis: These are incredibly difficult to do in the field as the cow will often go down during the procedure. Referral for a cow which requires a resection and anastomosis is recommended.

Duodenal Outflow Problems

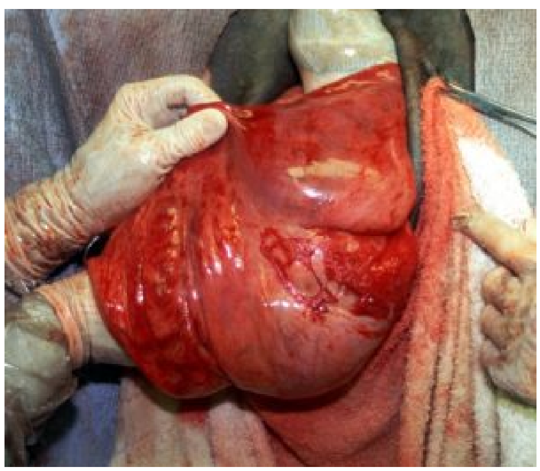
Duodenal outflow problems can occur in any age or breed and are due to obstruction or dysfunction. Duodenal dysfunction can occur due to peracute duodentitis, duodenal ulcers with or without perforation, clostridial duodenitis, or electrolyte abnormalities. Duodenal obstruction can occur due to trichobezoars (calves infested with lice or mites, or adult cattle in spring when shedding of hair occurs), foreign bodies, duodenal structure after an ulcer, obstruction by displacement of the viscera (gall bladder or uterus), iatrogenic after **omentopexy** or pyloropexy, extraluminal compression (liver abscess, omental abscess, or lymphosarcoma). Cases of duodenal sigmoid flexure volvulus have been described in cattle post omentopexy.



Clinical Examination: Animals with a duodenal outflow problem with present with clinical signs of dehydration, colic, weight loss, anorexia, recumbency, lethargy, and/or decreased fecal production. On physical exam, they have progressive right abdominal distension due to fluid buildup in the rumen, resembling severe bloat. On rectal examination there may be loops of small intestine but not necessarily. Ultrasound will identify distention of the duodenum and forestomach.

Calf with abdominal distention due to a duodenal obstruction. Picture from: Burgstaller, et al. Abomasal emptying in calves and its potential influence on gastrointestinal disease. Journal of Dairy Science, 2016.

Treatment: Requires immediate surgical exploratory via a right paracostal approach (beside the rib) and removal of the obstruction via enterotomy if identified. Treatment also includes IV fluids for stabilization, antibiotics, NSAIDs, and additional analgesics. If a cause cannot be determined, a presumptive diagnosis of ileus is made and the cow is treated aggressively with IV fluids for 12-24 hours.



Identification of a enlarged duodenum due to obstruction in a cow.

Resources

Duodenal obstruction caused by duodenal sigmoid flexure volvulus in dairy cattle. J Am Vet Med Assoc 2012 Sep 1;241(5):621-5

Hemorrhagic Bowel Syndrome

Hemorrhagic bowel syndrome (HBS or jejunal hemorrhage syndrome) is caused by intraluminal and intramural intestinal hemorrhage and necrosis with subsequent clot formation and intestinal obstruction. Although the extent of the SI can be effected, lesions are predominately found in the jejunum hence the alternative name of jejunal hemorrhage syndrome. The exact etiology is still under debate but is primarily thought to be due to Clostridium perfringens Type A or a fungal infection. The prognosis for these cattle is poor as 77% of cattle do not survive and those that do survive may have a recurrence of HBS.

Identified risk factors:

- Dairy cows > beef cows
- Early lactation
- High milk producers, fed silage or total mixed ration
- Free choice feeding
- Breed: Holsteins and Brown Swiss

Clinical Evaluation: Cows with HBE may be found suddenly dead in the field or present with severe colic, apparent depression, recumbent and lethargic. Given the severity of the disease, they will have significant dehydration and **hypovolemic shock.** Depending on location and duration, you may palpate distended loops of small intestine in conjunction with melena or scant feces containing blood clots. Ultrasound findings include distended, amotile loops of small intestine

Diagnosis: Presumptive based on clinical findings or confirmed via abdominal exploratory by identifying a movable, spongy, friable obstruction. Cows can ping if the blood clot obstructs the lumen (common) and often have blood in the feces. Differentials include coccidia (hemorrhagic diarrhea) and other SI lesions.

focal necrohemorrhagic enteritis of the distal SI

large blood clot occluding the jejunum

Treatment: Given the poor prognosis, euthanasia is typically recommended. For producers or owners that want to pursue treatment, three surgical option have been described: manual clot dissolution with massage, clot removal via enterotomy, or resection and anastomosis of affected intestines. One report found improved survival of surgical cases that utilized manual clot dissolution. A few successful cases of medical management with or without surgical dissolution have been reported using penicillin and multimodel analgesics/sedation (flunixin, butorphanol, xylazine and lidocaine CRI).

Resources

Medical Management HBS in Beef Cow Case Rep Vet Med. 2019

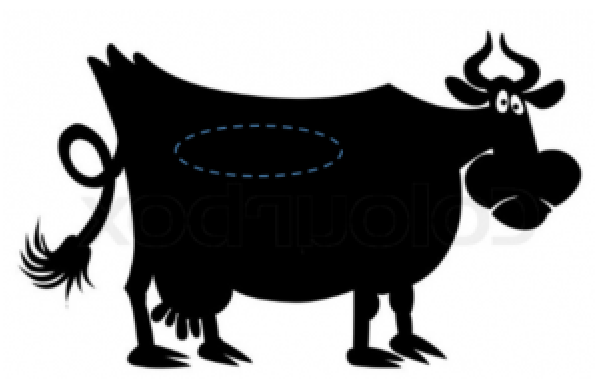
Hemorrhagic bowel syndrome in 22 dairy cows JAVMA 221(5):686-9

Cecal dilatation

Cecal dilation is a relatively common disorder in postpartum dairy cows.

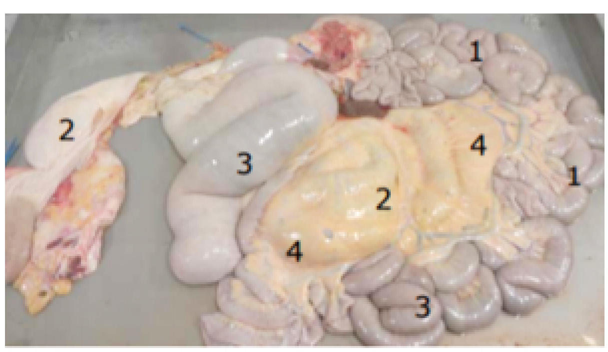
Signalment : same as LDAs– dairy cattle in the first 6-8 weeks after parturition, particularly those with other disorders. In the first few days after parturition, cecal dilation is seen in those cows with hypocalcemia. [Hypocalcemia occurs due to the heavy shift of calcium to milk production.].

Clinical signs : Right sided ping, extending horizontally below the transverse processes. The ping may extend up to 3 feet long. Cows with hypocalcemia often have cold ears and slow PLR. Cattle with hypocalcemia may have overall gut stasis and also have signs of rumen bloat. The ping may resemble an RDA except it is more horizontal and extends further caudally.



Rectal examination : A large viscus (long balloon) can be palpated in the pelvic inlet to the right of midline

Treatment: while cattle may respond to medical therapy (calcium supplementation), surgery can help by relieving the distension. The cecum is approached via right paralumbar fossa incision. In most cases, the distended cecum is readily identified with palpation on the inner aspect of the omental sling. The bovine cecum is just a plain sac- no bands or sacculations.



3= cecum

The cecum can be exteriorized for gas decompression (10-14ga needle inserted through a cruciate suture) or via typhlotomy (incision at the tip of the cecum).

The cecum may twist (cecal volvulus), causing ischemic necrosis. These cattle may show signs of colic. If cecal necrosis is identified, the necrotic portion of the cecum can be removed (typhlectomy) via standing surgery.

Resources

Surgery of the bovine large intestine, VCNA 2008

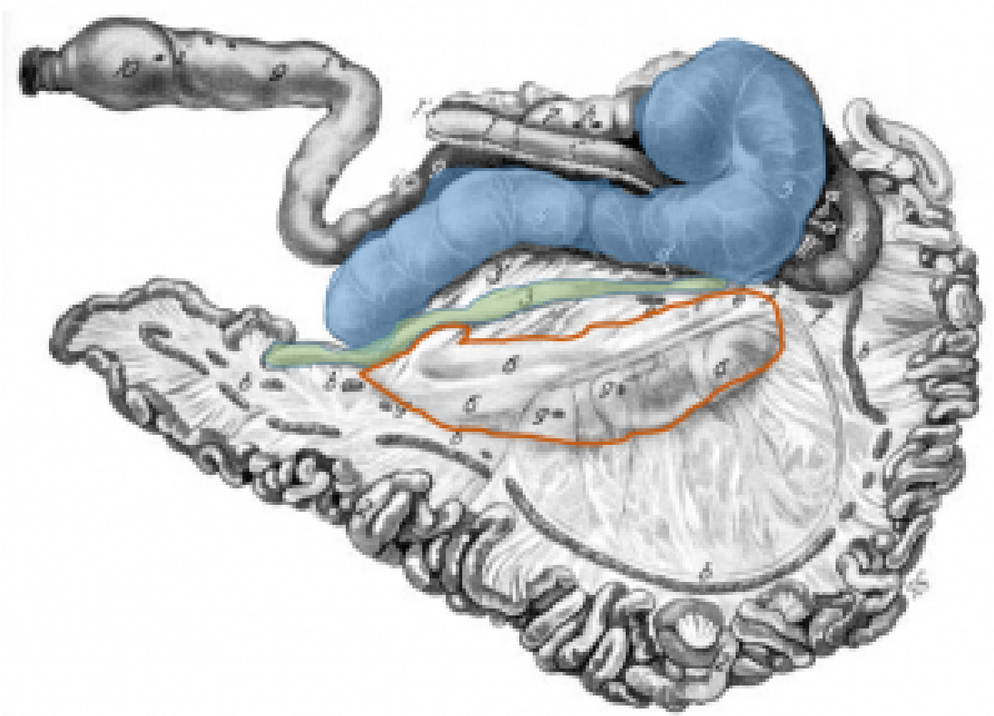
Clinical findings and treatment in cows with caecal dilatation, Vet Record 2012

How to - Typhlotomy

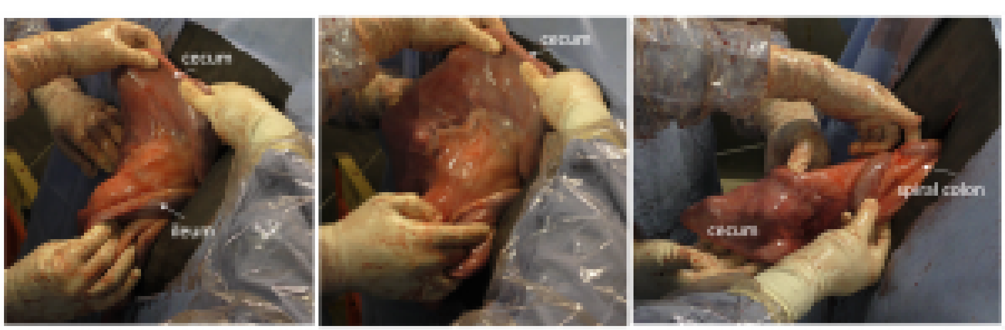
Indications

Typhlotomy is performed to quickly remove fermenting contents in cattle with enlarged ceca due to hypocalcemia and poor motility and with cecal displacements and torsions.

Relevant anatomy



Cecum (blue), and ileum (green) are visible. The spiral colon (orange) is visible through the jejunal omentum.



The cecum is a blind ended sac with the tip pointing caudally. It is connected to the spiral colon dorsally and to the ileum ventrally. It has no identifiable features on palpation in the abdomen but is usually found sitting on top of the viscera between the rumen and omental sling. When distended it is easier to find and will usually protrude out the incision. It can distend to up to 3 feet, creating a "ping" that runs the length of the abdomen below the transverse processes. It is not tacked to the body wall so can displace and can twist on its long axis.

Preoperative management

Food restrictions: NA

NSAIDs/analgesics: Recommended preoperatively. Flunixin meglumine 1.1-2.2 mg/kg iv is standard.

Antibiotics:Recommended. As cows can wall off infection, there can be surprises inside. If beef or non-lactating cattle, ceftiofur 2.2 mg/kg im is standard. In dairy cows, other options do exist. Remember: the label dose of procaine penicillin is ineffective!

Other: If the cow has signs of hypocalcemia (cold ear tips, slow PLR), calcium should be started.

Local blocks: A line block, inverted L or paravertebral are all reasonable options.

Position/preparation: See How to- Standing GI Surgery

Surgery Supplies- Additional

- Extra sleeves and gloves
- Additional laceration or surgery pack is ideal
- Sterile saline for lavage
- Sterile assistant
- Lap sponge forceps -optional
- 3-0 absorbable suture (taper needle) for typhlotomy
- DA simplex – long flexible tubing attached to a 10ga needle for viscus decompression -optional
- Biopsy instruments and formalin- optional

Surgery Supplies – Standard

- Standard surgery pack
- Sterile sleeves for internal palpation
- Scalpel blade and handle
- 2 or 3 absorbable suture material for muscle closure
- 3+ nonabsorbable suture material for skin closure

Surgical procedure

See How to- Standing GI Surgery and How to – Abdominal Exploratory

It may not be possible to complete the exploratory until after the typhlotomy but it should be attempted to minimize contamination risk.

Instruments should be separated into typhlotomy (will be dirty) and closure sets (should stay clean). The typhlotomy set should include a scalpel blade, sterile saline, gauzes, needle holders, suture, scissors and lap sponge forceps or large hemostats. The closure set (the rest of the instruments) should be covered to minimize the risk of contamination.

The surgeon and assistant surgeon should wear sterile sleeves and overgloves to ease clean up after the typhlotomy.

Exteriorize the cecum as much as possible.

The assistant is in charge of making sure the cecal contents and lavage fluid do not go into the abdomen. The assistant should hold the cecum near the tip but not at the tip. This will allow the assistant to direct the contents away from the abdomen and to keep the fluid flow downhill.

Create a 3-5 cm incision at the tip of the cecum. Use the sponge forceps or large clamp to pull out any obstructing chunks so the cecum empties as much as possible. Saline lavage can be provided by the sterile team or by an unsterile assistant.

Once the cecum is emptied, the assistant should elevate the tip of the cecum so that the incision is no longer ventral. This will minimize continued ingesta flow and keep the cecal incision clean for closure. The incision line is flushed gently (be careful of flush wanting to go back into the cow) and cleaned of any gross debris. The incision is closed with a double **inverting** pattern or a single continuous Lembert. It is important to ensure this line is tight. Midway through the pattern and at the end, hold the working end of the suture in your right hand and use the left to slide down the suture, pushing the sutured cecal tissue toward the suture knot. The cecum will gather slightly but leaks will be minimized. Once the closure is complete, the cecum is again cleaned and returned to the abdomen.

Occasionally the cecum will quickly refill. The incision can be opened and the process repeated.

The typhlotomy pack is covered or removed and the dirty sleeves and gloves removed. The remainder of the procedure can be completed as described in How to- Standing GI Surgery, making sure the cecum is in its normal position with the tip pointing caudally.

Postoperative care

- Antibiotics and NSAIDs should be continued for at least 3 days.
- Monitor calcium levels and for signs of peritonitis

Complications

- Peritonitis
- Incisional infection
- Continued motility disturbances

Videos

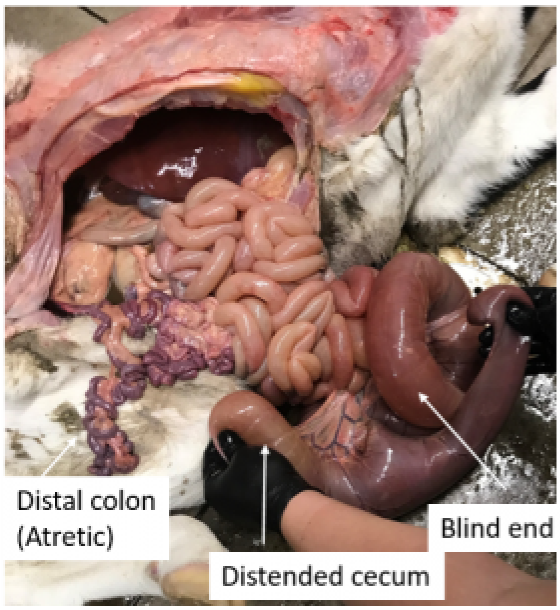
youtube video 1

youtube video 2

Resources

Colon and rectal disorders

Calves may be born with colonic atresia. Colonic atresia has been associated with early pregnancy palpation and as an genetic anomaly in Holsteins. Most of these cases involve a large gap between the proximal end of the colon and the part attached to the rectum. Calves will present at 1-2 days of age with abdominal distension. No manure will be present in the rectum. As it is easy to perforate the distal segment, diagnosis is usually made by exploratory laparotomy or based on clinical signs. In many cases, calves have peritonitis at the time of diagnosis.



In some calves, the ends will not reach and anastomosis is not possible. In others, anastomosis can be done but motility never recovers. The latest recommendation is to perform a colostomy to enable to the calf to reach market weight.

Modified colostomy technique for colonic atresia in calves, Vet Surgery 39(6):722-728, 2010

Other colon disorders include luminal or extraluminal obstruction (often by saponified hardened fat). The spiral colon is hard to exteriorize so surgery is challenging and often unrewarding.

Rectal abscesses are possible but not common.

Rectal prolapse occurs fairly commonly in calves with parasite infestations or chronic coughs. If undamaged, the rectum is cleaned and replaced under epidural anesthesia. A **purse string suture** is placed in the rectum to retain it until the straining stops. If damaged, the mucosa can be resected or the damaged area amputated.

Small ruminants

Small ruminants are not particularly predisposed to GI disorders except for bloat (eating too much fermentable feedstuffs). The most common surgery is a rumenotomy for gastric indiscretion. Small ruminants are not likely to stand for surgery so rumenotomy is typically performed with the animal in right lateral recumbency and under GA or heavy sedation. In most cases, the rumen will be distended and impairing respiration due to pressure on the diaphragm. The enlarged rumen will also make regurgitation very likely. Intubation allows better oxygenation, ventilation, more stable anesthesia management via inhalant anesthesia and minimizes the risk of aspiration if/when regurgitation occurs. Most small ruminants can be managed on standard surgery tables and with SA anesthesia machines.

Since GI disorders are uncommon, it is important to rule out urolithiasis as a cause of the abdominal distress.

> If goats and sheep do go off feed, they are very prone to neurological disorders related to thiamine deficiency. Give B vitamins.

Camelids

The most common cause of abdominal pain in camelids is uterine torsion. This is treated by rolling and/or abdominal surgery to detorse the uterus. The cria is usually close to term.

Camelids do occasionally need C1-otomies for gastric indiscretion or **impactions**. C3 ulcers present as mild colic but are not usually treated surgically. Camelids do form trichophytobezoars (hair+plant balls) and **enteroliths** that tend to lodge in the duodenum or spiral colon. GI tumors are also possible. Spiral colon obstruction is typically by enterolith. The spiral colon in camelids is tightly wound and more prone to obstruction than cattle. These camelids present with worsening signs of abdominal pain and decreasing manure production. Most camelids do NOT develop hypochloremic metabolic alkalosis. They do tend to become hypokalemic. Blood chloride values are not as useful as in cattle for identifying pyloric obstructions but C1 chloride levels have been found to be elevated with such lesions. Ultrasound guided abdominocentesis may also be useful. Barium studies can be useful for identifying obstructions in smaller animals.

Camelids do not typically show obvious colic signs. Abdominal exploratory should be considered with persistent, low-grade discomfort in a treated animal. Ultrasound is a key diagnostic tool for camelids. Digital rectal examination can be used to assess for feces; rectal palpation is often tricky and dangerous due to their smaller size. SI lesions will lead to more severe signs and more rapidly due to the normally high rate of secretions and fluid absorption.

Unlike cattle, the most common approach to GI obstructions or for GI exploratory is via a ventral approach under general anesthesia versus right paralumbar fossa in the standing animal. If a C1 lesion is expected, the incision is made in the left paralumbar fossa. For C2/C3, the incision is made either in the right paralumbar fossa or ventrally.
.

> Duodenal obstruction due to trichobezoars (hair balls) do present differently and require a different surgical approach. Duodenal obstruction leads to abdominal distension due to blockage of C3 outflow and to hypochloremic metabolic alkalosis. The duodenum is best accessed via a right paracostal incision (next to the rib).

Postoperative care often includes treatment with sucralfate and/or omeprazole to minimize the risk of gastric ulcer formation. Other complications include adhesions (between bowel loops) and stricture formation.

Other camelid disorders

Camelids are prone to megaesophagus and tooth root infections. Tooth root infections present as a draining tract or facial swelling and can sometimes be treated by prolonged antibiotic therapy but removal is often needed. Teeth are removed by oral extraction or by lateral buccotomy (bone flap).

Rectal prolapses are not uncommon. These are most frequently associated with straining due to parturition, urolithiasis, coughing or parasites. Once the swelling is reduced using osmotic agents, most can be replaced and kept in position with a **purse string suture**. Resection may help minimize recurrence if needed.

Camelids may also have atresia ani. If it is a female, affected animals often have a rectovaginal fistula so they are able to pass manure. Owners may be unaware of the atresia. Males will develop severe obstipation at an early age.

> Camelids that are off feed are prone to metabolic disorders related to fat mobilization. Ensure nutritional support!

Resources

Abdominal imaging in small ruminants: liver, spleen, gastrointestinal tract, and lymph nodes. VCNA FA 37 (2021): 55-74

Trichophytobezoar duodenal obstruction in New World camelids. Vet Surg 2005;34(5):524-9

Surgery of the gastrointestinal tract in camelids Part I AABP 2009; KD Newman, DE Anderson

Porcine GI issues

Pig Gastrointestinal Foreign Bodies

Given normal foraging and rooting behavior, pigs are at a high risk of developing gastrointestinal foreign bodies, especially pet pigs. Additional causes of gastrointestinal obstruction include adhesions (secondary to a previous surgery), intussusception, neoplasia (adenocarcinoma) and fecal **impactions**.

- Clinical signs: Vomiting. lethargy, anorexia, decreased fecal output and abdominal distension.
- Physical exam: Tachycardia, tachypnea, abdominal distention and pain on palpation.
- Diagnostics: Similar to a workup in the acute abdomen in dogs and cats including blood work, abdominal radiographs +/- contrast studies, and ultrasound.
    - CBC: Varies stress leukogram, inflammatory leukogram, or leukopenia +/- left shift inflammation leukogram (depending on severity)
- Stabilization: Owners may have a difficult time finding a veterinarian willing to treat a pet pig and pigs may present days to weeks after the initial clinical signs started. Pigs may present with hypothermia, dehydration, electrolyte abnormalities, and metabolic alkalosis due to vomiting and intestinal obstruction. As with most species, warming and administration of fluid therapy and correction of electrolyte abnormalities is essential for stabilization.
    - Hypochloremia, metabolic alkalosis
    - hyponatremia
- Most likely location of obstruction: stomach and small intestine (jejunum or duodenum). Can also obstruct in the spiral colon, transverse or descending colon
- Treatment: Typically requires surgical intervention
    - Ventral midline approach
    - Enterotomy and resection and anastomosis techniques similar to what is performed in dogs and cats
- Prevention: Rooting box in housed, pet pigs. Locks on cabinets and pantry doors.
- Differentials: Over-eating and viral or bacterial causes in young pigs
- Post-operative complications: A common complication in pigs with abdominal surgery is adhesion formation. Pigs may present in the future with abdominal pain due to a gastrointestinal obstruction from adhesions, or adherence of the gastrointestinal tract to the body wall. Therefore, it is not uncommon for pigs who have been spayed to have GI obstruction secondary to adhesions.

Additional Resources:

Evaluation of the reasons for and outcomes of gastrointestinal tract surgery in pet pigs

A case of a linear foreign body removal in a miniature companion pig

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=4569#h5p-106

How to - Rectal prolapse submucosal resection

Indications

Submucosal resection is indicated when a prolapse is too damaged to be replaced but the damage is restricted to the mucosal layer, when the prolapse cannot be effectively reduced with osmotic agents only, or when the prolapse has recurred. A resection decreases the size of the tissue and minimizes the amount of tissue that can prolapse.

Relevant anatomy

The exposed tissue is mucosa.

Preoperative management

Food restrictions: NA

NSAIDs/analgesics: NSAIDs and an epidural are indicated.

Antibiotics: Preoperative antibiotics are indicated.

Tetanus prophylaxis is recommended for small ruminants.

Local blocks: Epidural. Lidocaine may also be infused into the rectum.

Position/preparation: Standing procedure if possible; otherwise sternal recumbency. The tail should be tied or taped away from the surgical field.

Surgery Supplies:

- Scalpel
- Needle holders
- Hemostats
- Thumb forceps
- Suture – 2-0 or 3-0 absorbable, taper needle
- Spinal needles to hold the rectum out while suturing
- Syringe case (rectal lumen diameter)

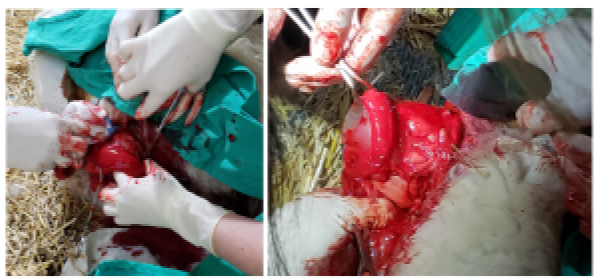
Surgical procedure

- Use older (duller) spinal needles to keep the rectum prolapsed while working. A syringe case is useful to keep the lumen identified and open.

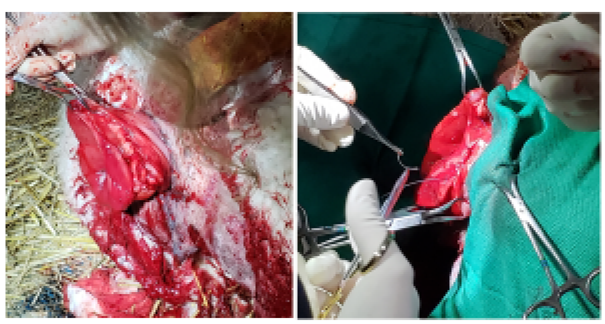
- Create two 360^o incisions to the depth of the submucosal layer. The first should be as close to the anus as possible, the second as distal as possible.

- Connect the two 360^o circles with a vertical incision to the same depth

Starting at the connecting line, dissect off the mucosa to the submucosal layer. Continue around the full circumference.



Suture the two 360^{0} incisions back together using a continuous pattern. Tie a knot midway to avoid a pursestring effect.

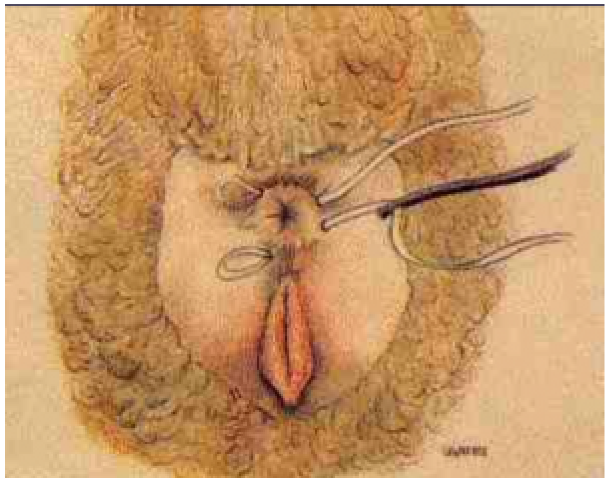


- Remove any spinal needles and syringe case.

Postoperative care

- Use a **purse string suture** around the rectum to keep the tissue in place

- tie to the side and leave in place for one week
- ensure opening is large enough for pellets to be evacuated



From: Rectal prolapse in food animals Part I. Comp Cont Educ 1991.

- Maintain soft feces using a legume diet and laxatives
- Continue NSAIDS for at least 3 days
- Epidural or lidocaine infusion if straining continues

Complications

This technique has fewer related complications than the amputation but recurrence is possible.

Videos

youtube video 1

Resources

Rectal Prolapse. Vet Clin NA FA 24 (2008) 403–408

How to - Rectal prolapse amputation

Indications

Rectal prolapse amputation is indicated in cases of rectal prolapse that are associated with full thickness damage or when facilities do not permit submucosal resection.

Relevant anatomy

The exposed tissue is mucosa.

Preoperative management

Food restrictions: NA

NSAIDs/analgesics: NSAIDs and an epidural are indicated.

Antibiotics: Preoperative antibiotics are indicated.

Tetanus prophylaxis is recommended for small ruminants.

Local blocks: Epidural. Lidocaine may also be infused into the rectum.

Position/preparation: Standing procedure if possible; otherwise sternal recumbency. The tail should be tied or taped away from the surgical field.

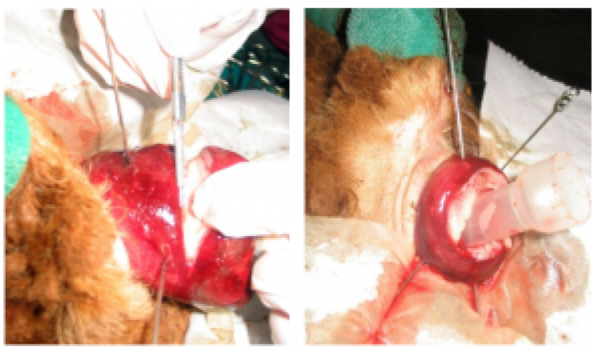
Surgery Supplies:

- Scalpel
- Needle holders
- Hemostats
- Thumb forceps
- Suture – 2-0 or 3-0 absorbable, taper needle
- Spinal needles to hold the rectum out while suturing
- Syringe case (rectal lumen diameter)

Surgical procedure

- Use older (duller) spinal needles to keep the rectum prolapsed while working. A syringe case is useful to keep the lumen identified and open.

- A full thickness incision is made distal to the spinal needles, cutting down to the syringe case.

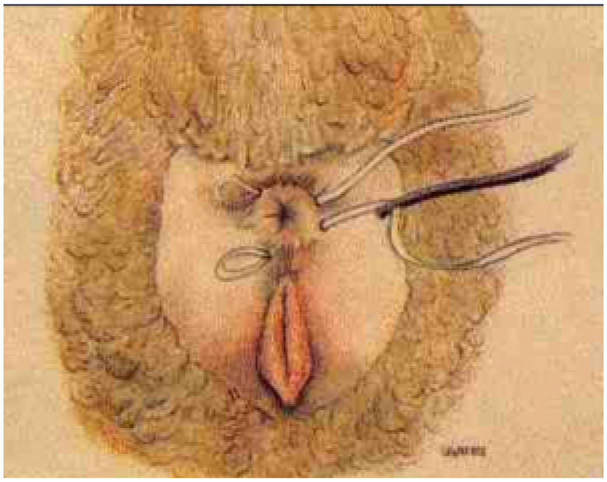


- Suture the mucosa to the serosa in a continuous pattern. Stop part way and tie a knot to avoid a pursestring effect. [Yes, the image below shows interrupted sutures]

- Remove the spinal needles and syringe case and return to the rectum.

Postoperative care

- Use a **purse string suture** around the rectum to keep the tissue in place
  - tie to the side and leave in place for one week
  - ensure opening is large enough for pellets to be evacuated



From: Rectal prolapse in food animals Part I. Comp Cont Educ 1991.

- Maintain soft feces using a legume diet and laxatives
- Continue NSAIDS for at least 3 days
- Epidural or lidocaine infusion if straining continues

Complications

This procedure does increase the risk of rectal stricture. **Dehiscence** is also possible and would further increase the risk of stricture as well as perirectal abscessation.

Videos

Resources

Rectal Prolapse. Vet Clin NA FA 24 (2008) 403–408

Practice

Practice Level A and NAVLE review

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Practice- Level B

Try the dairy cases at the UPenn field service site

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https://open.lib.umn.edu/largeanimalsurgery/?p=2307#h5p-181

FA GI Diagnostics & GI Surgery Principles

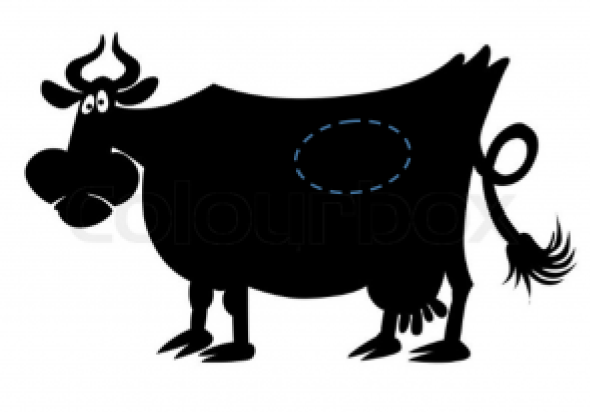
Pings, ultrasounds and standing exploratory surgery. General surgery principles.

Ruminant Pings

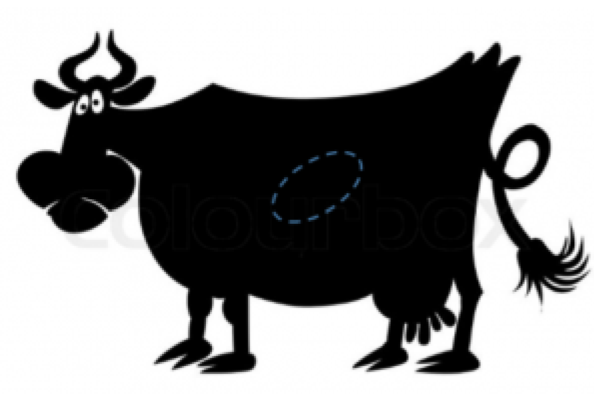
Pings are areas of resonance that develop at a gas-fluid interface. When the area is percussed (tapped firmly), a high pitched sound can be heard through a stethoscope. They are not heard in normal animals. Hear a great ping at the UPenn dairy case site.

Left sided pings

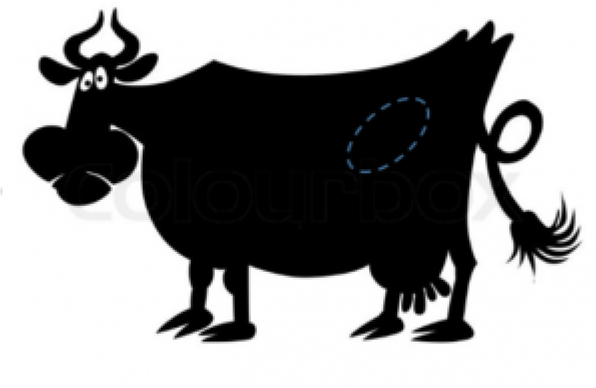
- Rumen – high horizontal ping. Can be heard with pinging the transverse processes
- LDA – ping at angle from the hip bones to the elbow. Is not heard when pinging the transverse processes
    - If it stays low, there are likely adhesions preventing the gas from floating up
- Uterus (bilateral) – caudal ping
- Pneumoperitoneum (bilateral) – high ping (gas floats)



Rumen or pneumoperitoneum ping.



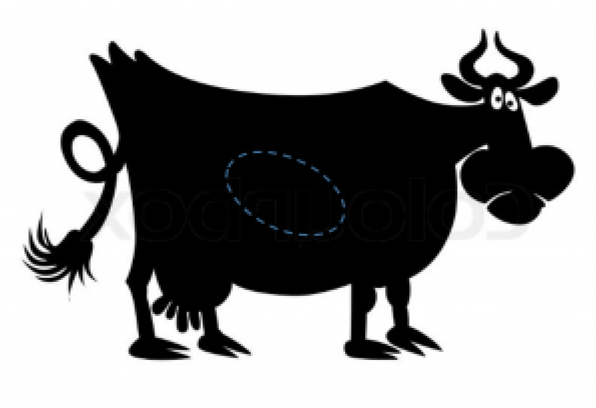
LDA



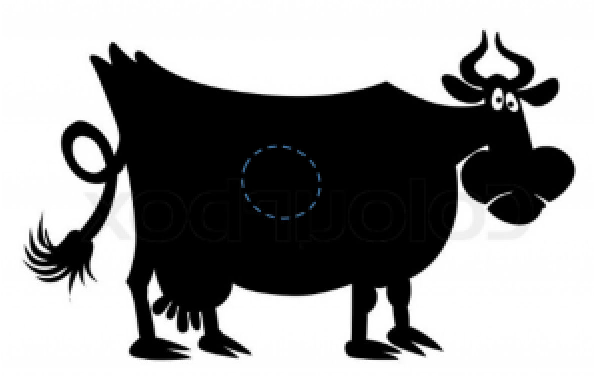
Uterus

Right sided pings

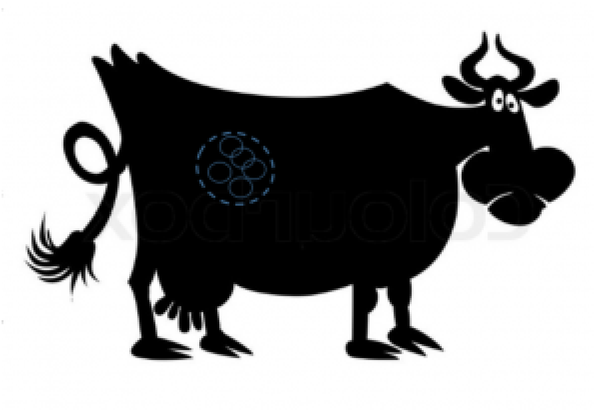
- duodenum – crosses the paralumbar fossa and forward under the last two rib spaces. Can be quite large and difficult to differentiate from other pings
- abomasum- on an angle from the hip bones to the elbow. Abomasal volvulus and RDAs have the same ping
- small intestine – multiple tones in the paralumbar fossa
- cecum- large ping extending horizontally below the transverse processes; can extend up to 3 feet long
- spiral colon – multiple tones in the paralumbar fossa
- uterus (bilateral)- caudal ping
- pneumoperitoneum (bilateral)- high ping
- rectum (post palpation)- caudal ping



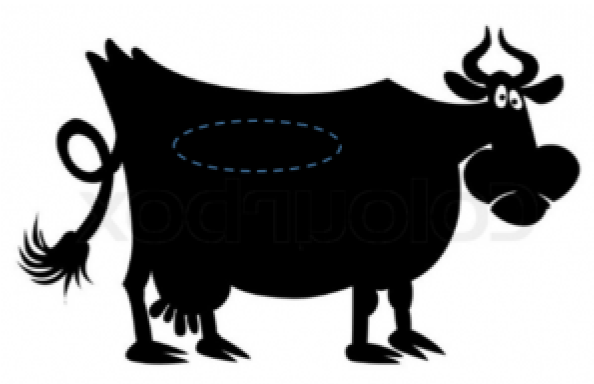
RDA or abomasal volvulus



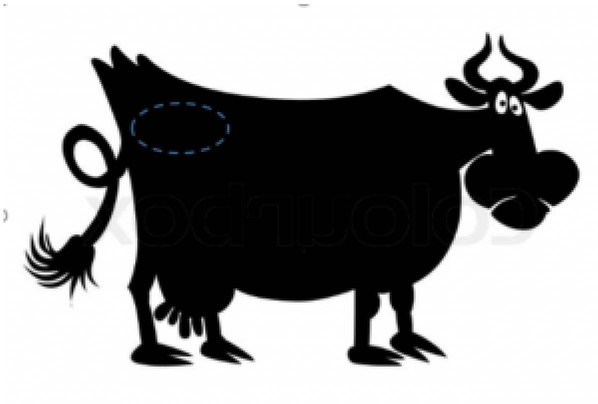
Duodenal ping



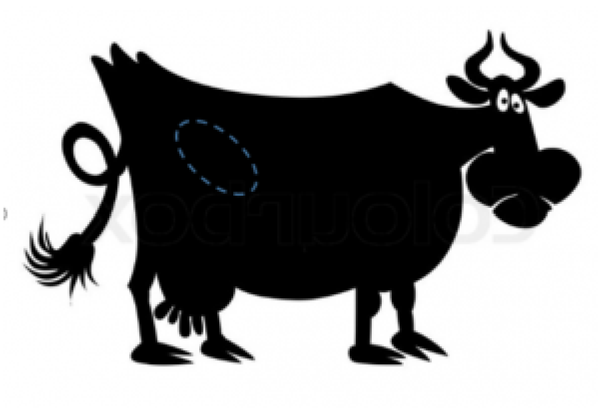
Spiral colon or small intestinal pings



cecum or pneumoperitoneum



rectal ping



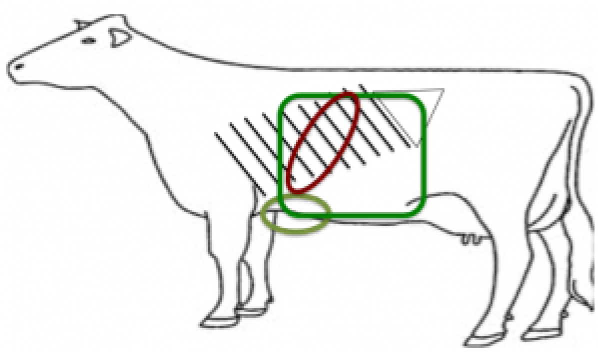
uterus

Abdominal ultrasound

Ultrasound is a valuable tool for identifying peritoneal and GI tract abnormalities in cattle. Many structures look similar when normal; location is an important key as is knowing the normal sonographic appearance. Most of these evaluations can be performed with a linear probe.

Start by scanning ventrally for fluid pockets. Check to the right of midline and under the flank fold, just beside the udder.

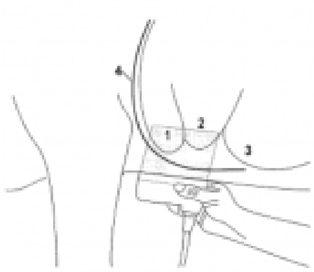
Left side evaluation



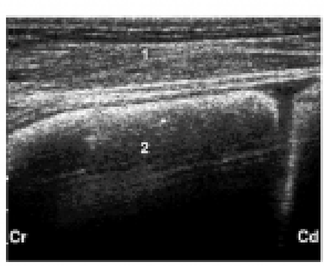
Left side structures are the reticulum, rumen, and spleen.

Reticulum

The reticulum can be visualized both the left and right of the sternum, ventral to the point of the elbow.



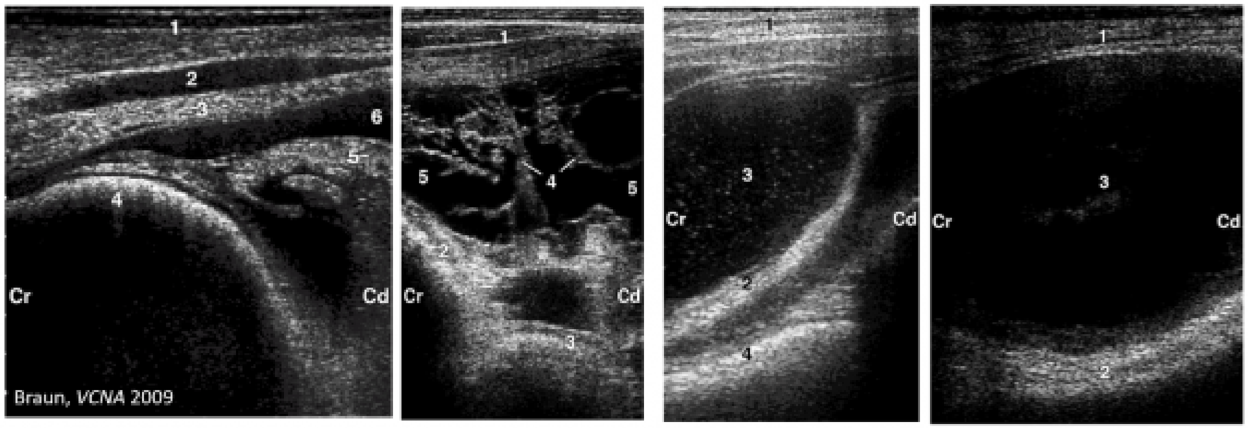
Braun, Vet J 2003



Braun, VCNA 2009

The reticulum normally has a half-moon shape. Due to the gas content, foreign bodies and magnets are not visible. In this diagram, 1 is the reticulum, 2 is the craniodorsal blind sac of the rumen, and 3 is the ventral sac of the rumen. Regular contractions that can be evaluated to determine whether motility is normal. The reticulum should have one biphasic contraction per minute; this is typically immediately followed by a rumen contraction.

Scan the caudoventral reticular wall to evaluate for hardware related reticuloperitonitis and reticular abscesses.

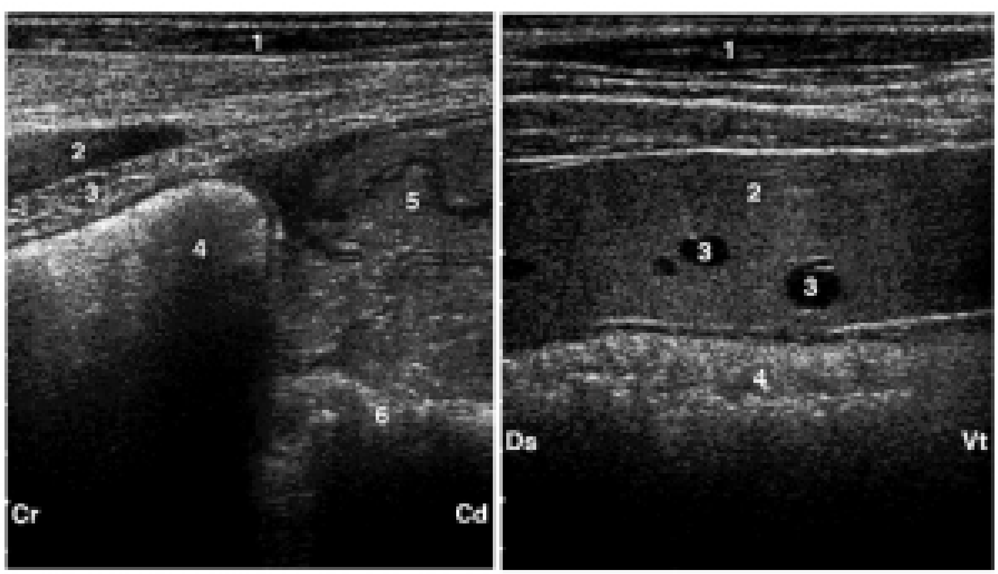


Reticuloperitonitis

Reticular abscess

Rumen

The rumen is visible along most of the left side. The gas cap means only the external layer is visible dorsally. More fluid contents can be seen ventrally.



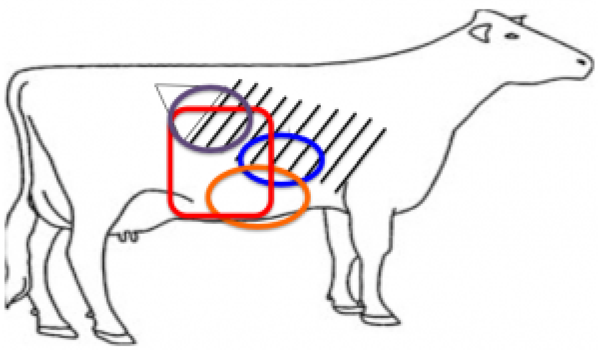
From Braun, VCNA 2009. 6 is rumen

4 is rumen, 2 is spleen

Spleen

The spleen has a hyperechoic texture with prominent vessels. Occasional abscesses can be observed within the spleen.

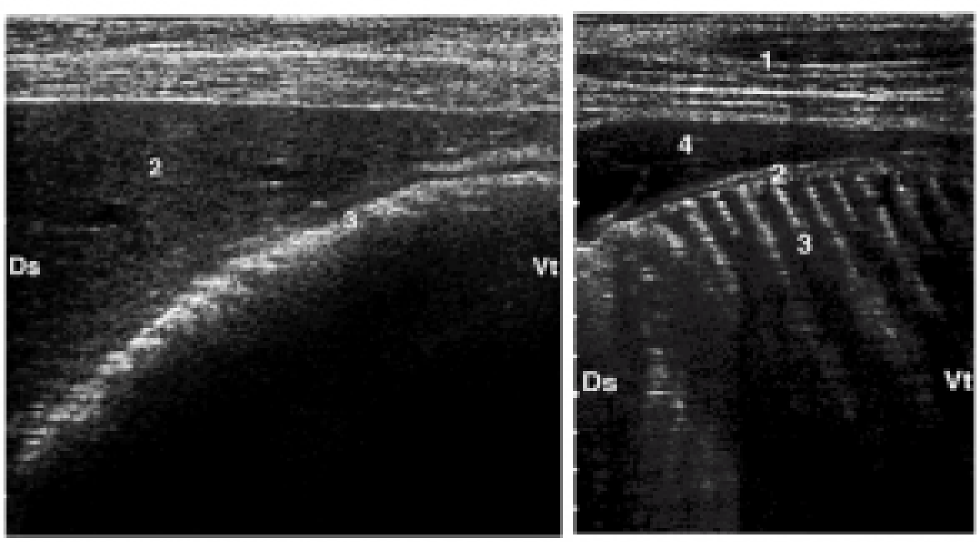
Right side evaluation



Structures on the right side include the omasum, abomasum, small intestine and large intestine.

Omasum

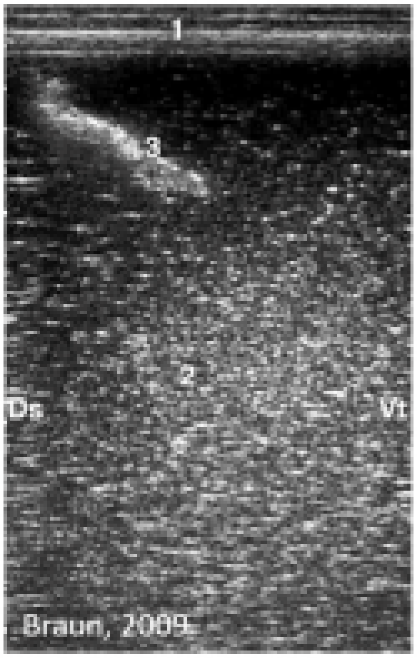
The omasum is a crescent shaped structure on the right, in the 6th to 11th intercostal spaces (ICS). It is easiest to see in the 9th ICS since it is closest the body wall in the 8th-9th ICS. The omasum should not contract. The leaves are not visible unless there is fluid reflux from the abomasum.



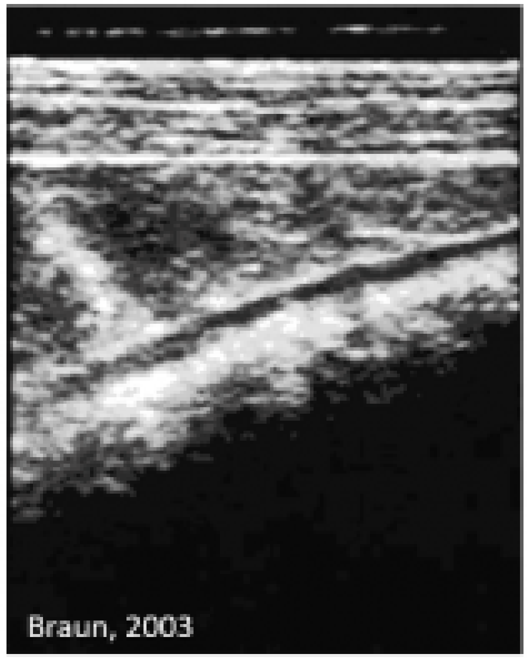
Normal omasum   Omasum with fluid reflux

Abomasum

The abomasum is typically found 10 cm caudal to xiphoid on the midline and just to either side.
Contents have a heterogenous echogenicity. A dorsal gas cap may be evident normally and is typically the only change seen with displaced abomasum. Location is important for diagnosis. With an RDA, the normal liver is blocked by the displaced gas filled abomasum.
No obvious changes are visible with abomasal ulceration unless peritonitis occurs.



Normal abomasum

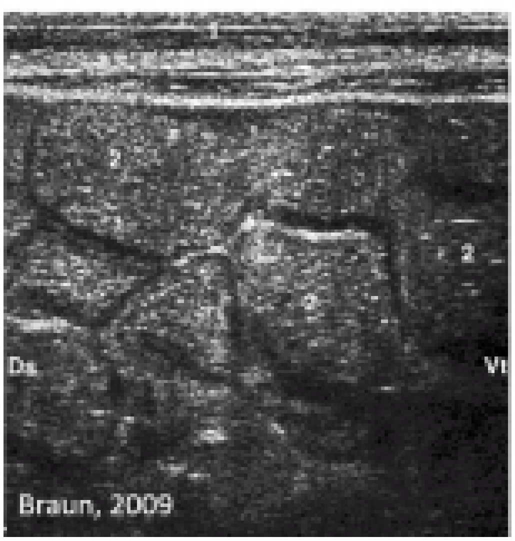


Displaced abomasum with gas cap

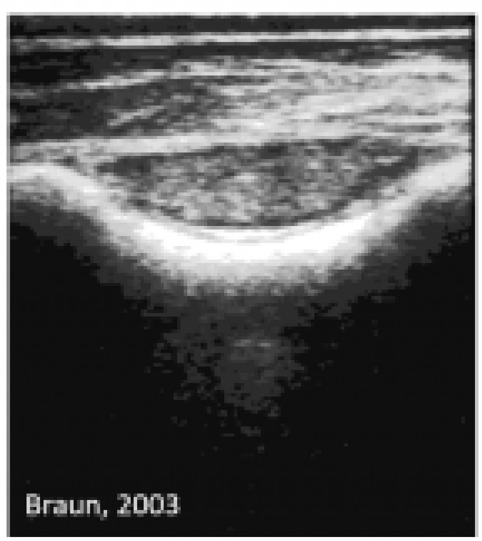
Small Intestine

Small intestine is visible ultrasonographically from the tuber coxae to the 8th ICS ranging from the transverse processes dorsally to the midline ventrally.

The duodenum is wrapped in omentum in the central aspect of the right paralumbar fossa.

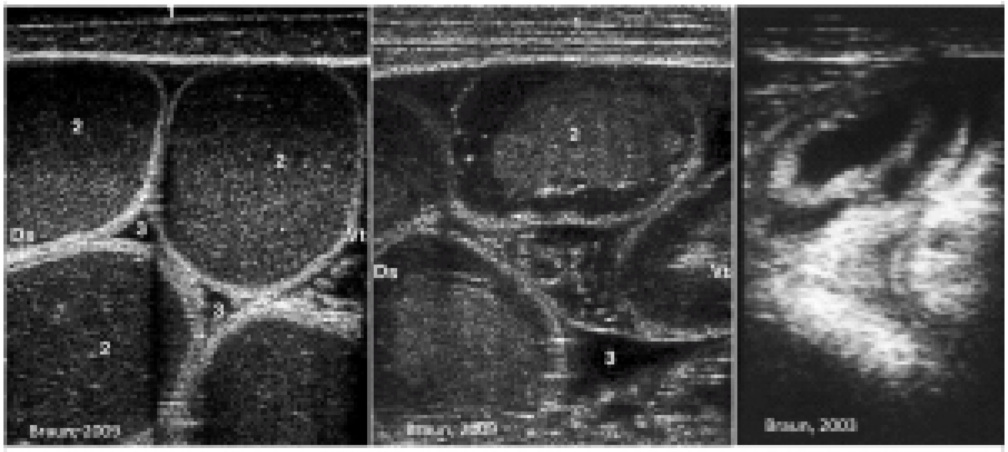


Normal small intestines



Normal duodenum

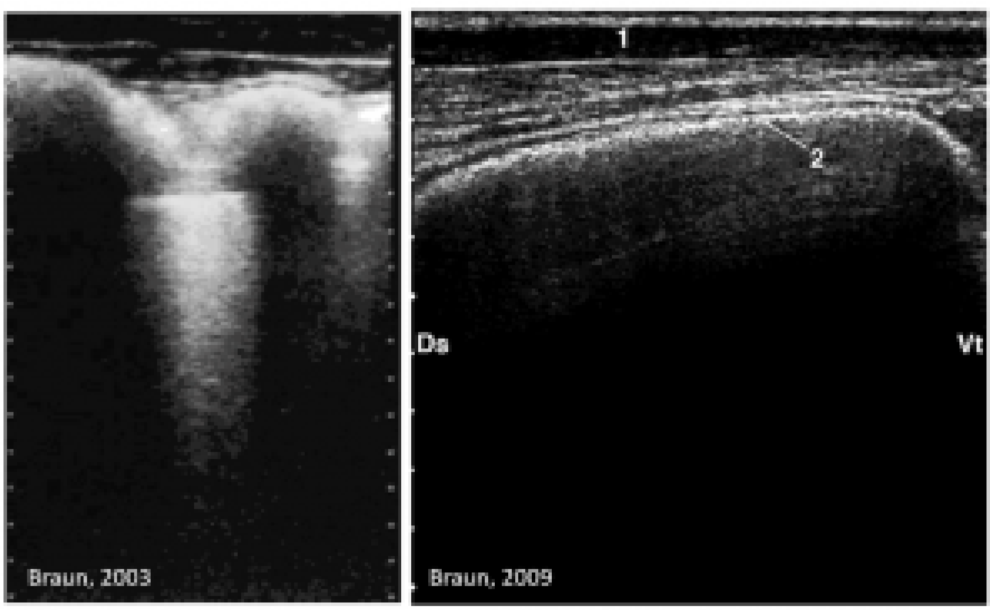
Detectable abnormalities include intestinal ileus or motility disturbances, hemorrhagic bowel syndrome and intussusceptions.



Anotile intestinal loops Hemorrhagic bowel syndrome Intussusception

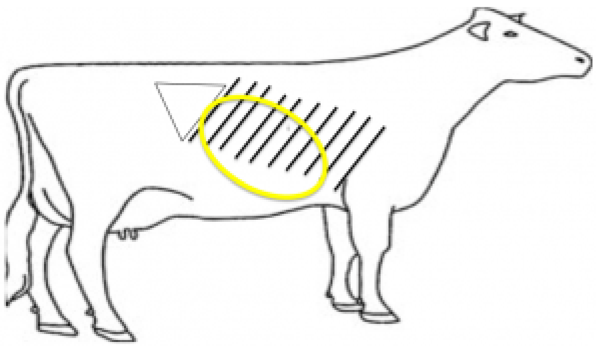
Large Intestine and Cecum

The large intestine is a gas filled structure medial to the descending duodenum. The spiral colon will often have a garland appearance. The cecum is nondescript but can be identified when distended and resonant.



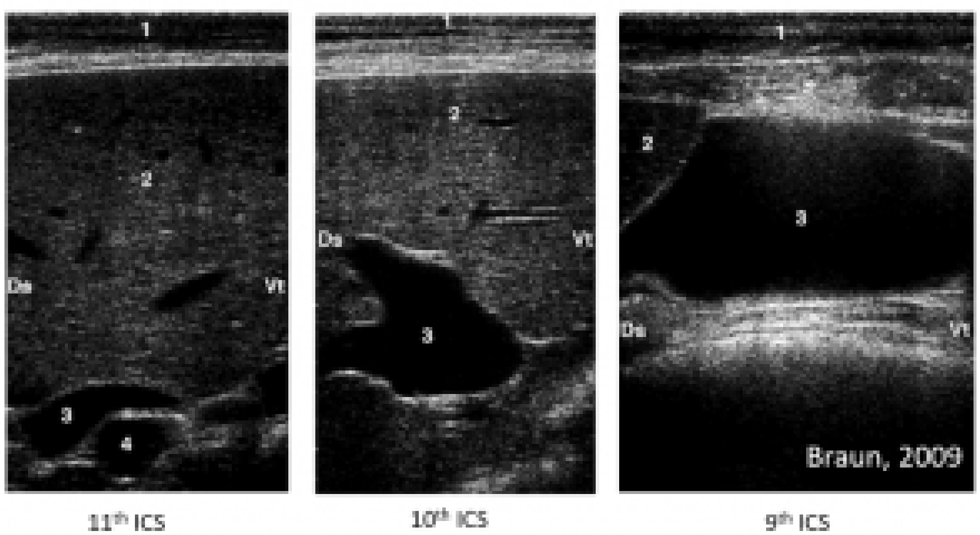
Spiral colon garlands Distended cecum

Liver



The liver is visible ultrasongraphically on the right, extending from just caudal to the last rib up to the 5th ICS. It is often partially obscured by the lung.

Normal liver is fairly homogenous with visible gall bladder and biliary tree.



GI Challenge

Play concentration with lesions and ultrasound images – Level B

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=3133#h5p-178

Resources

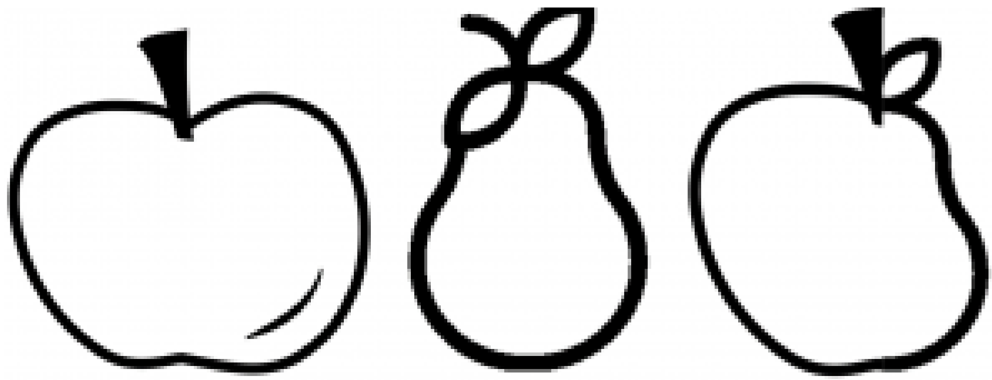
Braun. Ultrasonography of the Gastrointestinal Tract in Cattle. VCNA 25 (2009) 567–590

Braum. Ultrasonography of the Liver in Cattle, VCNA 25(2009) 591-609

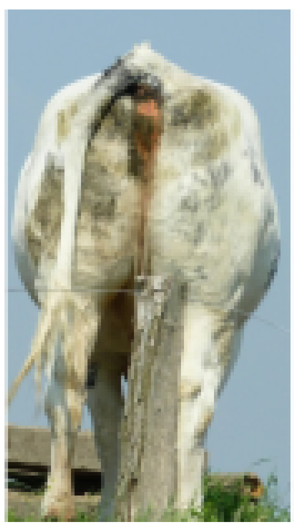
Braun. Ultrasonography in gastrointestinal disease in cattle. The Veterinary Journal, 2003, Vol.166(2), pp.112-124

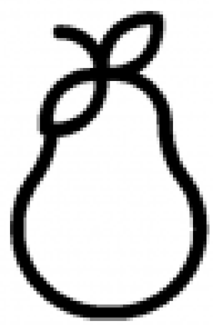
Abdominal contour

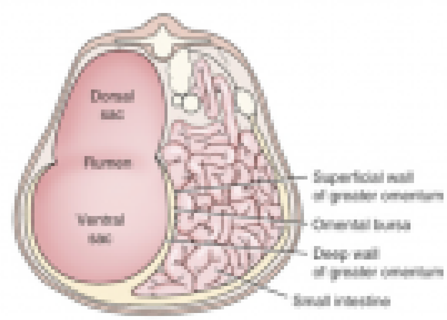
For cattle, we talk about apples, pears and papples. This is related to the outline of the fruit (or cow) from behind.



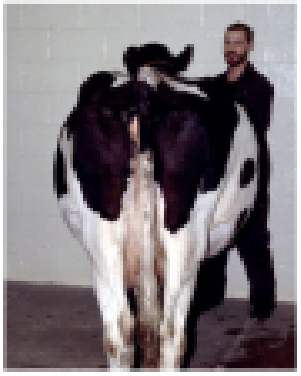
Cattle are usually more pear shaped than anything else.

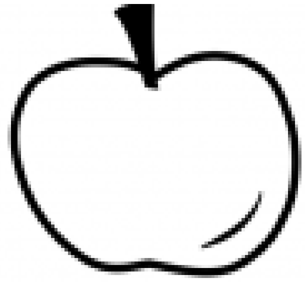


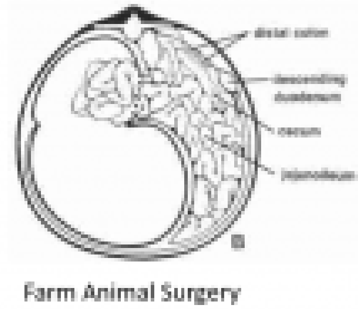




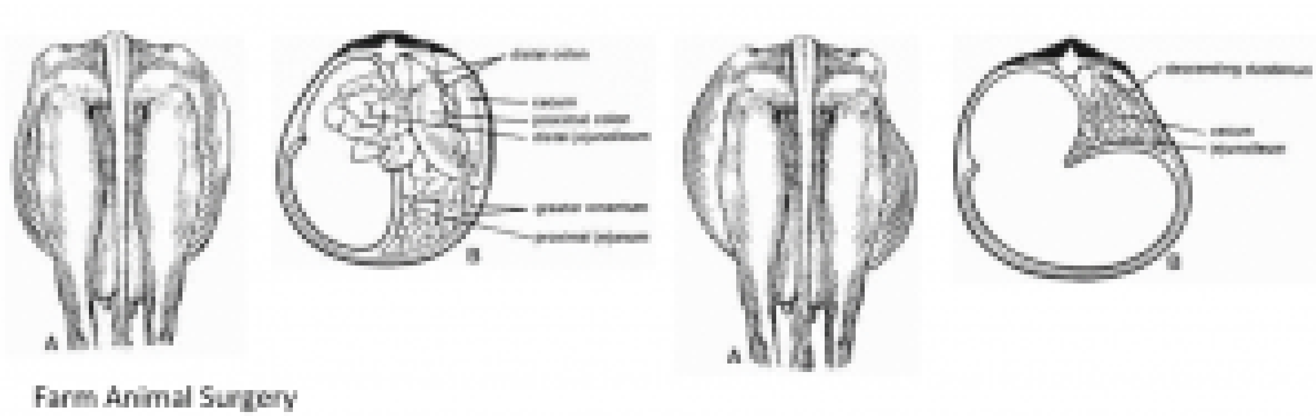
An apple shaped cow would have distension of GI structures on both the right and left. This is usually due to vagal indigestion and reflects poor motility. The rumen causes the distension on the left and structures such as the cecum and spiral colon distend the right.







Papples can be apple on the right or the left. Right sided distension (apple on the right) is typically cecum and/or spiral colon. Left sided distension is usually rumen.



[Management of the colicky cow](), UPenn 2017- good pics

Rectal examination

Rectal examinations in cattle are relatively safe for both the examiner and the animal. Rectal tears are much less common but care should be taken. Epidural lidocaine (3-5 cc) is easy to administer but is generally not required.

Left abdomen

- The rumen should have an indent-able rumen pack and a small gas cap. If another gas distended viscus is present, this is usually an LDA
- The spleen is not normally palpable.

Caudal abdomen

- Ovaries and uterine tone should be checked and compared to the expected stage of gestation
- The bladder and aorta are rarely abnormal
- Sublumbar lymph nodes should be checked to identify possible lymphadenopathy from bovine lymphosarcoma
- Pelvic fractures and hip displacements may be identified on rectal examination

Right abdomen

- Any intestinal distension is abnormal and is usually the cecum, spiral colon or small intestine
    - Explore any cows with palpable small intestine (right flank)
    - Surgery is recommended for many cows with cecal distension; hypocalcemia treatment may resolve it without surgery
- The abomasum is typically not palpable even with RDAs; a palpable abomasum usually means an abomasal volvulus and a very enlarged abomasum (not good)
- Both right and left kidneys are palpable to the right of midline and are normally lobulated
    - Painful kidneys usually indicated pyelonephritis. Kidney removal is doable but generally these cow should be treated medically or culled.

Other diagnostics

Colic signs

Cows do not show pain unless mesenteric traction is involved. Cows with LDAs, RDAs and even abomasal volvulus are off feed and may be recumbent but do not kick at their belly or show classic colic signs. Cows with peritonitis may show abdominal pain on local pressure or may show abdominal splinting (reluctance to scootch) but not obvious colic.

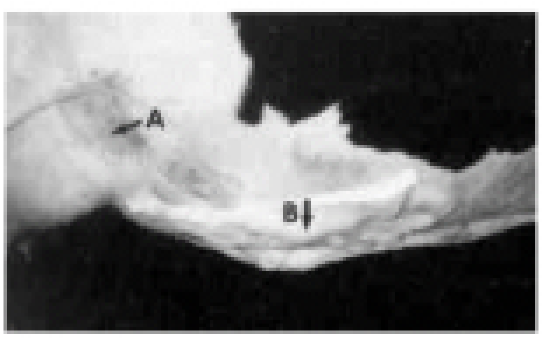
If a cow is kicking at her belly (even once or twice) or is restless, it is a sign of a surgical lesion and she should be explored (right flank). Referral isn't a bad idea as she is likely to go down during surgery.

PCV/TPP

Cows with anemia generally have abomasal ulcers. These cows are generally early lactation and often first calf heifers. Older animals that are anemic and in midgestation should be evaluated for bovine lymphosarcoma.

Abdominocentesis

Abdominal fluid is obtained to the right of midline (the rumen is on midline) and just above the udder. Ultrasound can help identify fluid pockets.



However, cattle are do good at walling off infection that they can have localized peritonitis and have a normal abdominal tap.

Manure type

Lack or decreased manure generally indicates a partial (DA) or full obstruction. Obstruction can be physical but is often functional (nerve or muscle damage)

Fresh blood indicates a distal lesion and is seen with coccidia, trauma, intussuception and hemorrhagic bowel syndrome. Melena is digested blood and often indicates abomasal ulcers

Rumen fluid

With abomasal outflow obstruction, abomasal content backs up into the rumen, lowering the chloride and killing the normal flora. Animals that have been off feed will also change flora as the cow's diet is primarily feeding the flora. No good diet, no good flora. High concentrate diets also change the flora.

Laboratory evaluation

Adult cows with GI lesions usually have metabolic alkalosis. Low chloride levels indicated abomasal outflow obstruction and can be used to localize lesions.

Arrhythmias

Cattle with GI issues can have associated atrial fibrillation. This usually resolves when the GI issue is fixed.

Choosing a surgical approach

Since cows are excellent patients, we often have multiple options for surgery. Localizing the lesion and narrowing the differential list helps the surgeon make the best guess. It is possible to close an approach and create a new incision in the same procedure.

Right paralumbar (right flank) approach

A right flank approach is the best approach for abdominal exploratory in any age ruminant (including calves) due to the left sided rumen. Exploratory surgery is a useful, relatively cheap and easily accessed diagnostic tool in cattle.

Due to the access to most structures, right flank surgery is used for abomasal displacements, intestinal surgery, (small and large) kidney removal (rare), Csections (rare), and for sampling of other right sided structures.

Left paralumbar (left flank) approach

The left flank is used for left displaced abomasum (if the surgeon has long arms), rumen and reticular disorders, esophageal access, dystocias and other disorders localized to the left on ultrasound or imaging. Exploration from the left is limited due to the size of the rumen. Surgeries include

- left flank abomasopexy
- rumenotomy for **hardware**, grain overload or foreign bodies (rumen, omasum or esophagus)
- rumenostomy for chronic bloat or nutritional needs including feeding and rumen flora donors
- Csection
- flank ovariectomy

Right paramedian approach

Midline approaches are not useful due to the location of the rumen. Most ventral incisions are made to the right of midline and cranially (a few inches caudal to the xiphoid) to access the abomasum. This approach provides the only real access to most of the abomasum and is used to fix adhesions and to perform right paramedian abomasopexies. It is also useful for draining liver abscesses as well as abscesses from hardware disease or perforated abomasal ulcers. Exploratory options are poor except in preruminants.

Cows are "cast" into recumbency using ropes and sedation. Feeding troughs can be used for smaller animals, maternity pens or other open spaces for adult animals. The cut out for the manure spreader can be used as a V trough.

Toggle pin procedures are also performed in dorsal recumbency but no incision is made.

Indications

Standing GI surgery is a common field and referral procedure in cattle. Right flank approaches allow for abdominal exploratory, correction of abomasal displacements, **typhlotomy** and other procedures. Left flank approaches allow for rumenotomy, Csection and correction of LDAs.

Relevant anatomy

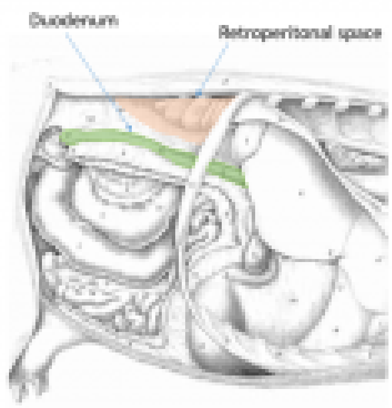
The musculature of the flank includes the exterior abdominal oblique, the internal abdominal oblique and the transversus. Each muscle layer becomes progressively thinner, with the transversus muscle usually being a fibrous sheath. There is no strength layer in the flank – muscles tear easily.

The nerve sensation to the flank muscles comes from the spinal nerves T13, L1 and L2. These can be blocked using local infiltration or paravertebral blocks. The peritoneum is difficult to numb.

The vasculature supply for the area is robust, leading to good healing.

The abdominal cavity is under negative pressure normally. When the peritoneum is opened, air flows in,c creating an audible noise. If air does not flow in, the main differentials are recent abdominal surgery or a ruptured viscus (leaking air).

The retroperitoneal space is relatively large in cattle. If an incision is made too dorsally, this space will be visible. The surgeon may feel they have encountered lots of adhesions. In the peritoneal cavity, the duodenum should be directly visible in the incision on the right and the rumen on the left.



Preoperative management

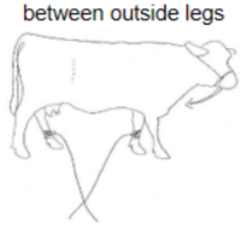
Food restrictions: NA

NSAIDs/analgesics: Recommended preoperatively. Flunixin meglumine 1.1-2.2 mg/kg iv is standard.

Antibiotics: Recommended. As cows can wall off infection, there can be surprises inside. If milking, ceftiofur 2.2 mg/kg im is standard. In beef or non-lactating cattle, other options do exist. Remember: the label dose of procaine penicillin is ineffective!

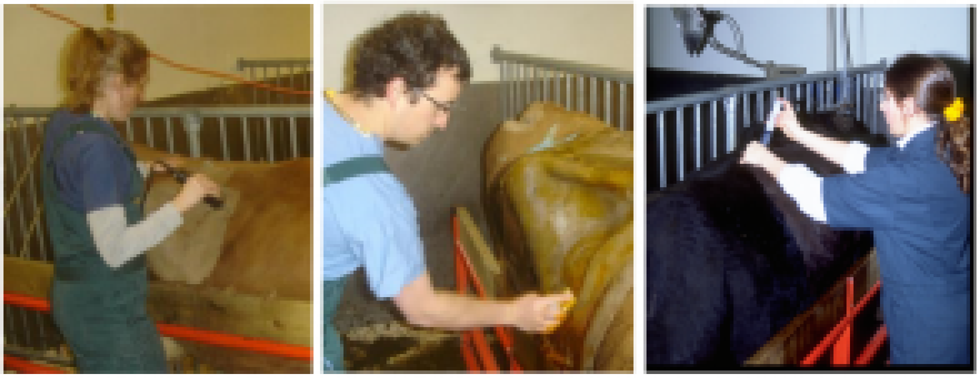
Local blocks: A line block, inverted L or paravertebral are all reasonable options.

Position/preparation: Healthy cows tolerate standing surgery very well. Many do not need sedation but will do fine with just a local block. If the cow is hypocalcemic or if the mesentery is stretched (by lesion or by exposure for evaluation), the cow may lie down. If this is a concern, we try to make it more likely that she will land incision side up.



Place ropes on the far legs and tie her head toward the incision. If she starts to lie down, nonsurgical personnel pull on the ropes and pull her legs out from under her. With the head tied in this direction, she is also more likely to fold that way and stay incision side up.

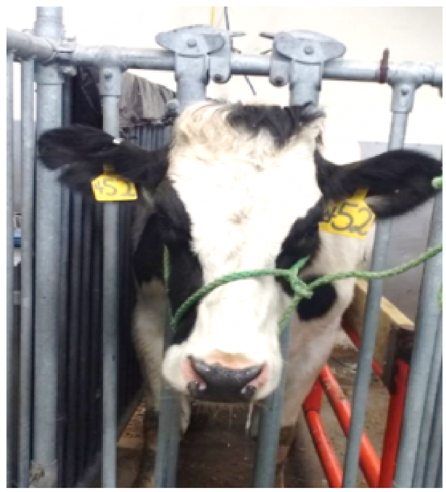
The flank is clipped, scrubbed, and the block performed.



Clipping over the backbone makes cleaning easier. Prep is usually a degreaser, 3 scrubs with water rinses. After the block, a final scrub and alcohol rinse.

Usually the most challenging part of the procedure is the block. Cows do not like needles. Options include a tail jack, towel over the face, or [sedation.](#) Or all 3. The [EasyBossE](#) is another humane restraint device that may help.

mad cow



stunned cow

A sterile paper drape can be clipped to the skin of the back using towel clamps. This is a cheap way to keep things clean and to minimize suture contamination. Gowns are less useful than the drape…

Putting the clamps on at the same time minimizes injury as she doesn't know who to kick. A nonsterile tech can help. Positioning the towel clamps as far apart on the back of the cow keeps the drape useful and not in your way

Surgeons should wear gloves and sterile sleeves. Double gloves are useful if a contaminated procedure is expected as the top layer of gloves can be removed quickly. Caps and masks are recommended but not often worn. Gowns are not helpful for sterility unless water impermeable but do help keep the surgeon a bit cleaner and warmer.

Surgery Supplies:

- Standard surgery pack
- Sterile sleeves for internal palpation

- Scalpel blade and handle
- 2 or 3 absorbable suture material for muscle closure
- 3+ nonabsorbable suture material for skin closure
- Biopsy instruments and formalin- optional
- DA simplex – long flexible tubing attached to a 10ga needle for viscus decompression -optional

Surgical procedure

After the cow is prepped, blocked and draped, a large window is cut in the drape. This window should be as large as possible without exposing any hair or facilities (side gate etc).

the hole should be big enough to not be in your way

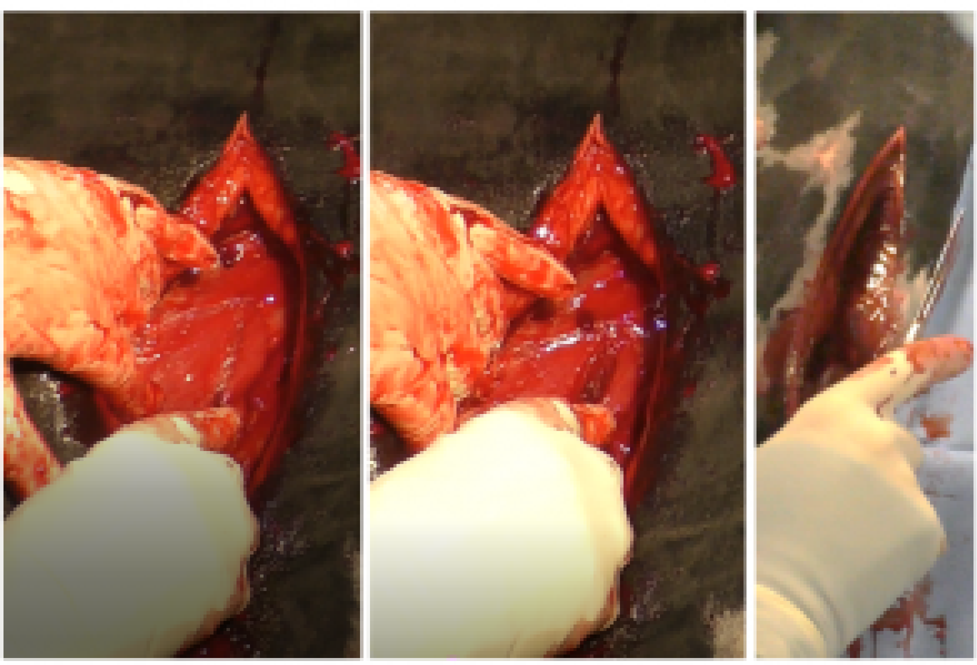
A vertical incision is made, typically in the center of the paralumbar fossa, starting at least 10 cm below the transverse processes and extending about 20 cm. [If you are struggling later, make the incision longer. It heals side to side, not end to end. Go too high and you will see kidneys. Lower makes access to the abomasum much easier.] Remember to keep your blade on the skin, using your other hand to spread the incision edges to see how deep you are. You generally won't be deep enough. Think about all the muscle underneath you and be bold.

Use your nondominant hand to pull the edges apart. Keep your blade on the skin. No lifting it up.

Incise through the external abdominal oblique.

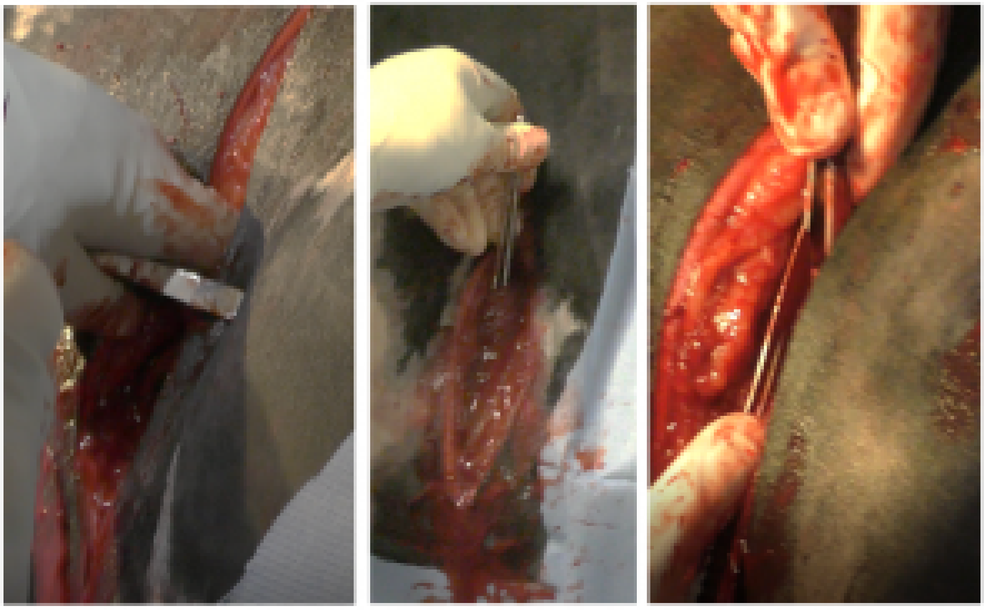
To safely and quickly cut through each muscle layer:

- First determine how thick a muscle is by starting with a 3 cm incision at the top, shaving (cutting in thin layers in the same area) until you reach the white fascia layer.



- Once the fascia is seen (and you can slide a finger between the muscles), slide a set of long thumb forceps under the external abdominal oblique and above the fascia (it should go easily). Slide them down as far as possible and turn these so the tongs are flat, creating a "groove director" between them.

- Use the center of the forceps as a "groove director" and as a guide for your incision. If the cow moves, the thumb forceps will help protect the deeper layers from accidental incision and enable you to incise without worry as long as you keep your blade flat.



Incise the internal abdominal oblique (it will be thinner) using the same technique. Tent the transversus and cut with scissors or with the blade turned so the cutting edge is facing the surgeon. This is to ensure you don't cut too deeply.

> Alternative to avoid: occasionally the muscles are split along their fibers rather than being cut. This is referred to as gridding. It is useful in rumenostomies but otherwise not useful. It creates a small deep hole that is very difficult to close.

Incise the peritoneum, listening to see if air rushes in. Extend the peritoneal opening to allow easy palpation with one arm.

Place a sterile sleeve on your left arm (regardless of whether left or right handed). If it is large for your hand, add a sterile glove over the top to improve your palpation skills. Generally this is one size larger than your normal glove size. **REMOVE ANY HEMOSTATS USED FOR BLEEDERS**. Finding these in the belly is somewhat challenging.

Exploration should be done from clean to potentially (or known) contaminated regions. In cattle, the riskiest areas are by the reticulum (**hardware disease**), liver (abscesses) and abomasum (perforated ulcers). As all of these are cranioventral, we typically start caudodorsal and to the left, followed by caudoventral, craniodorsal and finally, cranioventral.

A prophylactic omentopexy is often performed at the conclusion of right flank procedures, even if not for abomasal displacement.

Closure

There is no need to close the peritoneum or include it in your closure. Suturing the peritoneum does increase adhesions in cattle. This can be useful in some surgeries; not desirable in others.

The internal abdominal oblique and transversus can be closed as a unit, using 2 chromic gut or similar suture in simple continuous pattern. High levels of air in the abdomen can lead to pain so the cows are often “burped” during closure. Start the closure at the ventral aspect of the muscle layers. As you reach the top, preplace the final sutures and the first throw but do not tighten. Push in on the cow’s flank to push the gas out. With the flank still shoved in, tighten the last throw and then tie.

The external abdominal oblique is typically closed by itself in a similar fashion but no burping required.

Some practitioners close all muscles together. Because muscles tear easily, that can be risky if the cow falls during the healing period.

The skin is closed with a Ford Interlocking pattern using nonabsorbable suture in size 3 or 5. This is a great time to finish with an Aberdeen knot. A cruciate or simple interrupted suture is often placed at the ventral aspect. This can be removed to allow drainage if seroma or abscess develops.

Hint: Suturing cow hide is like sewing leather. If you try to insert your needle at an angle to the skin, you make it harder. If the needle is perpendicular to the skin, it goes in easier. The easiest way to do this is the change how you hold the skin. Make the skin perpendicular to the needle. It also helps to “choke up” on the needle – grasp it closer to the tip.

Postoperative care

- Suture removal in 10-14 days
- Monitor the cow for any signs of infection or peritonitis
- Consider rumen transfaunation if available

Complications

- Incisional dehiscence (rare)
- Incisional infection (common)
- Peritonitis

Videos

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=3025#oembed-1

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=3025#oembed-2

youtube video 1

Another opening

youtube video 2

youtube video 3

youtube video 4

Resources

PRACTICAL APPROACHES TO ON-FARM BOVINE SURGERY, Dr. Gordon Atkins, University of Calgary Veterinary Medicine

How to - Bovine Abdominal Exploratory- Right

Indications

An abdominal exploratory is a relatively cheap and effective diagnostic tool both in the field and in the hospital. Since most cows will not be shipped to a referral center, many diagnostics are not available. Lab-work typically needs to be run at the clinic or shipped off. Ultrasound is a powerful tool and can be utilized in the field. In most cases with an abnormal ultrasound, exploratory surgery is indicated. If ultrasound is negative, the next useful tool is exploratory laparotomy.

Relevant anatomy

The right flank is the preferred approach to an exploratory. Due to the rumen, ventral incisions are useful only for direct evaluation of structures in the abomasal area. From the right flank, most structures are palpable if not visible.

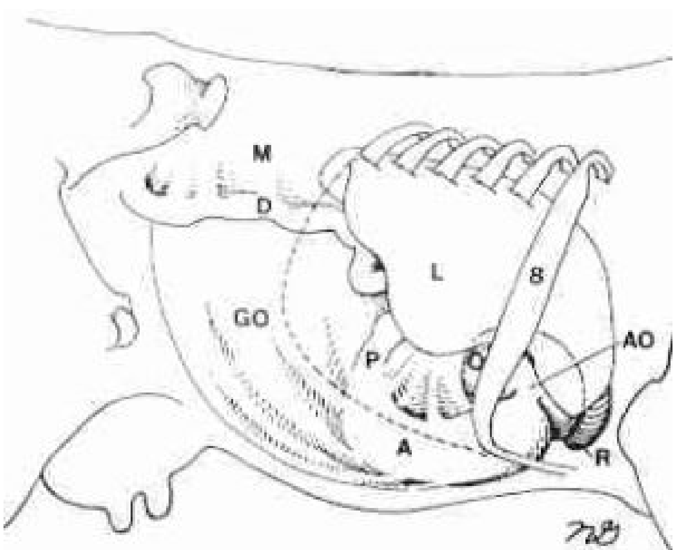


Fig 1. Note the duodenum(D) and greater omentum (GO)

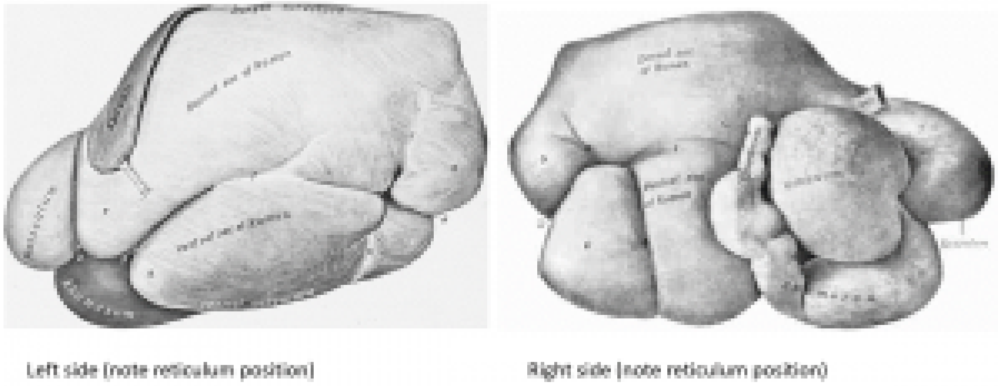


Fig. 2 Reticulum position

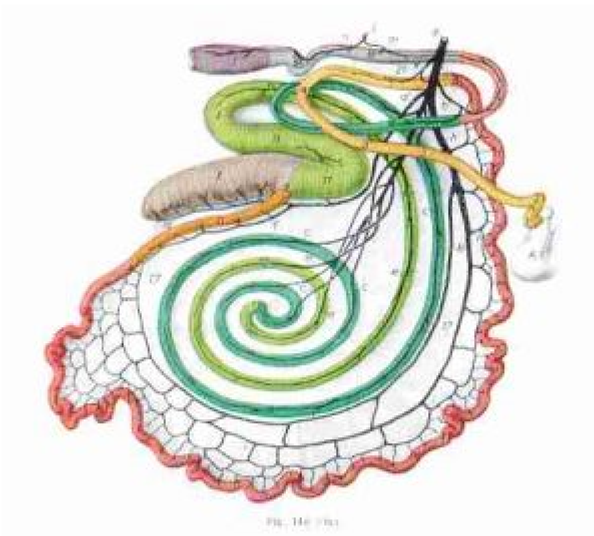


Fig. 3 Note the ileocecal and cecocolic junctions

Preoperative management

Food restrictions: NA

NSAIDs/analgesics: Recommended preoperatively. Flunixin meglumine 1.1-2.2 mg/kg iv is standard.

Antibiotics: Recommended. As cows can wall off infection, there can be surprises inside. If milking, ceftiofur 2.2 mg/kg im is standard. In beef or non-lactating cattle, other options do exist. Remember: the label dose of procaine penicillin is ineffective!

Local blocks: A line block, inverted L or paravertebral are all reasonable options.

Position/preparation: See How to- Standing GI Surgery

Surgery Supplies:

- Standard surgery pack

- Sterile sleeves for internal palpation
- Scalpel blade and handle
- 2 or 3 absorbable suture material for muscle closure
- 3+ nonabsorbable suture material for skin closure
- Biopsy instruments and formalin- optional
- DA simplex – long flexible tubing attached to a 10ga needle for viscus decompression -optional

Surgical procedure

Follow the guidelines for standing GI surgery.

Place a sterile sleeve on your left arm (regardless of whether left or right handed). If it is large for your hand, add a sterile glove over the top to improve your palpation skills. Generally this is one size larger than your normal glove size. **REMOVE ANY HEMOSTATS USED FOR BLEEDERS**. Finding these in the belly is somewhat challenging.

Exploration should be done from clean to potentially (or known) contaminated regions. In cattle, the riskiest areas are by the reticulum (**hardware disease**), liver (abscesses) and abomasum (perforated ulcers). As all of these are cranioventral, we typically start caudodorsal and to the left, followed by caudo ventral, craniodorsal and finally, cranioventral.

The omental sling will be in the palpation path unless pulled out of position by a late term pregnancy. In most cases, the duodenum and sling will be the only things visible in the incision (Fig 1). If there is a distended structure, it can be the abomasum (RDA or abomasal torsion) or gas in the omental bursa. Gas in the omental bursa develops after abdominal surgery or with a ruptured abomasal ulcer.

- Reach caudally and curve your left arm so that you can check the rumen and the left side. Palpate forward along the left body wall. Check the rumen gas cap and rumen pack. The rumen should have a small gas cap and be easily indentable.
    - An LDA will palpate as a second rumen gas cap.
- Return to the pelvis. Evaluate the structures in this region:
    - bladder – she will urinate
    - sublumbar lymph nodes
    - uterine – check involution
    - ovaries – evaluate for normal size and structure
- Evaluate the caudal intestines. The intestines should be fairly empty and located in the back 1/3 of the abdomen.
    - The intestines cannot be traced from duodenum to cecum

    - If the intestines need to be evaluated, exteriorize the cecum (a blind-ended sac with no bands). The spiral colon is connected on the dorsal surface and the ileum enters on the ventral surface. (Fig 3)
- Evaluate the kidneys. Reach forward on the inner aspect of the sling. The kidneys are both on the right side of midline, lobulated and should be nonpainful.
- Evaluate the ventral abdominal floor. Pass your hand along the ventral abdomen. It should pass easily without obstruction.
- Return to the outer surface of the sling and palpate the cranial abdomen.
- Evaluate the liver
    - Edges should be sharp. Rounded edges indicate likely fatty liver.
    - The gall bladder will be distended in cattle that are anorexic.
- Evaluate the ascending duodenum.
    - It should not be distended. Normal attachments connect it to the liver.
- Evaluate the abomasum
    - The abomasum can be identified by a mucosal slip.
    - The abdomen should be mostly empty and should be located on the right side of midline in the ventral abdomen
    - The pylorus is muscular but should be evenly muscled and a lumen should be palpable.
- Evaluate the omasum
    - This is a round firm basketball medial to the abomasum
- Evaluate the reticulum (Fig 2)
    - To find the reticulum, pass your hand down along the body wall, palm side down. Aim for the ventral midline about 6-12″ forward from the incision (NOT up by the tonsils). Turn your hand palm side up. The reticulum will usually be in your palm. The reticulum is a mostly empty sack that should be easily movable. It often contains sand. The honeycomb pattern is variably distinct.
- Evaluate the diaphragm
    - It should be intact with no herniation or defect.
- Note: When performing an exploratory on a cow who has recently calved, make sure to start caudodorsally to avoid contamination risks in the cranioventral abdomen

Closure : Follow the guidelines for standing GI surgery.

Postoperative care

- See standing GI surgery.

Complications

- See standing GI surgery.

Videos

We try not to break down adhesions in cattle; however, if she has had an **omentopexy** and this is impeding exploration, it may be necessary.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=3046#oembed-1

Resources

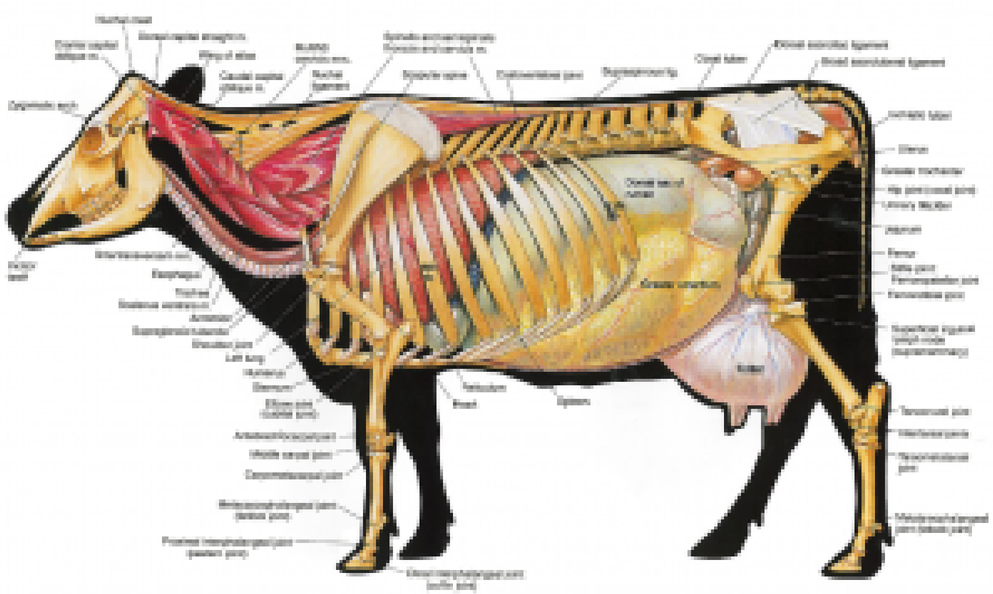
How to - Bovine Abdominal Exploratory- Left

Indications

Left flank exploratories are less common but are useful when the animal is showing signs of vagal indigestion or other left sided abnormalities. Anytime a procedure is performed on the left (Csection, rumenotomy) it should be accompanied by a full exploratory.

Relevant anatomy

The rumen takes up considerable space. How much of the intestinal structures are palpable depends on the size of the cow, arm length of the surgeon and the amount of intestinal fill.



Preoperative management

Food restrictions: NA

NSAIDs/analgesics: Recommended preoperatively. Flunixin meglumine 1.1-2.2 mg/kg iv is standard.

Antibiotics: Recommended. As cows can wall off infection, there can be surprises inside. If milking, ceftiofur 2.2 mg/kg im is standard. In beef or non-lactating cattle, other options do exist. Remember: the label dose of procaine penicillin is ineffective!

Local blocks: A line block, inverted L or paravertebral are all reasonable options.

Position/preparation: See How to- Standing GI Surgery

Surgery Supplies:

- Standard surgery pack
- Sterile sleeves for internal palpation
- Scalpel blade and handle
- 2 or 3 absorbable suture material for muscle closure
- 3+ nonabsorbable suture material for skin closure
- Biopsy instruments and formalin- optional
- DA simplex – long flexible tubing attached to a 10ga needle for viscus decompression -optional

Surgical procedure

Follow the guidelines for standing GI surgery.

Place a sterile sleeve on your right arm (regardless of whether left or right handed). If it is large for your hand, add a sterile glove over the top to improve your palpation skills. Generally this is one size larger than your normal glove size. **REMOVE ANY HEMOSTATS USED FOR BLEEDERS**. Finding these in the belly is somewhat challenging.

Exploration should be done from clean to potentially (or known) contaminated regions. In cattle, the riskiest areas are by the reticulum (**hardware disease**), liver (abscesses) and abomasum (perforated ulcers). As all of these are cranioventral, we typically start caudodorsal and to the right, followed by caudoventral, craniodorsal and finally, cranioventral.

- Reach caudally and curve your right arm so that you can check the intestinal fill on the right side.
- Return to the pelvis. Evaluate the structures in this region:
    - bladder – she will urinate
    - sublumbar lymph nodes
    - uterine – check involution
    - ovaries – evaluate for normal size and structure
- Evaluate the rumen pack
    - Normal fill and layers?
- Evaluate the ventral abdominal floor. Pass your hand along the ventral abdomen. It should pass easily without obstruction.

- Evaluate the cranial abdomen
    - Palpate the reticulum – is it freely movable? Adhered?
    - If no issues, reach across to the abomasum.
        - Normal fill and position?
- Evaluate the diaphragm and spleen
    - Diaphragm should be intact with no herniation or defect.
    - Spleen should be smooth, not nodular

Adhesions should NOT be broken down. They are usually attempting to wall something off.

Closure : Follow the guidelines for standing GI surgery.

Postoperative care

- See standing GI surgery.

Complications

- See standing GI surgery.

Videos

Resources

Monopoly

Use the monopoly game board to win properties by answering questions.

Everyone starts the game with equal moola (1 x 500, 4 x 100, 4 x 50, 4 x 20, 4 x 10, 4 x 5, 4 x 1)

Divide the group in 1/2 and select a token for your team.

Someone on the pair of teams should make a copy of the gameboard and share it with members of both teams. Everyone will need editing rights.

Go to your page of the ebook to get the questions (and answers) that the other team will have to answer. Your instructor will send you the password before you move into the breakout room.

- Team A poses these questions to Team B
- Team B poses these questions to Team A

Use the virtual dice to roll and move around the board.

If you land on a property you want to buy, you have to answer a question first. The other team will find the next question and pose it to you.

If you get the answer correct, you can buy the property. The teams decide how tough to be in assessing correctness.

No houses or hotels please. If someone lands on your property, they pay you the rent.

Chance cards – maybe

If a team goes bankrupt, give each team another 500 moola.

Game ends when time is called or all questions are asked. Winner has the most money +property value.

Diagnostics Practice- Monopoly Team A

Team A questions (to ask Team B)

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Diagnostics Practice - Monopoly Team B

Team B questions (to ask Team A)

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https://open.lib.umn.edu/largeanimalsurgery/?p=5875#h5p-194

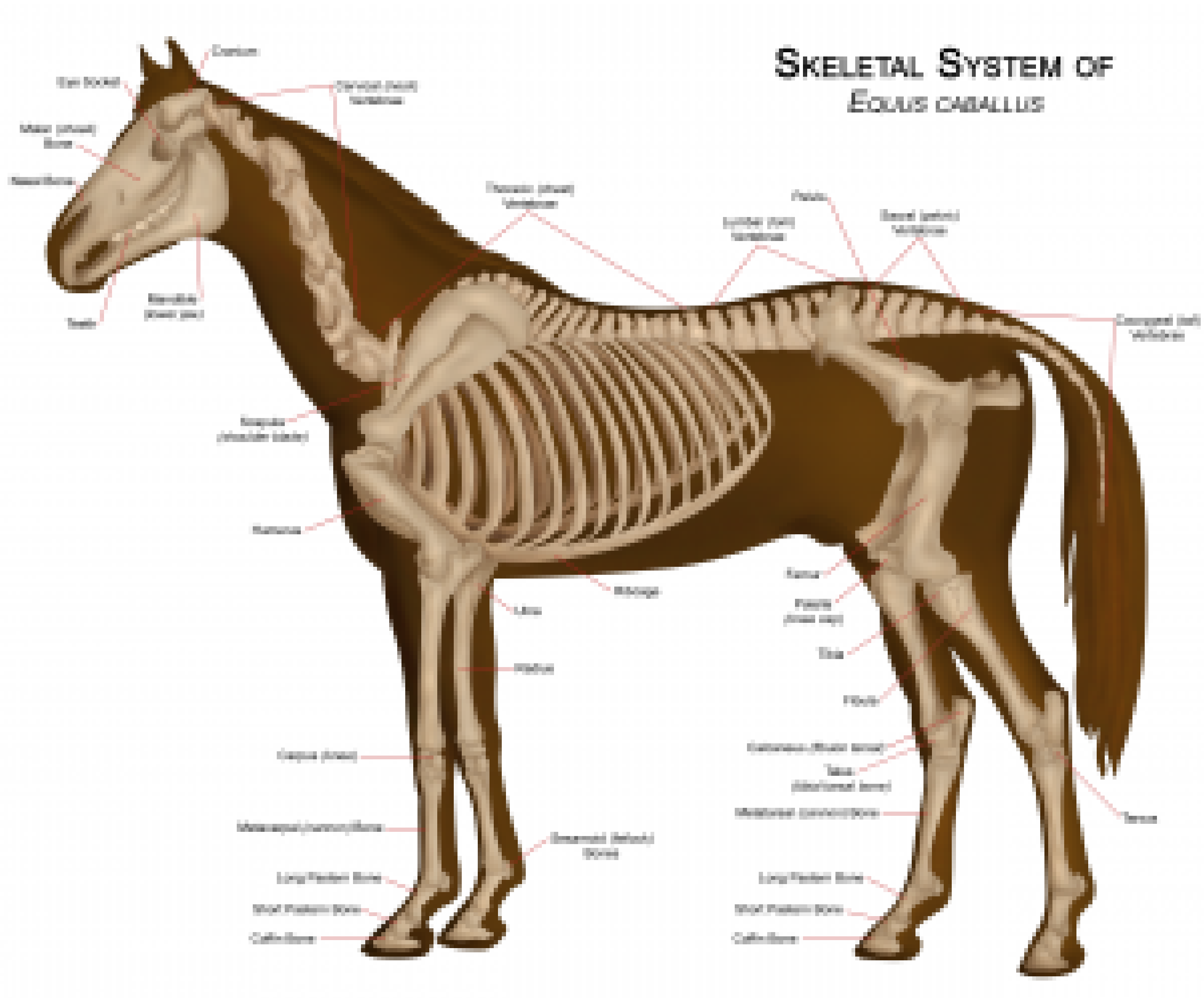
Practice

Try the dairy cases under the Upenn field service site

Equine Lameness

Background information for LAS I equine lameness- check out clinical skills and anatomy!

Really cool [3d distal limb model]



Palpation anatomy- forelimb

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Find a horse and have fun!

Palpation Instructions – Forelimb by Vic Cox

The distal equine limb is mostly bone with some tendons, ligaments and neurovascular structures between the skin and bone. Most soft tissue structures can be palpated by pressing them against the bone. With tendons and ligaments you should press fairly hard but with vessels and nerves a softer touch will work best. The following instructions will serve as a guide but the list is not exhaustive.

1. **Extensor tendons** in cannon region – grasp the cannon region firmly and rub your thumb over the dorsal aspect of the cannon bone. You should feel two tendons. Note that the smaller one is lateral and is the lateral digital extensor. The medial one is the common digital extensor tendon.
2. **Splint bones** – while still grasping the cannon region move lateral or medial and find the groove between the cannon and splint bones. Follow the splint bones distally to find the bulbous end of each splint bone which is sometimes referred to as a button. The splint bone is slightly longer on which side (M v. L)? Note that the distal part is flexible. It can be broken off on the lateral side by a kick from another horse. What might cause a medial splint fracture? Fractures of the distal splint bones are treated by surgical removal as are bone chips on the edges of joints.
3. On the palmar surface of the cannon with a soft touch run your index finger up and down over the digital flexor tendons. You should find a cord like structure between the skin and the flexor tendons. This is the **communicating nerve** between the medial and lateral palmar nerves. Note the oblique course of this nerve, which side is it higher on?
4. On the medial and lateral sides of the **cannon region** move your thumb forward and backwards while grasping the cannon with your other fingers. From dorsal to palmar you should feel the cannon bone –> splint bone –> suspensory ligament (lower half of cannon only) –> digital flexor tendons.
5. Continue to grasp the cannon and now move your thumb up and down the lateral side of the flexor tendons and try to find a "seam" between the **superficial and deep digital flexors**. If you can't, don't worry about it.
6. Pick up the forelimb and grasp the flexor tendons between your thumb and index fingers. Slip the digital **flexor tendons** between your fingers and note that the DDFT is big and round in cross section while the SDFT is thin and flat.

7. Put the limb down and find the **suspensory ligament** in the distal cannon using your thumb and index fingers to feel both medial and lateral sides. Note tension in the medial and lateral branches of the suspensory ligament which relaxes when the limb is not weight bearing. Follow the groove between the suspensory ligaments and the distal cannon down to the fetlock where it ends due to the strong horizontal ligaments that bind the sesamoid bones to the end of the cannon bone. The distal end of this groove is one site for injection into the fetlock joint.
8. Distal to the fetlock find the **extensor branch** of the suspensory ligament obliquely crossing the long P1. Remember that the main part of the suspensory ligament attaches to the abaxial aspect of medial and lateral sesamoid bones but some of the fibers form the extensor branch.
9. Using your thumb and index finger grasp the sides of the fetlock joint and with a soft touch feel the bundle of **digital vessels and nerves** which are superficial here. The pulse is difficult to palpate here unless there is inflammation in the foot, especially in laminitis. It is good to routinely attempt to feel the pulse here so that when it is easily found you will have physical evidence of inflammation in the foot.
10. With the same two fingers slide down to the pastern region and feel the long pastern bone and the flexor tendons. Next find the groove between the bone and tendons. In this groove lies the **palmar digital nerve**. It is difficult to feel, but the groove between the pastern bone and the flexor tendons is a good landmark to block this nerve for suspected navicular disease. This is the most commonly blocked nerve in lameness exams.
11. Palpate the palmar surface of the fetlock to find evidence of the **ergot,** which may be absent, but the ligament of the ergot will still be present. This ligament is useless to the horse, but can be confused with the palmar digital nerve which is cut for navicular or heel pain. If you pull up on the ergot area with one hand while palpating the area described in #10 above lightly, you may feel the **ligament of the ergot** as a thin cord under the skin running distal and somewhat dorsally from the ergot region on both sides of the palmar pastern.
12. Above the coronet in the region of the quarters and heel feel the upper edge of the **collateral cartilages** of P3. “Wiggle” them and note that they are flexible. Put your thumb between them and push down on the **digital cushion** which fills the space between the collateral cartilages and is deep to the bulbs of the heel.
13. Pick up the limb and **flex the carpus** so you can palpate the radiocarpal and intercarpal joints on the dorsal aspect of the carpus. Note that both open wide when the joint is flexed and the spaces are partially covered over by the extensor carpi radialis and common digital extensor tendons. Carpal chip surgery is done between these tendons. Carpal chips, or a slab fx (fracture) in the case of C3, are found on the dorsal edge of the carpal bones.
14. Put the limb down and palpate the insertion of the extensor carpi radialis tendon on the **metacarpal tuberosity** on the upper dorsal part of the cannon bone just distal to the carpal bones. The tuberosity is a reinforcement of the bone to withstand the constant pull of the extensor carpi radialis tendon as part of the stay apparatus.
15. On the palmar side of the carpus note the prominent “bump” caused by the **accessory carpal bone** (Ca). Wrap your fingers around the medial side of the carpus and palpate Ca with your thumb. Press hard above the Ca bone and feel the vertical “seam” between the two tendons that insert on Ca. Both

these tendons have ulnar in their names (ulnaris lateralis and flexor carpi ulnaris). Between these tendons the ulnar n. is found and the **dorsal branch of the ulnar n.,** a cutaneous branch emerges near the “seam” a few cm above Ca and runs laterally over the tendon of the ulnaris lateralis m.

16. On the cranial side of the cubital (elbow) joint find a vertical cord that is hard when weight bearing and soft when weight is shifted off the respective forelimb. This tendon-like structure is the **lacertus fibrosus** = long tendon of the biceps m.. The lacertus fibrosus serves to connect the biceps and extensor carpi radialis tendons making a complete tendinous “cable” from the cannon up to the scapula. This forms the main part of the forelimb stay apparatus.
17. On the cranial edge of the lacertus fibrosus feel a cord like structure that can be moved on the underlying lacertus fibrosus. This is the **cutaneous branch of the musculocutaneous nerve**. It supplies cutaneous innervation to the medial side of the antebrachium and carpus.

Palpation anatomy- hindlimb

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Vic Cox

For this exercise we will start distally and then move up the leg.

Begin by grasping the upper cannon region and run your thumb over the dorsal aspect of the cannon just distal to the tarsus. You should be able to feel and roll two tendons. The larger tendon is the long digital extensor tendon and the smaller more lateral one is the **lateral digital extensor** tendon. Trace the two of them distally and note that they fuse in the midcannon region. The lateral tendon is cut in order to treat the gait defect known as stringhalt. It is important to note that only the lateral tendon is cut, never the long digital extensor tendon. For that reason, it is important to palpate both tendons to ensure that only the lateral one is cut.

More laterally, in the upper cannon region, find the groove between the cannon and splint bones. The **dorsal metatarsal artery** will lie in this groove and must be carefully avoided when cutting the lateral digital extensor tendon. The artery runs under the tendon as it passes distally over the dorsal aspect of the tarsus onto the cannon bone. Careful palpation of this artery in the bony groove will enable detection of the pulse. This artery is an important source of arterial blood for blood gas determination during surgery.

Move up the leg on the lateral side and find the lateral digital extensor tendon above the tarsus where it will be wider than it is distal to the tarsus. As you palpate the lateral digital extensor tendon above and below the hock simultaneously you may be able to feel vibrations in the distal tendon due to palpation of the tendon above the hock.

On the dorsal side of the tarsus note the large cranial branch of the **medial saphenous vein** and palpate it with a light touch. One must be careful to avoid damage to this vein when performing a cunean tendinectomy.

Medial to the vein note the prominent tuberosity which is the **medial malleolus**. This important landmark is at the distal end of the tibia. Distal to the medial malleolus follow the **medial collateral ligament** of the tarsus which attaches to the medial malleolus proximally. Dorsal to the collateral ligament find a depression that represents the medial part of the tibiotarsal joint. It is here that the joint capsule pouches out when distended with fluid that is referred to as bog spavin.

Slide you thumb distally over the medial side of the tibiotarsal joint until you feel an oblique tendon which is the **cunean tendon**. It will lie between the collateral ligament and the saphenous vein and distal to the depression that corresponds to the tibiotarsal joint. The cunean tendon is cut to lessen the pain of bone spavin.

On the distal medial side of the tarsus observe the chestnut and compare its position to the forelimb chestnut.

To palpate the stifle joint begin by locating the tibial tuberosity. The tuberosity will be hard and above it the patellar ligaments can be palpated. The **middle and medial patellar ligaments** are easier to locate than the lateral patellar ligament. This is probably due to the fact that the medial and middle ligaments are part of the loop that forms the patellar locking mechanism. Note the acute angle like the letter “V” formed by the medial and middle patellar tendons where they attach to the tibial tuberosity. Note the tension on the medial and middle tendons and then move your thumb laterally to find the softer, less distinct lateral patellar tendon.

Follow the patellar tendon proximally to the patella. If it is locked, you should be able to feel the large medial part of the femoral trochlea which will be covered with a thin layer of fat. In some cases you will be able to feel the base and then the apex of the patella. Hold the flexor surface of your fingers over the patella and move stifle joint in and out of the locked position. As you do so you will be able the feel the patella locking and “unlocking”.

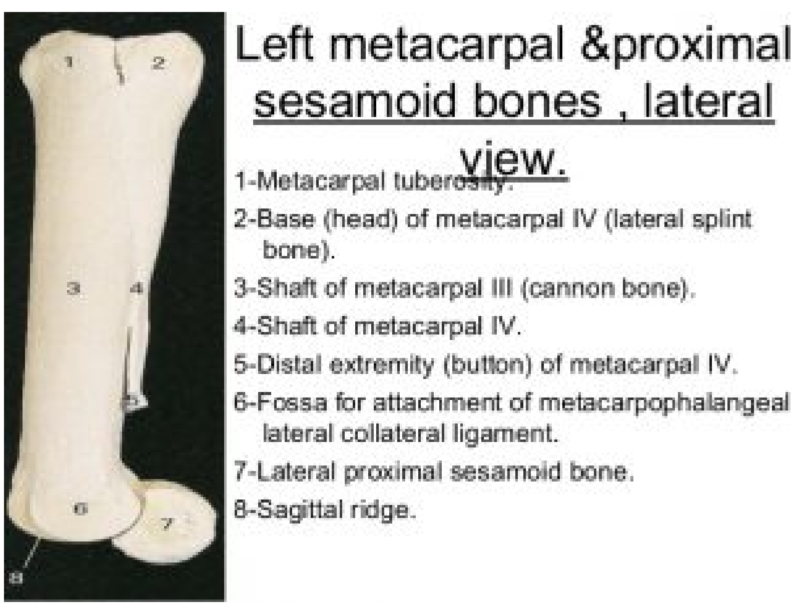
Grasp the distal crus on its dorsal aspect and lift the leg in order to flex the stifle joint. As you do so note that the tarsus flexes as the leg is hiked up and the stifle joint flexes. This parallel flexing of the tarsus when the stifle is flexed is evidence of the reciprocal apparatus. With the tarsus elevated pull on the distal part of the limb and note resistance to tarsal extension due to an intact peroneus (fibularis) tertius. This is the test for rupture of the peroneus tertius.

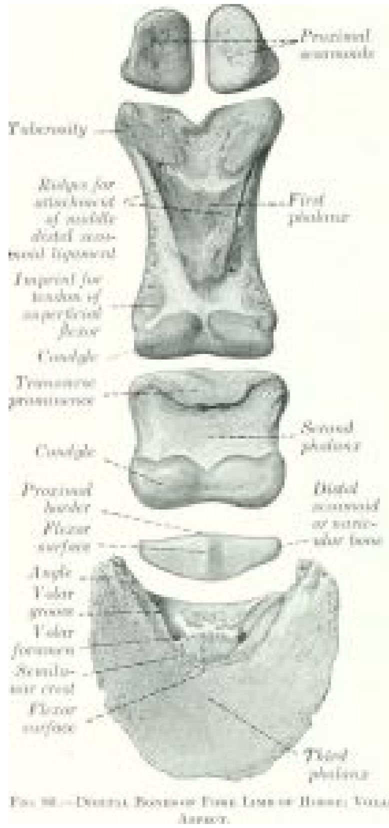
Note that as the tarsus is hiked up and flexes, the fetlock becomes more flexed also. This is due to the action of the superficial digital flexor tendon which is stretched as it passes over the point of the hock (tuber calcis). In contrast, when the hind limb is carried forward in extension, the fetlock is in the extended position as is the hock and stifle.

Distal limb bones review

Fetlock and Digit Set Bone Box- Dr. Cox

Really cool [3d distal limb model]





Distal cannon bone (metapodium = metacarpal or metatarsus)

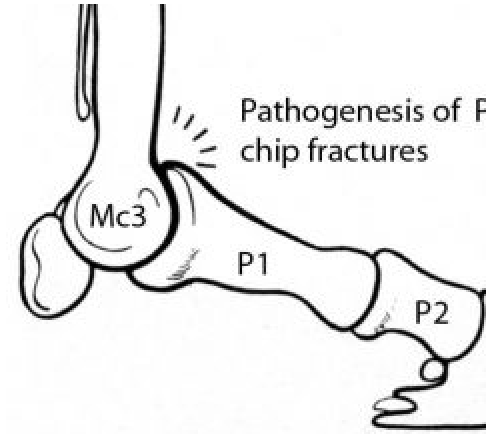
A. medial and lateral fossae provide attachment sites for the collateral ligaments.

B. The condyle is the distal articular surface of the cannon bone and P1 and P2. Note, however, that the distal cannon has a sagittal ridge while the condyles on the distal ends of P1 and 2 are saddle shaped.

Proximal phalanx (P1)

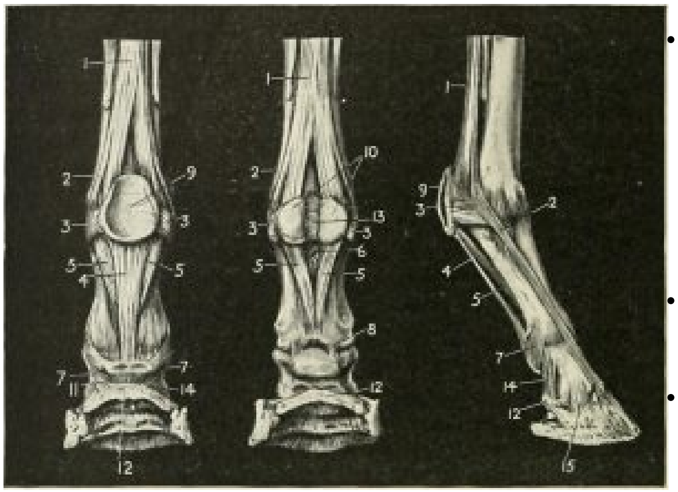
Note the sagittal groove on the proximal end of P1. This groove interdigitates with the sagittal ridge on the end of the cannon bone. A screwdriver fracture starts at this groove and runs longitudinally to split P1 into 2 pieces. The screw driver analogy pictures the sagittal ridge of the cannon bone as the blade of a screwdriver and the proximal end of P1 as the head of a screw. According to JR Rooney, these fractures are caused by rotary motion and acceleration. Consider a screw in oak being unable to twist as rapidly as the screwdriver above it resulting in fracture of the screw.

Hold P1 and the cannon bone together as they articulate. Note that the dorsal proximal edge will butt up against the dorsal surfa cannon bone when the fetlock joint is over extended as happens during extreme downward translation of the fetlock. This is another conse excessive downward translation of the fetlock region. Previously mentioned were fractures of the sesamoid bones and bowed tendons.



On the palmar/plantar surface find the triangular area where the middle distal sesamoidean ligaments are inserted. On the distal end of P1 and P2 note the shallow indentation of the articular surface to form a saddle shaped surface as described by radiologists. On the palmar surface of the distal end of P1 are facets for attachment of the SDF tendon.

Proximal sesamoids are what make the fetlock the widest part of the distal limb (other than the hoof). Aside from their articular surfaces, the rest of the sesamoids are covered with a variety of tendons and ligaments. Therefore, even after removal of the skin and loose subcutaneous tissue, the sesamoids are hidden from view by their many attachments.



- The fibrocartilagenous intersesamoidean ligament binds the axial surfaces together to form a groove on the palmar surface for the digital flexor tendons. On the articular surface is a narrow groove that interdigitates with the sagittal ridge of the distal cannon.
- Note that the articular surface of the proximal sesamoids is the only smooth surface
- Abaxial surfaces have a roughened depression for insertion of the suspensory ligament that covers the entire abaxial surface.
- Basal surface is covered by the attachments of the distal sesamoidean ligaments.

Middle phalanx (P2), a short very compact bone. Proximal phalanx (P1) is twice as long as the middle phalanx (P2).

Note the strong proximal palmar (planter) edge. This area is strengthened for insertion of the superficial distal sesamoidean ligament and the SDF tendon. Not seen is the attached complementary fibrocartilaginous ridge of P2 which is part of the insertions. On the sides of the ends of P1 and P2 there are depressions for attachment of the collateral ligaments of the PIP and DIP joints respectively.

Distal phalanx = P3 = coffin bone.

The extensor process on the coronary border is the place of insertion of the main extensor tendon. Just behind the extensor process note the depression on the lateral side of the coffin bone for attachment of the collateral ligaments of the coffin joint.

The palmar/plantar extensions of P3 are often referred to as the wings of P3 by radiologists. This is the site for attachment of the collateral cartilages of the coffin bone. Unfortunately these cartilages as often referred to as the hoof cartilages but this is a misleading term because the cartilages are attached to P3 and not the hoof. Instead, the collateral cartilages are inside the hoof but their upper parts are above the coronet where they can be palpated easily in the live horse. The collateral cartilages are attached to the wings of P3 just behind the depressions for the collateral ligaments and extend into the heel beyond the coffin bone

Distal sesamoid bone = Navicular bone.

This bone gets the popular name from its boat shape. Note that the distal edge is rounded like the bottom of a boat, the proximal surface is straight like the deck of a boat. Note the foramena on the distal edge. These are probably for blood vessels, but if the blood vessels recede, the foramena may contain invaginations from the distal palmar pouch of the coffin joint. The other surfaces are the flexor surface adjacent to the navicular bursa and the articular surface which forms part of the wall of the coffin joint = DIP joint.

Split limbs study. Find the following: DDFT, SDFT, pastern (PIP) joint, straight sesamoidean ligament, navicular bursa, coffin (DIP) joint pouches (dorsal, proximal and distal palmar), digital cushion and distal sesamoidean impar ligament.

Summary of synonyms

- Interosseous tendon = suspensory ligament (suspends the fetlock and sesamoids)
- Proximal phalanx = long pastern bone = P1
- Middle phalanx = short pastern bone = P2
- Distal phalanx = coffin bone = P3
- Superficial distal sesamoidean ligament = straight sesamoidean ligament (Z) [unpaired]
- Middle distal sesamoidean ligament = oblique sesamoidean ligament (Y) [paired]
- Deep distal sesamoidean ligament = cruciate sesamoidean ligament (X) [paired]
- Collateral cartilage of P3 = hoof cartilage = ungual cartilage

- Proximal interphalangeal joint = PIP joint = pastern joint
- Distal interphalangeal joint = DIP joint = coffin joint
- Podotrochlea bursa = navicular bursa
- (Podotrochleosis = navicular disease)

Forelimb nerve anatomy

Vic Cox

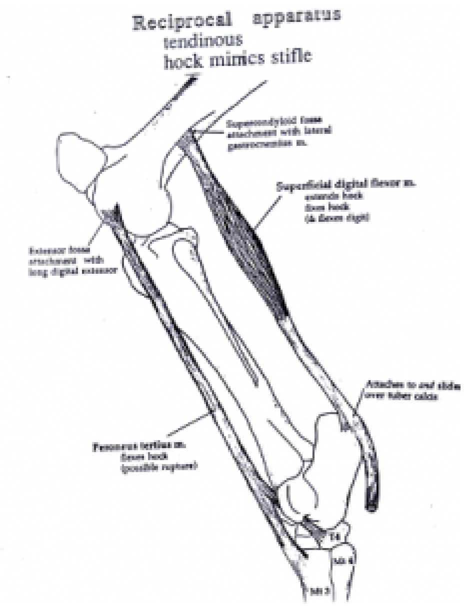
- The medial and lateral **palmar nerves** in the cannon region are adjacent to the deep digital flexor tendon. Much deeper are the medial and lateral **palmar metacarpal nerves** that lie on the palmar side of the metacarpus deep to the suspensory ligament. These nerves emerge at the distal ends of the splint bones and are sensory to the fetlock joint.
- At the fetlock the palmar nerves split to form the small dorsal digital nerves and the larger palmar digital nerves which are the continuation of the palmar nerves. Note that the name is similar with digital inserted.

  palmar digital nn. -> heel and navicular region

  dorsal digital nn. -> toe and dorsum of digit

- While the palmar nerves follow the deep flexor tendon, the palmar digital nn. are attached to the palmar side of the digital arteries. The palmar digital nerve must be carefully dissected from the artery when a palmar digital neurectomy is performed.
- The **palmar digital nerves** are the most commonly blocked nerves in the horse. They are blocked bilaterally in the midpastern for navicular and heel pain diagnosis and treatment. A horse with this block still knows where its toe is and therefore is safe to ride, but if blocked higher up (5.) so that the dorsal digital nerve is included, the horse is likely to stumble on an uneven surface.
- The **ligament of the ergot** lies superficial to the palmar digital nerve and is sometimes mistaken for it during an attempted neurectomy. The ligament of the ergot crosses over the palmar digital nerve and digital vessels obliquely. While the nerve must be dissected off the digital artery, the ligament of the ergot is superficial and not attached to either of these structures.
- The **palmar sesamoid block** is at the level of the sesamoid bone and both the palmar and dorsal digital nerves are desensitized. Therefore, the entire digit will be desensitized with the possible exception of the proximal long pastern and the dorsal part of the fetlock joint.
- The **low palmar (volar)** block will block the palmar nerves below the communicating branch and also the palmar metacarpal nn. at the level of the distal ends of the splint bones.
- The **high palmar (volar)** block is performed above the communicating branch and blocks the same structures as the low palmar at a higher level. In turn, most of the suspensory ligament is blocked also.
- The distal blocks (4, 5) are usually done with the foot elevated but the upper two blocks can be done with the foot on the ground.
- Volar is a collective term meaning palmar ***or*** plantar. In most cases the nerve blocks are used in the forelimb but in occasional cases hind limb blocks may be needed.

Reciprocal apparatus



Biomechanics

Veterinary Biomechanics Summary (Vic Cox)- optional reading

I. Statics vs. Dynamics

A. **Statics** refers to stationary support, dynamics refers to movement. Most muscle tendon systems serve both functions. Static analysis of material strength is commonly done by civil and mechanical engineers and has been applied to biological materials such as bone and tendon. The properties usually measured are:
1. **compressive strength** – how much force must be exerted to crush the test material
2. **tensile strength** – how much force must be exerted to pull the material apart
3. **shear strength** – how much force must be applied in offset directions to cause a material to split in half (to shear)
B. The **stay** apparatus of the horse is probably the best example of a structure designed for static function. That is, for support during rest.
C. **Dynamic** function requires greater muscle mass, hence the hind limb which is designed for thrust, is twice as massive as the forelimb.
D. The **check ligaments** allow the digital flexor muscles to rest during static function. During the support phase of motion the check ligaments work together with active muscle tension to withstand momentary high stress as body mass passes over the supporting fetlock.
E. **Kinesiology** is the study of animal motion. It is studied by an analysis of the geometry of limb positions or by a measurement of forces.

1. **Kinematics** is the study of the geometry of motion. Study of the moving horse spurred the initial development of motion picture technology. Until recently, quantification of cinefilm was an extremely laborious technique requiring frame by frame tracing of limb positions to provide digitized data for computer analysis. Video analysis now allows this process to be done automatically. Angle/angle diagrams usually involve a comparison of the changes in joint angle of adjacent joints. If a joint is painful its range of motion will be decreased and the angle/angle diagram will appear different than that of normal joints (shortened stride length)
2. **Kinetics** refers to the study of forces. Methods used here include force plates that measure rapid changes in the force applied to a plate as the foot strikes it. Pain will cause an animal to step softly and hence less force will be recorded by a force plate.

II. Muscle TypesA. **Antigravity muscles** serve both static and dynamic functions. The quadriceps muscle, for example, prevents collapse of the stifle joint during standing but extension of the stifle joint contributes to thrust during movement. The antigravity muscles include:

1. Extensors of proximal joints.
2. Digital flexors support the fetlock. When these tendons are stretched due to overexertion downward translation of the fetlock will occur, and if severe can result in fracture of the proximal sesamoids. Afterwards, swelling results in bowed tendons.

B. Flexor muscles function to:

1. Lift the leg off the ground so that it can be swung forward during the protraction phase of the stride. The faster the gait the greater degree of flexion to reduce angular mass by keeping the mass close to the pivot point.
2. Withdrawal of the limb from noxious (harmful) stimuli.

III. Velocity = stride length X stride frequency. A**. Stride length** is determined by:

1. **Length of limb** – digitigrade and unguligrade modifications increase limb length.
2. **Pivot point** modification – movable shoulder with pivot point at caudal angle of scapula (serrated face) allows the limb to reach forward farther.
3. **Unsupported intervals** – the animal is momentarily flying through the air. Usually two such intervals occur per stride of carnivores but only one in the case of ungulates.
4. **Foot fall pattern** – each foot individually propels the body forward. The more the limbs act independently, the greater the effect of each. When foot falls are close together their separate effects are lost as they are merged together. Close footfalls have a large overlap time. Smaller overlap time was correlated with longer stride length in a cinefilm analysis of Secretariat.

B. **Stride frequency** (rate) is determined by:

1. **Contraction rate** of muscles – generally smaller animals have more rapidly contracting muscles due to a higher metabolic rate.
2. **Gear ratio** – like a motor vehicle, the low gear muscles deliver power while the high gear muscles deliver speed. Both types work together to provide an optimal balance of speed and power. There are various anatomical arrangements of lever arms and the pivot points (fulcrum). The output force is the ratio of the input force times the length ratio of the lever arms. The same is true of the output velocity except that the lever ratio is reversed (reciprocal). This makes intuitive sense because force (or power) must be sacrificed to get speed.
3. **Angular mass** (moment of inertia). This corresponds to mass in rectilinear motion, that is, it resists acceleration. As the speed of equine gaits increases, the limbs are flexed more in the protraction (advancing) phase. Flexion reduces the effective length of the limb and thereby angular mass is reduced. Angular mass is the product of mass times effective length squared.

IV. Center of gravity – is cranial to the intersection of diagonals drawn from forelimbs to opposite hind limbs. This is because the cranial part of the body is heavier.

A. Stay apparatus – the limbs form a tripod, both forelimbs are firmly fixed but only one hind limb is fixed.

B. Head position – the center of gravity shifts forward as the head is lowered and extended forward. It is shifted caudally when the head is raised because raising the head also makes the center of gravity more caudal.

1. Head is lowered before **kicking** – this shifts the center of gravity forward so that the body is more stable.
2. **Head nod** up when painful fore foot hits – this tends to shift center of gravity back off of the painful forelimb. The often quoted rule in the clinic is “down on sound” meaning the head goes down when the normal foot hits but up when the lame foot hits.

Lameness evaluation in horses

No hoof, no horse. No limb, no horse. Lame horse, money lost (they are expensive lawn ornaments). We spend a lot of time evaluating horses for lameness. Sometimes the owner doesn't recognize the horse is lame but maybe just not performing up to snuff or not happy about the work. Horses may also be presented for a prepurchase examination in order to verify soundness (no lameness) prior to being purchased by a new owner. The goal is generally to localize the lameness in order to target advanced diagnostics and to be able to reassess the horse at a later date.

The main parts of a lameness examination

The history

When evaluating lameness, context is crucial. Beyond the presenting complaint and a general health history, we also need to know a lot about the situation.

What is the horse supposed to be doing? Backyard pleasure? Grand Prix Jumper? When is it supposed to be doing this? Tomorrow? Next year? Owners may have high hopes and unrealistic expectations but good to know what they are.

How hard and how frequently the horse is worked? Horses may be lunged (worked in a circle) in soft footing as a warm up -this is tough work! How long do they do this? How many does of the week does the horse work? How often is it shown? How long is each work out? What is the footing?

Horse owners also tend to medicate their animals. Is the horse currently on medication? Has it received any medication? What type and for how long? Did it make a difference? Is the horse on any supplements? Note: they may not consider these medications!

Horses may be outside 24 hours a day or inside most or all of the time. Standing is a stall is different from free choice exercise. What is the horse's environment. Note: If the horse has been prescribed stall rest, ask open ended questions. Horse owners will often give up on stall rest and be reluctant to admit it directly.

Horses are also athletes and some get regular therapies. It is very useful to know if the horse has had surgery or joint injections before and when the last treatment was. Hooves grow over time. If the horse is due for a hoof trim (most get trimmed every 6-8 weeks) or needs a shoe reset, that can change your interpretation of radiographs and can affect treatment plans.

Weight shifting does need to happen when a horse is lame. Owners might notice secondary shoulder pain (foot issue) or back pain (hock issue).

The visual examination

left forelimb held forward, "knobby" carpus

Prior to nearing the horse or touching the horse, the overall appearance, conformation, stance and symmetry should be evaluated (along with attitude). Is the horse shifting weight equally between limbs? Shifting weight excessively? Not putting weight on a limb? Pointing a limb? Are any limbs or parts of limbs swollen or atrophied?

The passive examination

The passive examination is performed with the horse standing still, often during history collection. The horse is palpated from poll to toes and assessed for *range of motion of joints* (how well do they bend), lumps and bumps, fluid in tendon sheaths and joints, and warm or painful areas. **Knowing the palpable anatomy is crucial.** Hoof structure, shoe wear and tear and hoof balance is also evaluated. Abnormalities are recorded for consideration after the active examination. Not all will turn out to be significant.

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Hoof tester examination

Generally, hoof testers are applied as part of the passive examination. Large tongs are used to pinch the hoof. A consistent response (withdrawal of the limb each time the hoof tester is applied) is indicative of pain. [A single withdrawal means the horse doesn't want this exam but doesn't necessarily mean pain.] Pain over the heel region is often associated with navicular bone issues. Pain in other areas could be a hoof abscess, sole bruise or laminitis. Pain all over (no distinct area) is often a hoof abscess or a fracture.

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using hoof testers – great images

The active examination

Rusty midtrot. LF and RH on the ground.

The horse is evaluated at a walk and a trot as part of most examinations. Occasionally the horse is worked at a canter and/or ridden. The trot is a two beat gait which allows overall shifts in weight to be evaluated since one hind foot and one fore foot are on the ground at one time. At a canter, the horse can protect a lame limb by using one "lead" – one leg starts the stride, the other 3 follow. Horses with significant lameness will prefer to canter rather than trot.

Note: If you are worried about a fracture (from the history, level of pain), DO NOT TROT the horse. Incomplete fractures can become complete fractures.

Most vets use the AAEP 5 point scale. This allows someone else to evaluate the horse and determine if the lameness has changed. Grade 5/5 is nonweight bearing, while grade 1/5 is a lameness seen only under certain conditions.

AAEP Lameness scale

0: Lameness not perceptible under any circumstances.

1: Lameness is difficult to observe and is not consistently apparent, regardless of circumstances (e.g. under saddle, circling, inclines, hard surface, etc.).

2: Lameness is difficult to observe at a walk or when trotting in a straight line but consistently apparent under certain circumstances (e.g. weight-carrying, circling, inclines, hard surface, etc.).

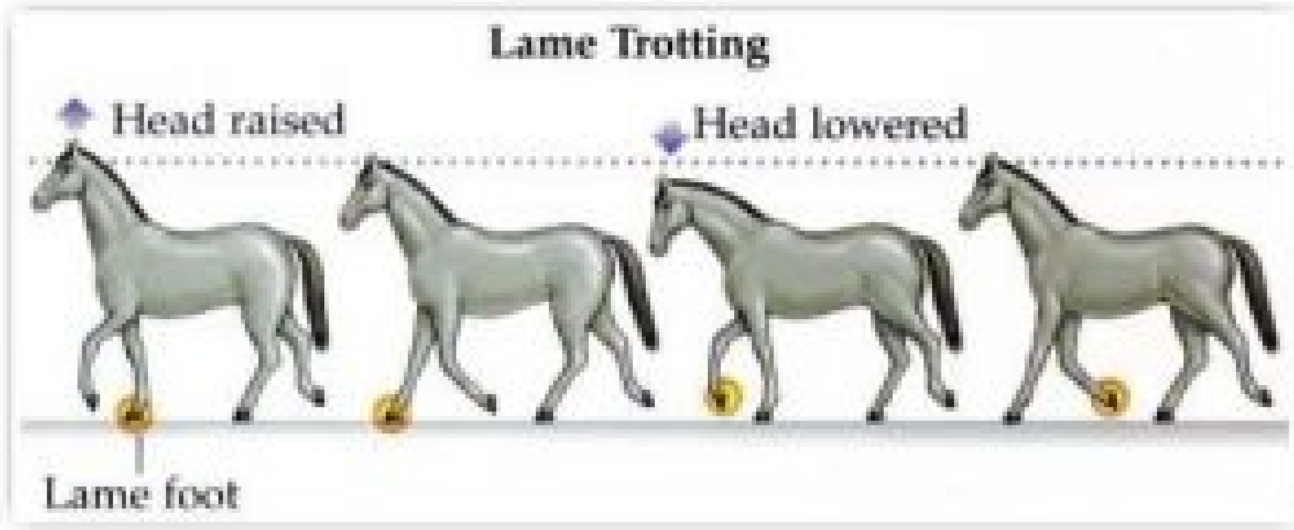
3: Lameness is consistently observable at a trot under all circumstances.

4: Lameness is obvious at a walk.

5: Lameness produces minimal weight bearing in motion and/or at rest or a complete inability to move.

Horses are evaluated from the rear, the front and the side. We are looking for symmetry, stride length, foot flight and foot placement.

When a limb is painful, the horse will try to adjust his/her weight to avoid much pressure on the limb. This shifts the head and body to other limbs, changes how long the horse stays on the lame limb and often changes how much the horse raises and lowers the limb (minimizing joint bending). The weight and timing shifts are what we look for. A *"head nod"* means the horse is shifting the weight of its head to change the weight on the sore limb. If the horse is lame on the left forelimb, it will throw its head up and back when the left fore is weight bearing. Newton tells us the head will have to come back down (equal and opposite force). So we see a nod downward when it does; and this is when the opposite forelimb is on the ground. Hence we say "down on sound". We can often hear the harder landing on the sounder limb, as well.



https://www.thevetexpert.com/a-complete-guide-on-lame-horse-identification-and-treatment/

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For the hindlimb, we look for hip excursion. Normally the hindlimb joints bend and the hip doesn't move up and down much. However, if the hock joint hurts, the horse will try to avoid bending it. To lift the foot, the horse has to lift the whole leg (raising the hip more). A *greater hip excursion* is usually found on the lame limb. With these horses, the greater drop in the hip is usually in the lame leg, while a hip "hike" may be observed in the sound leg.

Rule of sides

Occasionally a horse will throw its head forward with a hindlimb lameness. Due to how the trot works, this can look like a forelimb lameness on the same side. If the horse throws it's weight forward with a left hindlimb lameness, the head will be nodding down at the same time the right fore is hitting the ground. Down on sound means we can interpret this a left fore lameness. Just keep in mind it could also be a left hind lameness! Rule of sides – if it looks like a LF nod, consider LH too; if it looks like RF nod, consider RH too.

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There are now tools that can help identify more motion on a limb, making lameness exams more objective. However, the more we know the more confusing it can get!

Horses may be worked on both *hard and soft footing*. Hard footing emphasizes weight bearing issues (a bone bruise will be worse on hard footing), while soft footing emphasizes soft tissue issues (a tendon injury will be worse on soft footing).

Horses are also worked in a circle (lunged). *Lunging* exacerbates weight bearing issues on the inside limb and soft tissue issues on the outside limb. A horse that is bilaterally lame won't show as much lameness on a straight line as the horse can't pick a limb to more extra weight on. We may not see a nod or change in hip excursion. Often we just see a short, choppy gait. When the horse is lunged, however, now one leg is working much harder than the other and we can see lameness. We lunge the horses in both directions to ensure we have found all the affected limbs.

Stress tests are used s to try and confirm lame limbs or to localize the limb. Taking full limb radiographs on a horse would cost over $1000 so we need to better define what we want to image. We do this noninvasively through *flexion tests* (bend the limb and stress the joints) and *wedge tests* (a bar is put under different parts of the horse's foot to stress different areas).

The distal limb will be flexed on both fore and hindlimbs, usually for 30 seconds. The lower limb is bent to stress the coffin joint, pastern and fetlock joints. It is impossible to flex these joints individually. The person flexing the limb avoids putting pressure on tendons or ligaments as pain in these regions could complicate the interpretation. After 30 seconds, the horse is trotted off and the lameness reassessed. Often the first 1-2 steps will show pain; these are generally ignored and the examiner focuses on the later steps. Persistent lameness is called positive.

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In the forelimb, the carpus can be flexed by itself. This flexion is held for 60 seconds. In the hindlimb, the reciprocal apparatus makes it impossible to flex any normal joint all by itself. The distal limb, stifle and hip will flex when the hock is flexed. The upper limb flexion is often called a spavin test. This test is not terribly specific so we are trying to determine if it is markedly worse than the distal limb flexion. A positive spavin that was worse than a distal limb flexion would suggest hip, stifle or hock pain.

A heel wedge test is similar to a very big (horse sized) hoof tester and puts pressure on the caudal heel structures. A toe wedge test places strain on the flexor tendons.

Local blocks

Once we have identified the limb, we usually still need to confirm the region causing the pain. In most cases, we start at the hoof and move up. We numb each region and reassess the lameness at a trot. When the lameness goes away (or moves to the other limb), we know that the pain is coming from the region we just blocked. If we start too high, we numb large regions and are back to needing to localize further but now we have to wait for the local anesthesia to wear off. Knowledge of anatomy is again crucial!

Example :The horse is lame on the left forelimb. If we block the palmar digital nerves and the horse is still lame, we can assume the lameness is **not** in the heel region (orange shading in the image). Then if we perform an abaxial nerve block (blue shading+ orange shading) and the horse goes sound, we can say the pain is in the region below the fetlock and above the area blocked by the palmar digital nerve block. In the image, this would be the blue area above the orange.

This “subtraction” means it is important to move up the limb and to do so carefully so we don’t have a large region to evaluate (radiograph, ultrasound.).

Joint blocks above the foot are an exception. Local anesthesia injected into the joint generally numbs the joint and not much else if the horse is evaluated sooner rather than later (later the local anesthetic leaches out and finds nerves). If the carpus is swollen on a racehorse, we may just radiograph it. However, if it is swollen but not painful or painful on flexion but not swollen (eg unclear diagnosis), we will often inject it to see if it is the source of pain. If this doesn’t resolve the pain, we can still do effective distal limb nerve blocks.

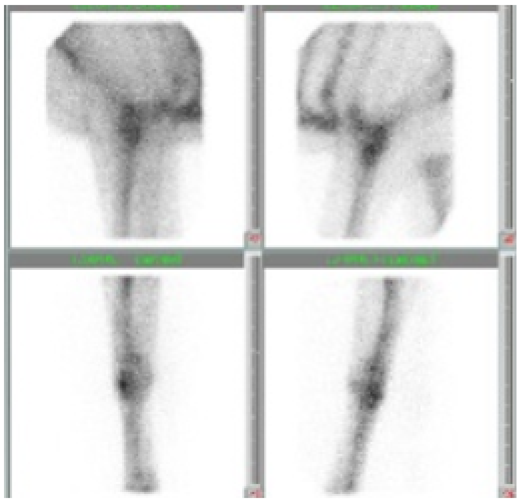
It is not uncommon for the horse to change which limb is lame during a series of blocks. Lameness is often bilateral as it is typically related to wear and tear and conformation issues. Once we numb the pain on one side, the horse can now show us the lesser pain on the other side. The veterinarian needs to carefully check which limb is showing pain at each step! In the example above, the horse would typically go lame on the right forelimb rather than becoming sound.

A response of 50% (50% better) is pretty poor. A response of 100% is rare. Once we have the lameness improved to the point where we can no longer tell a difference, we have made significant improvement, or the horse is getting tired of needles, we will move to diagnostics such as ultrasound or radiographs.

Note: if you cannot see the lameness consistently, it will be hard to tell if your local blocks help. Try a different modality!

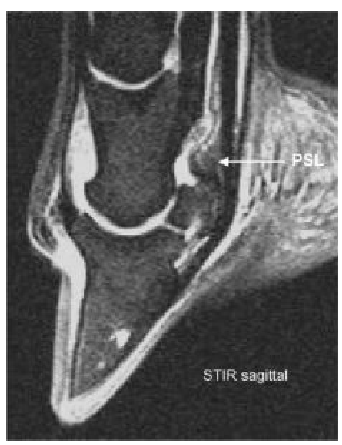
Scintigraphy

If the horse will not tolerate local blocks, if multiple limbs are lame or if the examination is pre-performance, it may be more effective to perform a bone scan. The horse is injected with a radioactive substance that collects at areas of remodeling bone (some do soft tissue too). The highlighted areas (hot spots) are then evaluated more closely, generally with radiographs.



Imaging

Most lameness exams end with diagnostic imaging. *Radiographs are best for bony structures; ultrasound for soft tissue. The foot has both and is best evaluated with MRI.*



Resources

[LAMENESS EXAMS: Evaluating the Lame Horse](), AAEP. Date unknown – short and sweet synopsis

2018 Sporthorse lameness exam, TA Turner, FAEP- lots of great hints and explanation

Manual of clinical procedures in the horse. Eds: Costa & Paradis- Chs 27 and 28- how to's with lots of pictures

Adams & Stashak's Lameness in Horses, 6th edition; Ed: Baxter.
Lameness in the Horse; 2nd edition; Eds: Ross & Dyson.

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Other examples

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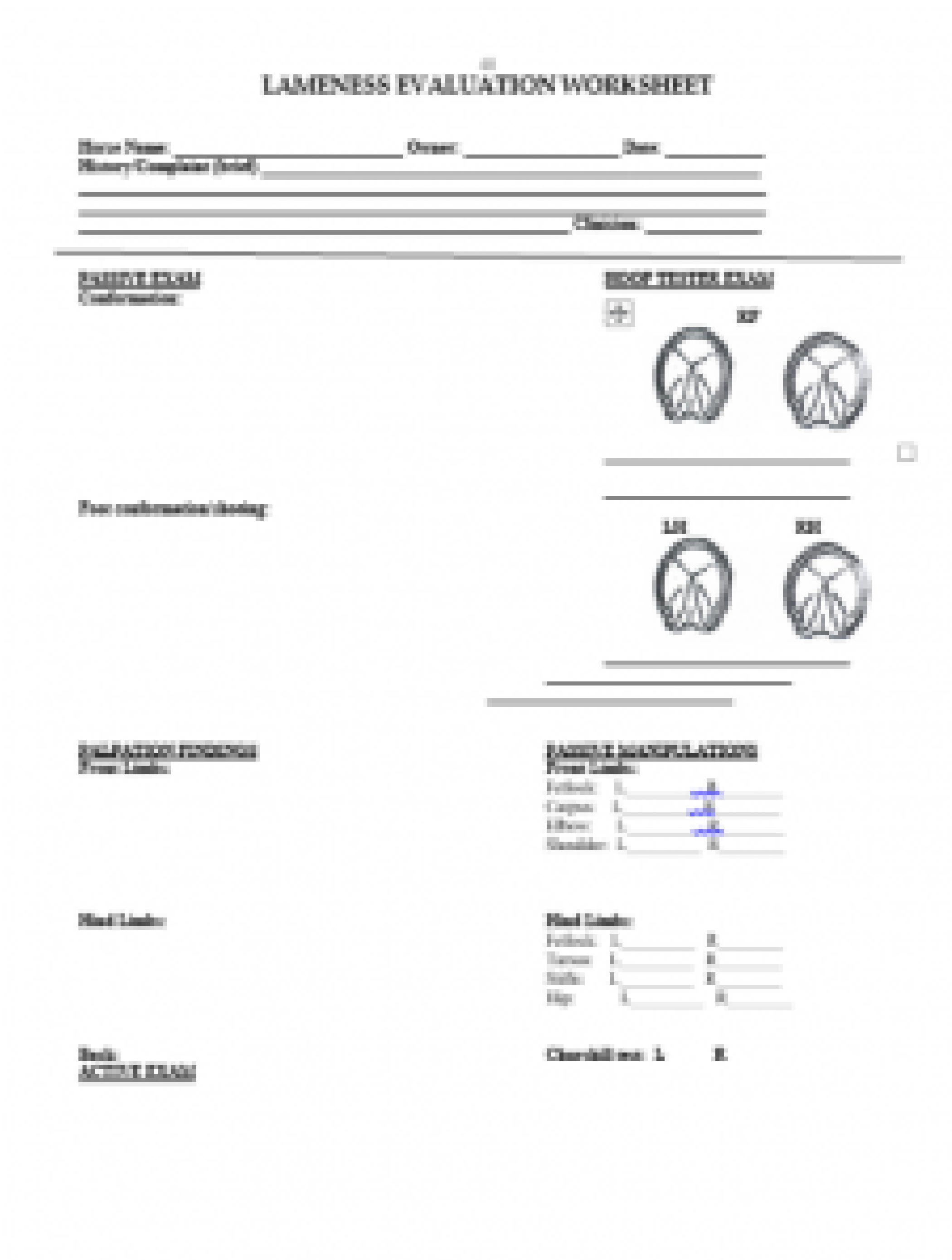
Lameness Locator info

Lameness examination form

Sample form


LAMENESS EVALUATION WORKSHEET
LH
RH
Hind Limbs:
Hind Limbs:

Walk: **Left Circle:** **Right Circle:**

Trot:

Baseline Lameness:	**Left Circle:**	**Right Circle:**
LF 0 1 2 3 4 5	LF	LF
RF 0 1 2 3 4 5	RF	RF
LH 0 1 2 3 4 5	LH	LH
RH 0 1 2 3 4 5	RH	RH

FLEXION TESTS:

Fore Limb:

Phalangeal: L______ R______
Carpus: L______ R______
Elbow/Shoulder flex. L______ R______
Elbow/Shoulder ext. L______ R______

Hind Limb:

Phalangeal: L______ R______
Full limb: L______ R______
Hip flex. L______ R______
Hip ext. L______ R______
Hip abd. L______ R______

WEDGE TESTS:

Fore Limb:

Heel wedge: L______ R______
Toe wedge: L______ R______

Hind Limb:

Heel wedge: L______ R______
Toe wedge: L______ R______

DIAGNOSTIC BLOCKS:

Block	**Pass**	**Result**
All performed individually (unless were off)		
Palmar digital nerve block	______	
Distal interphalangeal joint block	______	
Navicular bursal block		______
Flexor tendon sheath block	______	
Fetlock joint block	______	
Palmar digital nerve block	______	
Distal interphalangeal joint block		
Navicular bursal block		______
Flexor tendon sheath block	______	
Fetlock joint block	______	

OTHER:

Lameness exam interpretation

LAMENESS EXAMINATIONS CHEAT SHEET

Lameness grades (AAEP)

- Grade 5: non-weight bearing
- Grade 4: lame at a walk
- Grade 3: lame at a trot
- Grade 2: lame consistently under special circumstances (eg lunging)
- Grade 1: lameness difficult to observe and inconsistent, irregardless of circumstances

Straight line lameness exam

Foreleg lameness : HEAD NOD

- “Down” on the “sound”
    - The horse throws his weight to his hind limbs when he has to step on the sore leg
    - This is the equivalent of “up” on the “lame” leg.
    - Forelimb lameness is more challenging when the problem is bilateral, such as with navicular syndrome. The horse can’t decide which leg to bear more weight on and instead shows a short choppy gait.
    - Sometimes it is easier to hear the lameness better than to see it (change in force of landing)

Hind limb lameness : HIP “HIKE”

- More hip motion, either up or down, on the lame leg
    - not necessarily a hike
    - occasionally will lead to a mild head nod (the horse usually keeps his/her head higher overall – no deep nod)

Lunging

- Used to exacerbate lameness (jog in a tight circle)
- In most instances, the lame leg will be worse when on the inside of the circle

- If it is more lame when the leg is on the outside of the circle, think soft tissue (pulled more)

Flexion tests

- Used to exacerbate lameness; generally signifies joint pain; can be soft tissue if pulled when limb flexed
- Distal limb flexion : flexes fetlock, pastern and coffin joint
- Carpal flexion : flexes carpus only
- Spavin test : flexes hock, stifle and hip
- Upper limb flexion, forelimb : flexes elbow or shoulder; extends other joint

Passive Lameness Exam

Palpation

- Check for asymmetry, swellings, and pain in response to palpation.
- Horses with forelimb lameness will often be sore in the shoulder region even if foot pain due to abnormal carriage of the limb
- Similarly, horses with hindlimb lameness will often have back pain

Hoof testers : around white line ; from frog to walls and across bulbs of heel

Check hoof -pastern axis and hoof balance (coronary band parallel to the ground)

Churchill hock test : tests for pain in the lower hock joints (bone spavin)

> Done by trying to pull the medial splint bone around to the lateral side of the leg. If painful, horse will react by abducting the leg (not positive if he pulls back or forward; has to pull away from the source of pain on the medial aspect of the leg)

Range of motion (ROM) : amount of flexibility in joint. E.g. should be able to flex carpus so that heel touches elbow; if can’t, this is restricted ROM

Local anesthesia

Used to numb an area to determine if pain is coming from that region. Generally start low and work up

Common causes

In the forelimb, the source of the majority of the lameness is in the foot. In the hindlimb, the source of the majority of the lameness is in the hock. This does vary by age and performance.

Foot pain will often cause the horse to overstress the shoulder due to changes in how the limb is advanced. Hock pain will often lead to secondary back pain as the horse tries to protect the limb.

Lameness skills self assessment

Evaluating equine lameness takes practice. Try your hand on youtube videos, clinic cases etc. Find a Horse Angel and practice your passive examination! Or ask SkillsPac to run a session.

	Beginner	Novice	Intermediate	Advanced
Forelimb lameness	Understand what to look for; sometimes can see it	Can see a lameness at a walk	Can usually see a lameness at a trot	Can detect grade 2 lamenesses
Forelimb lameness	Can determine which leg if holding it up or pointing it	Occasionally know which leg is affected	Generally accurate at which leg is affected	Almost always accurate at which leg is affected
Hindlimb lameness	Can see if major asymmetry	Can see a lameness at a walk	Can usually see a lameness at a trot	Can detect grade 2 lamenesses
Hindlimb lameness	Can identify leg if major asymmetry	Occasionally know which leg is affected	Generally accurate at which leg is affected	Almost always accurate at which leg is affected
Head nod	Slow motion makes it visible	Can sometimes see the head nod	Can see the head nod and can often correlate with weight bearing limb	Can detect subtle head nods and can correlate with weight bearing limb
Short stride	Not sure of meaning	Can tell short stride if slow motion or lunging	Can occasionally see the short stride at regular speed	Can usually see the short stride
Foot placement (alterations in tracking)	Not sure of meaning	Understand and can see if exaggerated	Can see if watch for it	Remember to check for it and can see with little effort
Range of motion	Yeah right!	Can see changes in joint flexion if in slow motion	Can sometimes see a difference in joint flexion	Can often see a difference in joint flexion
Hip “hike”	Hip huh?	Understand but don’t often see without tape markers	Can see in many if right conditions (color of horse, background)	Can see in most
Flexion tests	Understand the principles; not sure could do on own	Know the principles behind; can identify structures affected	Understand principles; know when and how to use; could do with supervision	Comfortable doing and interpreting
Palpation skills	Can safely palpate	Could pick up asymmetries but might need a refresher on what the structure is	Can pick up abnormalities, know the larger structures	Can pick up abnormalities even if bilateral and comfortable determining the structures
Hoof testers	Understand the principles	Can apply safely	Can apply and can determine if positive	Can apply and interpret

How to - Nerve and joint blocks

Mepivicaine is typically used for local blocks. It acts quickly and lasts ~2 hours. Lidocaine starts to act quickly but also wears off quickly (sometimes within the hour). If it wears off before the lameness is fully localized, things get very confusing. For example, if the horse improved 50% with a palmar digital block but you are still trying to get to 100%, you need that block to stay working. Bupivicaine is very long lasting (3-6 hours) and more tissue toxic. It is usually reserved for pain relief with laminitis or fractures, rather than for lameness evaluation.

Drug	Onset of Action (min)	Duration of Action (min)
Lidocaine	5–15	60–120
Mepivicaine	5–30	90–180
Bupivacaine	15–45	180–480

Joint injections are prepped as for surgery and a fresh (unopened) bottle of local anesthetic used. Infection can occur with injections through skin that is not well prepped. All sites anywhere near joints or tendon sheaths are scrubbed as for a joint injection as sometimes the joint or tendon sheath is inadvertently pricked by the needle. Larger needles are used for joint blocks to prevent the needle breaking off in the joint when the horse bends its limb.

> Note: we don't always clip the hair! Clipping can cause trauma to the skin and the clipped hair particles have been observed in the joints during arthroscopic surgery. Every joint or potential synovial injection should get a sterile scrub!

Perineural blocks are assessed by checking the related skin sensation with a pen or pen cap. Eg a palmar digital nerve block should numb the skin of the heel bulbs but not the skin of the dorsal coronary band. Joint blocks don't have related skin sensation but joint fluid may be seen in the needle hub (this isn't always true) and the injection should flow smoothly with minimal pressure. Both are checked at 10 minutes (perineural blocks can be checked at 5 minutes); joint blocks may be reassessed up to 30 minutes or longer as the local anesthetic diffuses through and out of the joint.

Horses are typically blocked without sedation as most drugs alter the gait. Twitches and good restraint are used along with careful positioning and attention to horse limbs.

Palmar digital nerves

The neurovascular bundle is a group of structures that you can “strum” in the midpastern region. Usually blocked as low in the region as possible. A 25ga needle is used to inject local anesthetic subcutaneously around the nerve. Usually the order of the structures is vein -artery – nerve, starting dorsally (nerve is most palmar). To desensitize heel region and sole, block both medial and lateral branches.

This block numbs the foot except for the dorsal laminae and dorsal coronary band. This includes the navicular bone, coffin joint, bursa, caudal heel region and sole. The caudal heel includes the impar ligament, navicular suspensory ligament, collateral cartilages, frog, digital cushion and part of the deep digital flexor tendon. The PDN block does not always fully block the collateral ligaments of the coffin joint.

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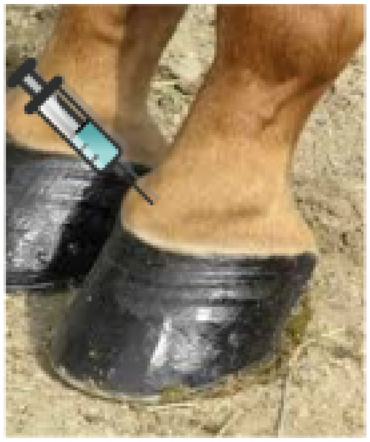
Coffin (DIP) joint

1. Thumbs’ width above the coronet and thumbs’ width off dorsal midline to either side : find a depression adjacent to the extensor tendon. Insert 20 ga needle either medial or laterally, angling to opposite corner of foot (eg if lateral stick, aim toward 2:00). The needle should sink into a “hole” and it should be easy to inject fluid
2. On the lateral or medial aspect of the foot, one thumbs’ width above the coronet (dorsal to the collateral cartilages, aim toward the center of the foot (again, should sink into a hole and be easy to inject).

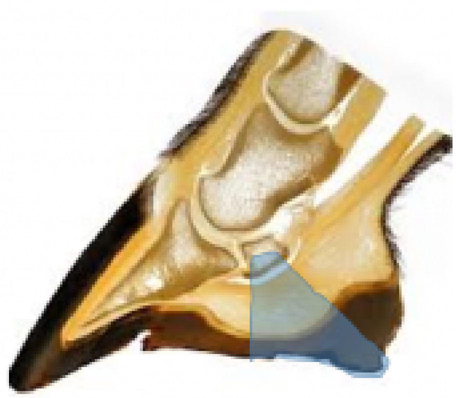



This block numbs the coffin joint, parts of the coffin bone, the coffin joint collateral ligaments, the impar ligament and the navicular bone. Over time it diffuses out to block the navicular bursa and the caudal portion of the foot (coffin bone, soft tissue structures in the heel).

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=1660#oembed-2

Navicular bursa block

A spinal needle is inserted between the heel bulbs, parallel to the sole of the foot. Location is checked radiographically before and after injection of local anesthetic combined with contrast dye.

This block numbs the navicular bursa, the navicular bone and the caudal portions of the heel.

Pastern (PIP) joint

Very similar to coffin joint but just a little higher – find widest part of long pastern bone and go just below this area. Insert 20 ga needle just under extensor tendon, superficially into joint pouch (don't need to get between bones). Can also inject with limb flexed : find "V" shaped notch at palmar distolateral aspect **:** aim needle just distal and dorsal.

This block numbs the pastern joint. With time it can diffuse out and also act as a PDN block.

Basisesamoid nerves (abaxial nerve block)

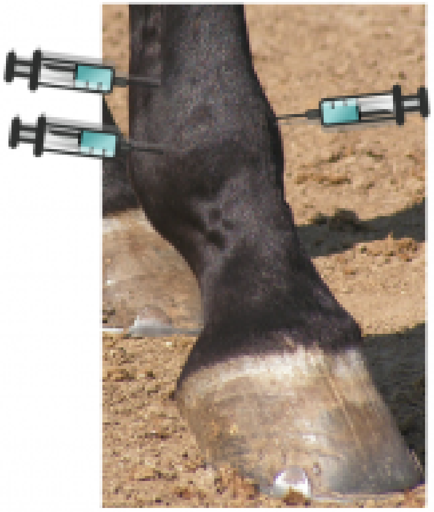
The same neurovascular bundle is readily palpable as it courses over the sesamoid bones. Nerve remains most axial. 25ga needle used for subcutaneous injection in area of nerve. Both medial and lateral branches blocked to desensitize foot and pastern.

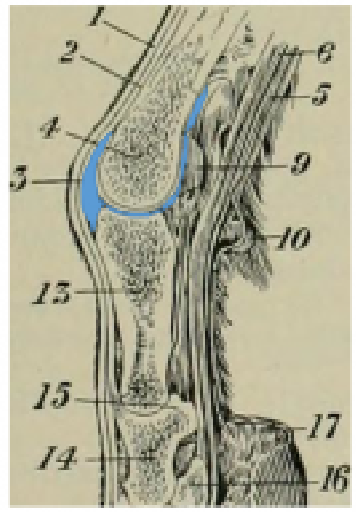
This block numbs the foot and the palmar/plantar aspects of the pastern.

Fetlock joint

1. Insert 20ga needle in lowest area of rectangle formed by splint bone proximally, cannon bone dorsally, suspensory ligament palmarly (plantarly) and sesamoid bones distally. Needle should be parallel to ground if horse is weight-bearing. Injects easily.

2. Insert 20 ga needle under extensor tendon dorsally (shallow injection into joint pouch).
3. Insert 20 ga needle between cannon bone and sesamoid bones when joint flexed





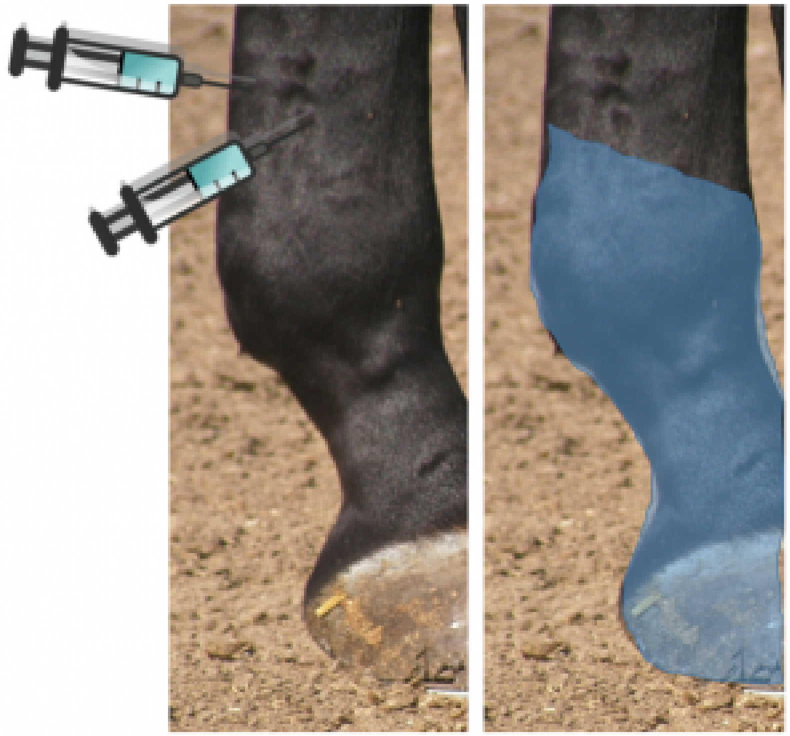
This block numbs the fetlock. Over time it can also act like an abaxial sesamoid block.

Fetlock joint injection – video

Low 4 point/ low volar nerve block

4 nerves to block : deep nerves course between the splint bones and the cannon bone on the axial surface of the splint bones-block just distal to the end of the splint bone using 25ga needle

Superficial nerves course between the suspensory ligament and the deep flexor tendon but can be on either side of a fascial reflection: need to fan needle (move it around) with sufficient local anesthetic to cover moderate sized area.



This block numbs the fetlock and distal cannon bone (palmar or plantar aspect).

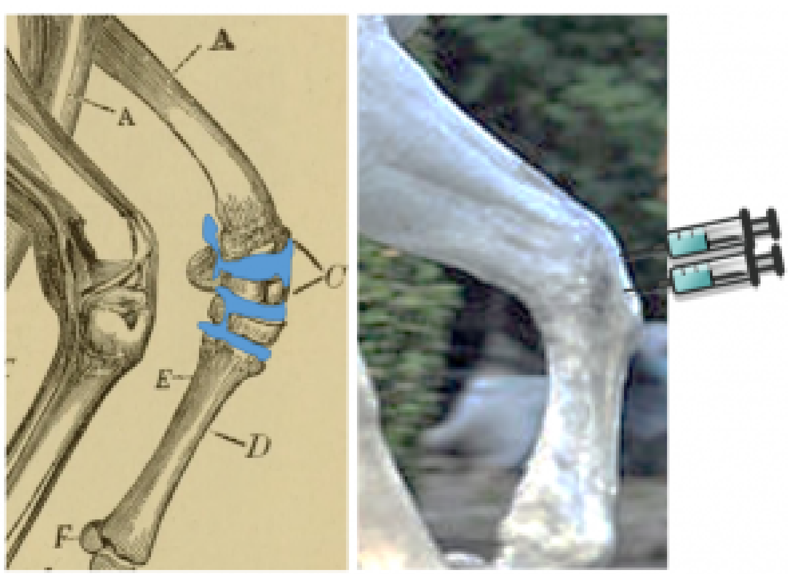
High 4 point/ high volar nerve block

very similar to low volar block but performed above communicating branch ; can also inject all but deep medial branch by injection between distal aspect of accessory carpal bone and cannon bone.

This block numbs the fetlock and more of the cannon bone and below. It can also numb the suspensory area and distal carpus or hock joints.

Carpal joints

Flex the carpus. Note the 4 indentations. Inject above of proximal row to block radiocarpal joint; inject above the distal row to block the intercarpal (midcarpal) joint which communicates with the more distal carpometacarpal joint.

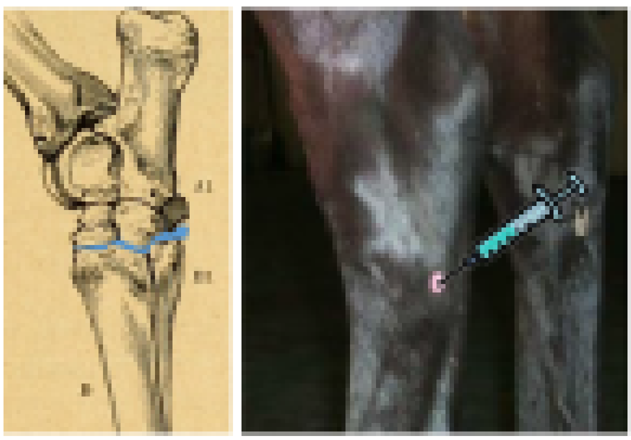


The indentations lie on either side of the wide tendon of the extensor carpi radialis m. that runs vertically over the dorsal aspect of the carpal joint. When removing carpal chips the surgeon must work on either side of this tendon.

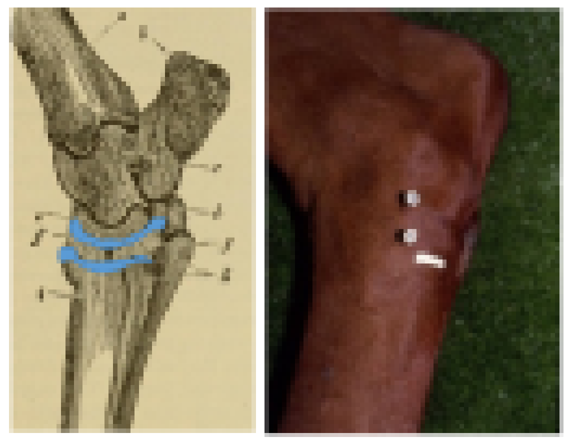
[Video -carpal joint injections]

Tarsometatarsal joint

On the lateral aspect of leg, follow splint bone up until you reach a flat, thumb sized area (slight depression). This is the region above the caudolateral extension of the splint bone. This flat area is above the tarsometatarsal joint (find a skeleton). Insert a 1″ 22ga needle slightly distally and slightly dorsally until it sinks its full length into a hole.



lateral



medial

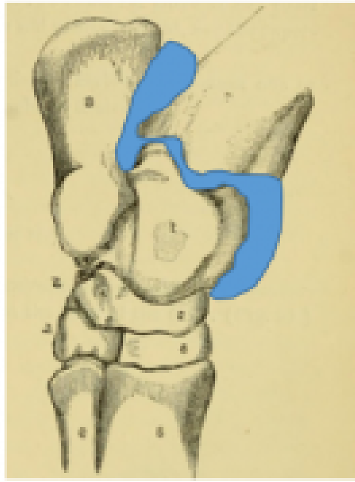
This joint can also be injected medially in a very small depression on the distal aspect of the cunean tendon.

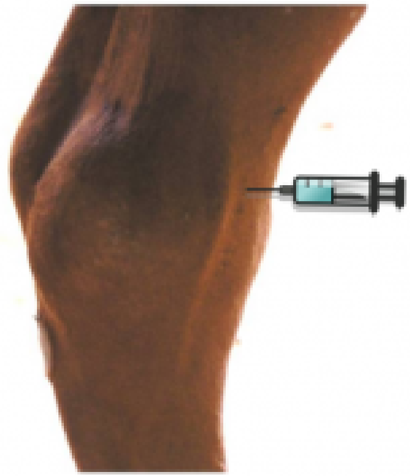
Distal intertarsal block

On medial aspect of hock, find small depression on proximal aspect of cunean tendon; insert 22ga 1″needle (see upper needle on image above).

Tibiotarsal joint

Inject on either side of saphenous vein on dorsal aspect of leg using 20 ga needle parallel to ground



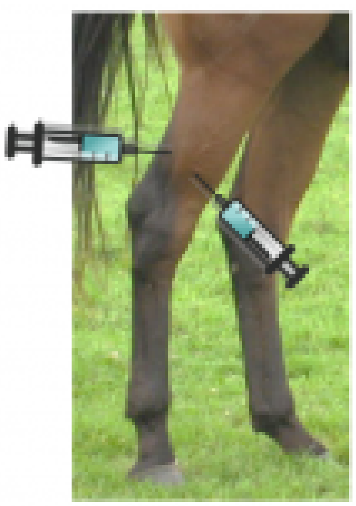


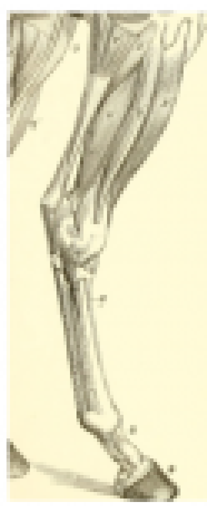
[Videos of hock joint injections]

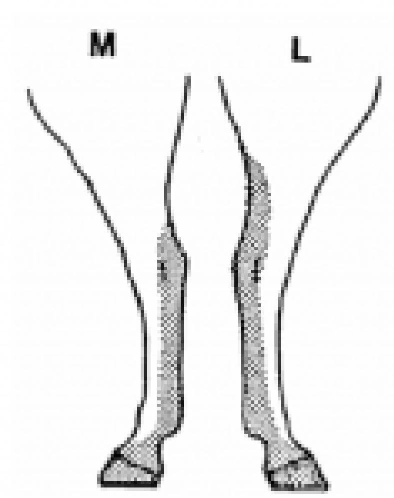
Tibial/peroneal nerve block

Tibial nerve : about 4″ above point of hock, insert 22ga needle from lateral side until point can be felt just under skin medially.

Peroneal (fibular) nerve : at same level, inject on lateral aspect of leg between muscle bellies; fan local anesthetic.







This block can numb the hock and the plantar surface of the distal limb.

Resources

[General info about joint injections] – video

[Local anaesthetics for regional and intra-articular analgesia in the horse], Equine vet. Educ. (2021) 33 (3) 159-168. Review article

Manual of Clinical Procedures in the Horse Ch 28

Where does it hurt? Problems with interpretation of regional and intra-synovial diagnostic analgesia, 2015 EVE

Injecting the stifle video

Nerve block challenge questions

1. What sort of anesthetic agent would you use to perform a lameness examination and why?

(Typically we use lidocaine, mepivicaine, or bupivicaine as local anesthetics but in different situations.)

1. How would you block out the entire foot?
2. How would you block out the fetlock ? Give 2 options.
3. How would you block the suspensory ligament?
4. How would you evaluate a horse for bone spavin?
5. How could you block the tibiotarsal joint? Give 2 options.
6. There are 3 joint pouches in the stifle. Do you need to block all three separately? What about the 3 joints of the carpus? The hock?
7. Are there any complications related to local anesthetic procedures?
8. How long will the anesthetic last (eg if you want to do a different block, how long will you have to wait)?

Nerve block challenge answers

1. What sort of anesthetic agent would you use to perform a lameness examination and why?

(We typically use lidocaine, mepivicaine, or bupivicaine as local anesthetics but in different situations.)

We typically use mepivicaine (Carbocaine) as it provides a moderate duration of activity (about 2 hours), has a relatively rapid onset of action (10 min), and is relatively nonirritating. Lidocaine is used when you want a fast response (3 min) and want it to wear off quickly (or don't care if it does). However, it can be more irritating and the duration depends upon the animal. Bupivicaine is used for long lasting blocks (eg the treatment of laminitis or pain control).

2. How would you block out the entire foot?

Basal sesamoid (abaxial) nerve block

check for sensation at the dorsal coronet to make sure the entire foot is blocked

3. How would you block out the fetlock? Give 2 options.

Low volar (4 point) nerve block or fetlock joint block. Volar = palmar ***or*** plantar

4. How would you block the suspensory ligament?

Regional infiltration, high volar (4 point) or modified high volar (2 point) nerve block

5. How would you evaluate a horse for bone spavin?

Inject the tarsometatarsal +/- the distal intertarsal joints

6. How could you block the tibiotarsal joint? Give 2 options.

Intraarticular injection or tibial and peroneal nerve blocks

7. There are 3 joint pouches in the stifle. Do you need to block all three separately?

   What about the 3 joints of the carpus? The hock?

   Stifle : usually the medial femorotibial and femoropatellar joints communicate but only one in four lateral femorotibial joints communicate with the femoropatellar joint.

   Carpus : the intercarpal and carpometacarpal joints communicate

Hock : sometimes the tarsometatarsal and distal intertarsal joints communicate; the proximal intertarsal and tibiotarsal joints usually communicate

8. Are there any complications related to local anesthetic procedures?

Local irritation and swelling is possible with larger volumes (eg volar blocks)

Risk of creating a septic joint is always a possibility with intraarticular injections but is low with proper preparation of the joint

9. How long will the anesthetic last (eg if you want to do a different block, how long will you have to wait)?

It depends on if you want it to or not. With mepivicaine, count on at least 2 hours, but it may take up to 4; with lidocaine, it should be gone in 1-2 hours

Gait abnormalities

These conditions are not always painful so will not block out. Being able to identify them will save you time and trouble!

Sweeney

Etiology: Atrophy of the shoulder muscles: this allows the shoulder to luxate since there are no collateral ligaments of the shoulder joint. Muscles such as supra- /infraspinatus, subscapularis are so called "active collateral ligaments". In the past, this was associated with cart horses and pressure on the suprascapular nerve. Now it is most often associated with trauma to the shoulder: eg a kick or fracture that damages the nerve or running into a gate or fence post.

Clinical signs : Shoulder joint moves outward from the scapula. Can also see this with damage to the muscles : torn or stretched muscles

Treatment : rest, anti-inflammatory drugs, surgery to decompress the nerve

Surgery is not usually performed until after 3 months of rest and waiting to see if the muscles will regain tone

Prognosis : guarded to poor for return to normal function

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Upward fixation of the patella

Etiology : lack of tone in the quadriceps, allowing the patella to lock in place. This is most common in young horses and those that have been out of training for awhile

Clinical signs : stiff extended leg, particularly when the horse is backed up. May be bilateral . When the stifle "unlocks" horse moves forward normally. May be able to manually move patella into locked position fairly readily

Treatment: old treatment was to cut the medial patellar ligament, thereby preventing the locking. However, normal horses that have this surgery have a strong tendency to develop arthritis in the stifle joint. Now we recommend exercise to strengthen the quads : hill work, over culverts, etc. Other treatments include tendon splitting, irritants injected around the medial patellar tendon to tighten it up, and hormone injections to change the amount of ligamentous/tendinous relaxation.

Prognosis : good if no other problems with the stifle joint

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Fibrotic myopathy

Etiology : trauma to the semitendinosus muscles (injection, injury)

Clinical signs: restricted forward motion to hind limb action at a walk. Limb moves forward only so far and then is slapped to the ground due to the restricted muscle action. Cannot be seen at faster gaits

Treatment : old treatment was to resect the scar tissue but this made more scar tissue. Now most people either ignore it, transect the tendon of insertion of the semitendinosus muscle, or cut some of the restrictive areas under local anesthesia in the standing horse.

Prognosis: there are complications associated with the treatment; If it is mild, it may be best to avoid surgery

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Peroneus (fibularis) tertius rupture

Etiology: overextension of the hind limb such as when it is caught in or under something. It may also be iatrogenic during recovery from anesthesia when the leg is in a full limb cast. This occurs because the cast makes the hock more immobile than the stifle joint.

Clinical signs: loss of reciprocal apparatus — the hock can be extended when the stifle is flexed and the hock does not flex much when the horse is moving (straight leg)

Treatment: rest and anti-inflammatory drugs

Prognosis: good

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Stringhalt

Etiology: thought to be neuronal dysfunction or adhesions around the lateral digital extensor tendon; plant toxin in Australia

Clinical signs: overflexion of the limb during the forward phase of the stride –the hind limb is pulled up in an exaggerated motion and may even hit the ventral abdomen; may be bilateral

Treatment : can try lateral digital extensor tenotomy If acute lesion, try anti-inflammatory drugs and physical therapy to prevent adhesion formation

Prognosis : guarded for full recovery

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Shivers

Etiology : neuromuscular disease that likely involves an abnormality in the feedback loop between afferent and efferent nerve fibers

Clinical signs : involuntary jerky flexion of the pelvic limb (and testicles) as well as extension of the tail : leg is held off the ground in a flexed position and muscles of hind limb and tail may quiver. Mild cases may be intermittent. Generally noted when horse is backed, turned, or made to step over an object. Most common in draft breeds.

Treatment : none

Prognosis : slowly progressive; overall prognosis is poor;

It is important to determine that the signs aren’t caused by PSSM (polysaccharide storage myopathy) as that disease is very treatable

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Gastrocnemius rupture

Etiology : Foals may develop gastrocnemius rupture during dystocia and with assisted delivery. Rupture of the gastrocnemius muscle occurs when the stifle is forced into overextension while the tarsus is flexed. Adult horses may develop gastrocnemius rupture during exercise (in humans, this is generally with twisting; in horses with strenuous stopping).

Clinical signs: Dropped tarsus with extended stifle. inability to straighten the hindlimb. Mild to severe swelling in the upper limb. If the rupture is complete, the horse is unable to bear weight on the affected limb. Bilateral hindlimb gastrocnemius ruptures will result in recumbency due to the inability to stand. Ultrasound, radiographs (calcified injury area) and CT have been used to confirm incomplete ruptures.

Treatment : stall rest, fixation of the affected limb by a full limb cast and/or Robert Jones bandage and administration of anti-inflammatory agents have been used with varying success. Lack of stabilization of the limb makes casts challenging as rub sores are almost inevitable. Affected foals have been reported to return to full function without bandaging or splinting. Intensive supportive care is needed to ensure the foal can stand to nurse. The contralateral limb is at risk of developing angular limb deformities (foals) or laminitis (adults) due to increased weight bearing.

Prognosis : fair if incomplete, guarded to grave if complete rupture


Practice

Practice videos with explanations

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Practice Level A

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Localizing lameness – Level A if you use your resources; Level B if you try without

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Practice Level B

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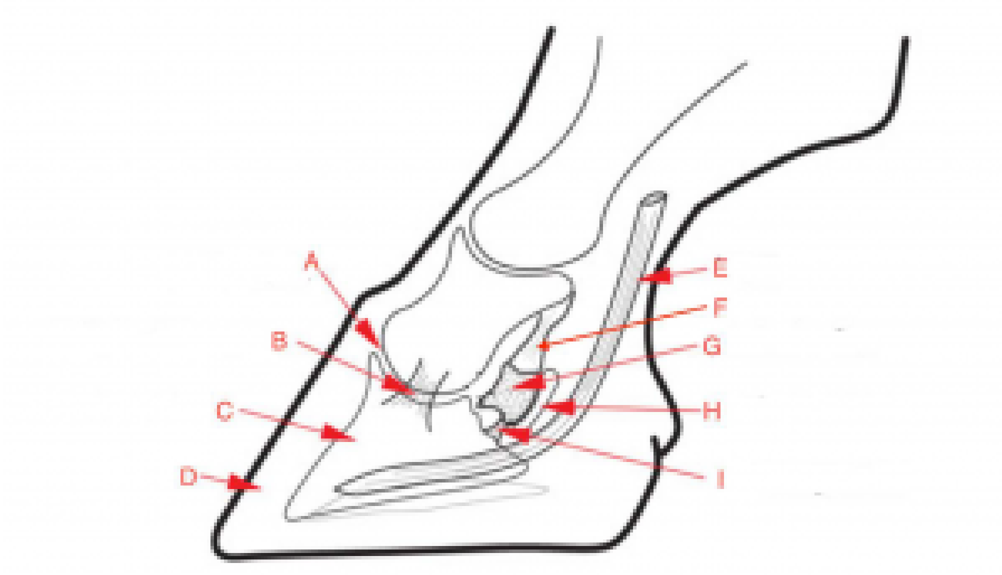
Equine podiatry

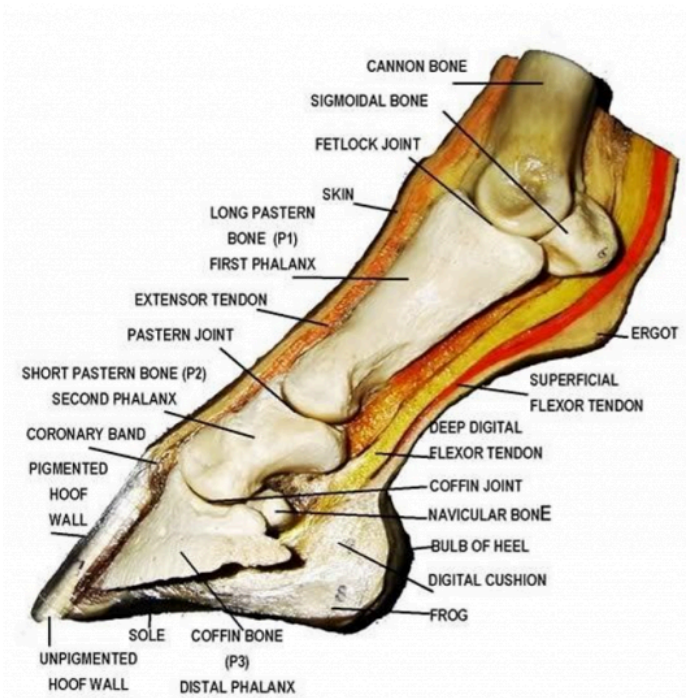
No foot, no horse.

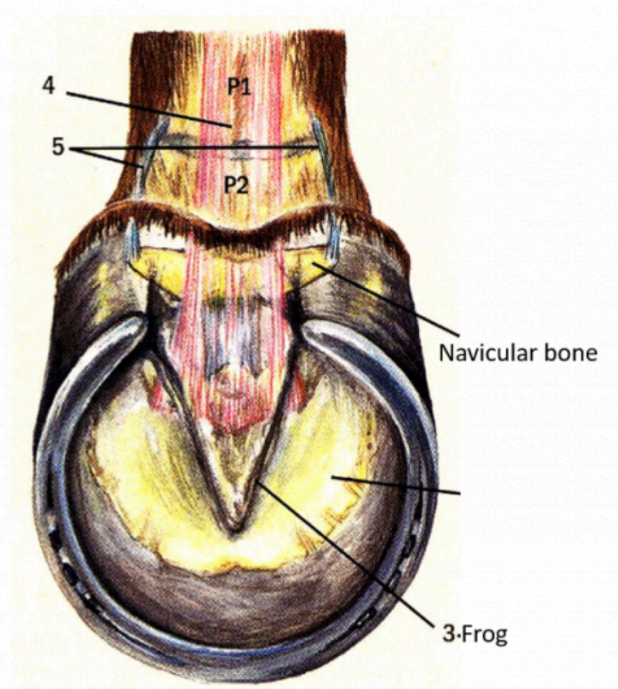
Pathology in the distal limb is one of the most common etiologies of lameness and poor performance in horses. Problems in the distal limb or foot account for greater than 50% of forelimb lameness cases.

Foot anatomy



A – coffin joint. B -lateral collateral ligament of the coffin joint. C -P3, pedal bone or coffin bone. D-hoof wall. E – deep digital flexor tendon. F- suspensory ligament of the navicular bone. G- navicular bone. H- navicular bursa. I- impar ligament.





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Supplemental foot notes – Vic Cox

Famous quote "No Foot, No Horse", Jeremiah Bridges, 1752, in an essay so entitled.

Definitions

The equine foot= the hoof and its contents. The problem with this definition is that if strictly interpreted, it would include only the distal parts of the collateral cartilages and P2.

Collateral cartilages are often referred to as the ungual cartilages but this is misleading because the cartilages are connected to P3 but not to the hoof (ungul- = hoof). Instead, they are partially within the hoof.

Hoof balance = the object of proper trimming and shoeing. If the foot is in perfect balance a sagittal plane through the foot will not only produce symmetrical halves of the foot, but also, the digit and cannon region. Many authorities state that hoof imbalance is a common predisposing factor in lameness, especially of the foot.

Breakover = the point where the coffin (DIP) joint is flexed maximally and the foot lifts off the ground. The longer the toe, the longer the time on the ground before break over occurs. A long toe makes a smoother ride for the rider but can be harder on the horse. Toe vs. heel length is another aspect of hoof balance.

Podium = the foot, *Metapodium* = adjacent to the foot = metacarpus **or** metatarsus = cannon bone plus both splint bones.

Capsule or hoof capsule is another term for the hoof, farriers may use this term and they may refer to the collateral sulci as the *valleys* alongside the frog.

Foot structure

In theory, all the weight of the horse is borne by the hoof wall and hence the laminae. This is why laminitis (founder) is so painful. The frog and sole are soft and not made for weight bearing but will bear some weight on a soft surface, but not on a hard surface, especially if shod. This may be the reason why hard surfaces are cited as one of the causes of foot lameness. The sole is concave and may flatten some at the point of foot contact with the ground surface

600 = approximate number of laminae in a horse foot. Due to numerous secondary laminae, the surface area for connection of the laminar dermis to the hoof is large. Vessels of the laminar dermis have numerous arteriovenous anastomoses which are important in heat regulation and laminitis. Cattle lack secondary laminae and much of their weight is born by the bulbs which would be considered "under-run" if similar heels were on a horse.

Hoof growth is very slow. Therefore, the older part of the wall is, the dryer and hence harder it is. Since the toe is the longest part of the hoof, it is both thicker and less flexible than the heels. On impact the wall bends in slightly near the coronet, especially at the heels. Since the heels should remain flexible, horseshoe nails are only put in the toe and quarters, not the heels.
The collateral (ungual) cartilages are fibrocartilage and the digital cushion lies between them. The digital cushion is a mixture of collagen, elastic tissue, adipose tissue and cartilage. According to Dr. Robert Bowker at MSU, there are 2 extremes here and everything in between.

1. Thin ungual cartilage (UC) and little fibrocartilage in the digital cushion. (Vulnerable foot.)

2. Thick UC and considerable fibrocartilage and collagen in the digital cushion. (Healthy foot.)

The navicular bone acts as a trochlea (pulley) around which the DDFT bends before inserting on P3. Hence the navicular bursa = podotrochlear bursa. Structural components of the navicular syndrome (podotrochleitis) are difficult to identify due to inconsistent findings from one case to another. That is, structural changes such as seen with radiology don't consistently correlate with clinical signs of navicular pain.

The clinical term navicular is often interchanged with the anatomic term distal sesamoid as in DSI = distal sesamoidean impar ligament which attaches the distal edge of the navicular bone to the coffin bone deep to the insertion of the DDFT

While there is but one impar (unpaired) ligament, the proximal (suspensory) ligaments of the distal sesamoid bone are paired. They wrap about the pastern joint and attach to the distal end of the long pastern bone (P1).

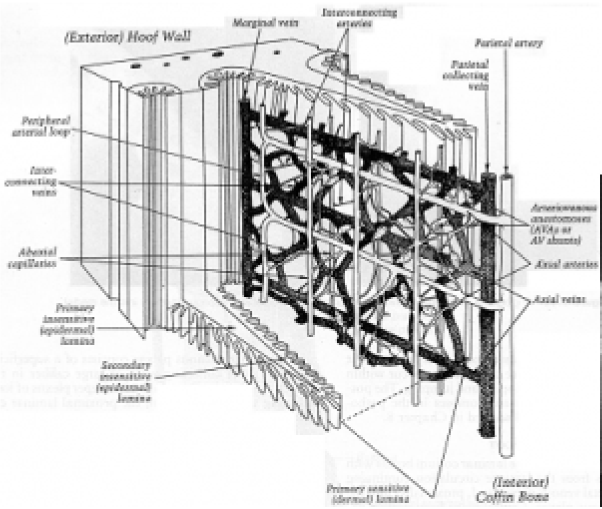
The flexor cortex of the navicular bone is strengthened to withstand the constant pressure of the DDFT on it (although separated from it by the navicular bursa which lubricates the fibrocartilage of the flexor surface. On the next page, note sections of the navicular bone showing differences in the radiodensity of the flexor cortex of the navicular bone. Pre-training 2 year old on left, and similar horse after training on the right. The flexor cortex is on the right in both images.

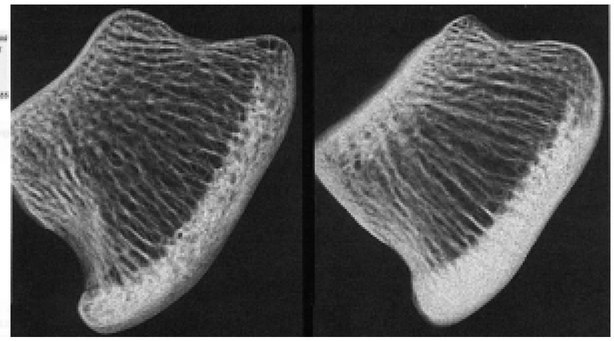
The distal border of the navicular bone furnishes attachment for the distal sesamoidean impar ligament. Dorsal to this, the distal border is exposed to the coffin joint as can be seen in sagittally split feet. Since this border is frequently seen to have foramena on radiographs, the question has long been what is in the foramena. Traditionally the foramena were referred to as vascular foramena but now it is thought that they may be filled with extensions of the synovial membrane of the coffin joint. The following is the opinion of Bob Bowker, VMD, PhD at MSU, East Lansing, MI from e-mail to V. Cox, March 2000**:**

"The foraminae do contain blood vessels initially. But later I have not been able to see any. You made me think a bit as we have found that as the horses "age" (don't think that it is related to age but rather that the stress in the region where the DDFT and the DSIL attaches onto P3 cause damage to microvessels.) I believe that with the reduction in the vasculature (others have shown in navicular horses that the blood flow changes from distal to proximal flow so that in navicular horses 75% enters proximally now versus 25% distally. (normal horse its just the reverse.) entering the distal edge of the navicular bone, there is bony remodeling within the navicular bone. Where the blood vessels are now absent there will be holes. Where they are there is no DSIL attaching to the navicular bone, which I think is the way it was before the fossae were formed. This can explain why there is a large hole on the flexor side of the bone in chronic cases (the overlap of the small arterial tree from the distal

(75%) to proximal (25%) blood flow in normal horses shifts from a proximal (75%) to distal (25%) blood flow in navicular horses. I think that the synovial membrane merely is filling in the hole created by the new remodeled bone, i.e. hole.   The answer is more gray than black and white."

DDFT = deep digital flexor tendon, DSIL = distal sesamoidean impar ligament

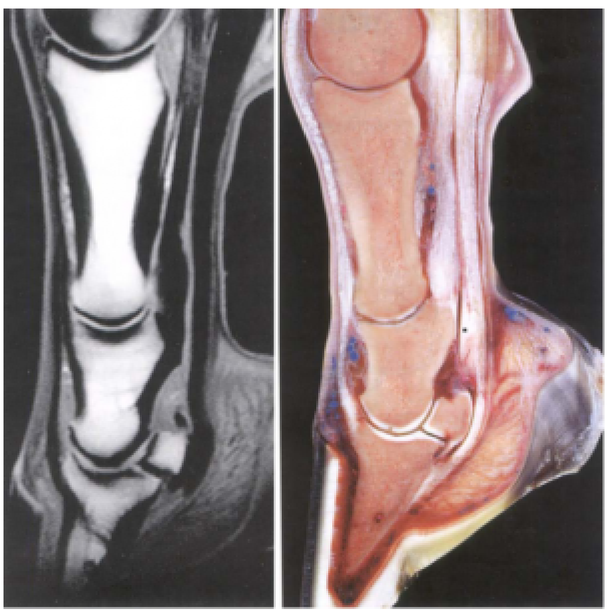




Foot imaging related anatomy

Advanced imaging of the foot, Vic Cox

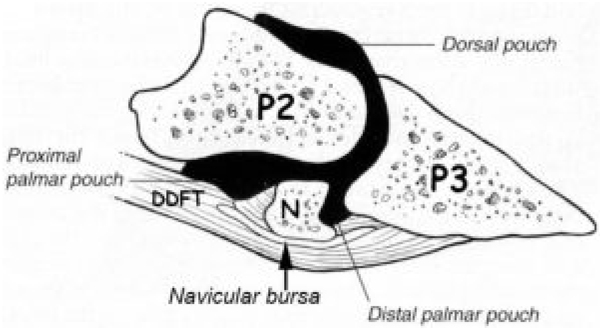
Study of 2D sections is essential for understanding CT and MR images. One weakness of conventional radiographs is that they are limited to full thickness images while CT and MR images can isolate a plane (slab) of tissue so that a small lesion is not obscured by larger structures in adjacent planes that are lumped together to form a full thickness image. Therefore, study of foot bandsaw sections is helpful for understanding CT and MR images. CT is best for mineralized tissues (like conventional radiographs) while MRI is best for soft tissue. MR images are brightest for tissues containing water or fat because MRI depends upon signals from the protons of hydrogen atoms and these are most commonly found in water and fat. For that reason, cortical bone will be dark while medullary bone will be bright (as seen below). Likewise, synovial fluid will be bright and inflammation (edema) will be brighter than normal tissue in MRI images



Note the bright medullary bone and dark cortical bone in the MR image on the left. Also note how synovial fluid is bright and articular cartilage is dark. Likewise, the DDFT and the straight distal sesamoidean ligament are dark. *=fibrocartilaginous part of DDFT on right.

We will review three types of sections:

- Sagittal and parasagittal sections. A sagittal section divides the foot into nearly symmetrical medial and lateral halves. Any parallel plane is called a parasagittal section.
- Transverse sections are perpendicular to the long axis of the distal limb.
- Frontal (dorsal) sections are perpendicular to both sagittal and transverse planes.



This is a sagittal section showing the DIP (distal interphalangeal joint) with three distended pouches. Not labelled is the thin distal sesamoidean impar (unpaired) ligament that binds the navicular bone to P3. Because the DDFT curves around the navicular bone, this bone acts as a trochlea (pulley). Hence the term podotrochlear apparatus (bone and ligaments).

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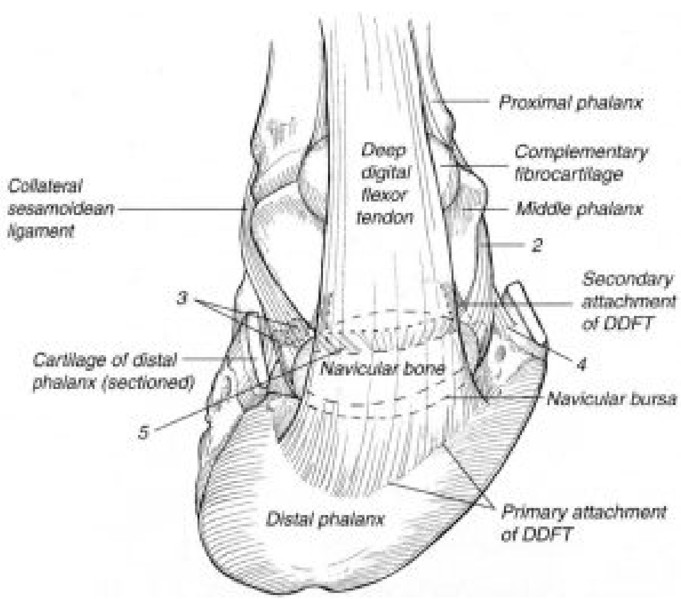
DorsoPalmar views of coffin joint. Arthrogram of DIP joint on right.

Contrast injection of a coffin joint



The impar (unpaired) ligament attaches to the distal edge of the navicular bone while the paired collateral sesamoidean ligament attaches to the proximal edge of the navicular bone. It is a collateral ligament because there are medial and lateral parts that wrap around the pastern bones and attach to the distal part of P1 and also to the “sides” of P2. The collateral sesamoidean ligament (see image above) is also known as the suspensory ligament of the navicular bone. It counteracts the distal end of P2 which pushes down on the navicular bone when the foot makes contact with the groundThe collateral sesamoidean ligament is bilateral and attaches to both P1 and P2 (2) and the collateral cartilage (4). 3 = parts of proximal palmar recess of DIP joint. 5 = origin of the collateral sesamoidean ligament from the proximal edge of the navicular bone. Note that as the DDFT passes distally it gets wider but thinner. The wide thin part is prone to tearing, but the lesion is difficult to see because the DDFT is dark on MRI although tearing may result in enough inflammation or granulation tissue to suggest the injury. Proximal to the navicular bone the DDFT is thicker and has a fibrocartilaginous part (asterisk in fig. 1) but best seen on transverse sections. In the region of the navicular bone the DDFT is divided by a groove into medial and lateral parts.

Dorsosolar radiograph of the navicular bone showing the axial ridge (arrow) on the flexor surface of the navicular bone. The palmar parts of P3 are sometimes referred to as the “wings” of the coffin bone. This radiograph reveals good differentiation between the cortical and medullary parts of the navicular bone. Note that the navicular bone is deep to the apex of the frog. Also note that the wall is more radiodense than the sole and the frog looks like the letter “A”.

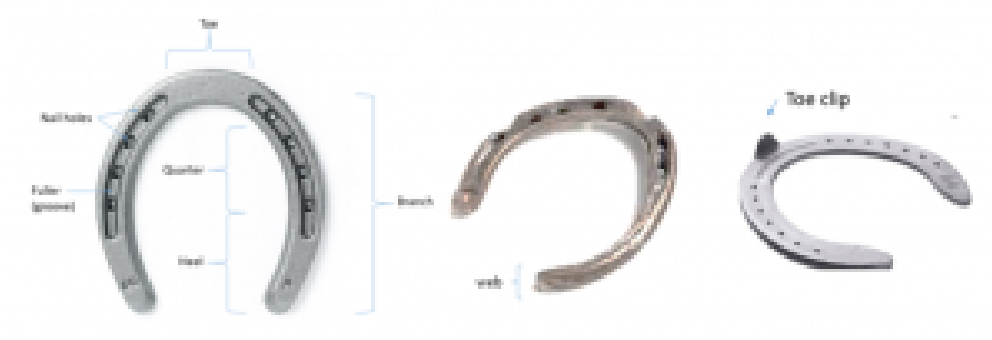
Shoes and pads - an introduction

Horseshoeing is very complex topic. This section will just introduce the basics.

Horse shoes

Most shoes are metal (aluminum or steel) but can be plastic or rubber.

Metal shoes can be manufactured in bulk (“keg” shoes due to the original shipping container) or made by hand using a forge.



Shoes are typically designed to protect the foot, enhance the horse’s action, or provide therapeutic support.

Pads

Pads may be added between the shoe and the sole to protect the sole, elevate the heel, prevent snow and ice buildup, change the gait or alter weight bearing. Pads can cover the entire sole (full) or just the outside edges (rim pads). Pads can be flat or wedged.

full snowball pad; soundhorse.com

Shoeing the horse

Shoes can be applied using nails, metal clips and/or glue. Most shoes are applied by farriers. Farriers have different classification levels and can attend school for a few months or several years.

Resources

Common types of horseshoes

Farrier certification

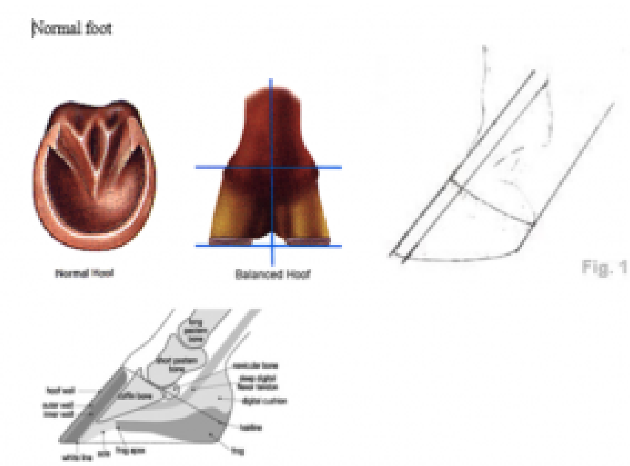
One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=6471#oembed-1

Influence of trimming, hoof angle and shoeing on breakover duration in sound horses examined with hoof-mounted inertial sensors, Vet Rec 2021 – good explanation of ***breakover*** and how shoes impact it

Foot conformation

The horse foot rarely looks perfect. Common abnormalities are medial/lateral imbalance, underrun heels and club feet.

The normal hoof



The heel is parallel to the toe.

The heel is ~1/3 the length of the toe.

The frog and walls are weight bearing. The sole is not. The sole should be “cupped” versus flat (able to hold water if held sole pointing up).

The heels are wide spread. The frog width is at least 2/3 of the frog length.

The coronary band is parallel to the ground.

A line drawn through the middle of the cannon bone extends through the heel region (not behind it).

On a radiograph, the dorsal surfaces of P2 and P3 are aligned.

Broken back hoof-pastern axis

With a broken back hoof-pastern axis, P2 and P3 are not aligned but P2 is more vertical. This tends to accompany long toes (too long between trims) and/or underrun heels. This conformation places extra weight on the navicular bone, rather than on the digital cushion.

Therapy: Trim more frequently (at least every 4-6 weeks in summer, 6-8 weeks in winter) and/or elevate heels with pads and/or shoes.

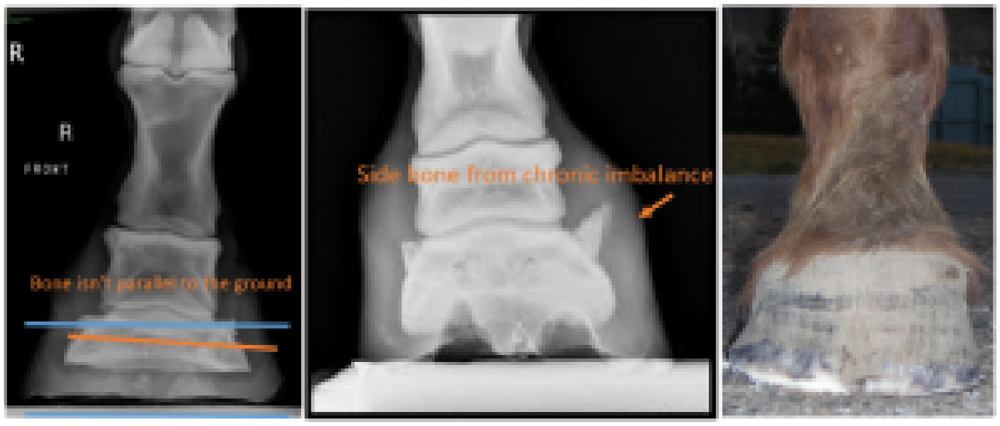
Broken forward hoof-pastern axis

With a broken forward hoof-pastern axis, P3 is more vertical. Heels are vertical and long. This occurs in club footed animals and with P3 rotation secondary to laminitis. This conformation places more stress on the coffin joint, leading to synovitis and arthritis.

Therapy: Inferior check desmotomy to realign the hoof-pastern axis, combined with heel trim.

Medial-lateral imbalance

Often, one side of the hoof grows faster than the other. This leads to uneven weight bearing and more trauma to one side of the hoof. Chronic or severe issues predispose a horse to collateral ligament damage (sprain). Evaluating the coronary band (is it parallel to the ground) and radiographs can identify this imbalance. Chronic imbalance will also lead to calcification of the collateral cartilages as they try to strengthen themselves.



Therapy: More frequent trimming (at least every 4-6 weeks in summer, 6-8 weeks in winter). Monitor coronary band.

Flat sole

The horse should not be weight bearing on the solar surface. The sole be thin and flexible. This means it will transmit pressure to the sensitive laminae and weight bearing on a rock or dirt clod will be painful. The walls and frog should be the primary weight bearing structures.

Good weight bearing structures and cupped soles

Overgrown sole (needs paring), missing wall and dropped sole (laminitis)

Contracted heels and sheared heels

Heels tend to be narrow with pain. If a horse has heel pain, he doesn't put weight in the heel region and the heels aren't encourage to spread apart. Narrow heels or narrow frogs are a big warning sign that the horse has chronic heel pain. Look for signs of navicular syndrome. Treatments are available to encourage widening; however, treatment is often short-lived if the heels stay painful.

Contracted heels – narrow frog Sheared heels

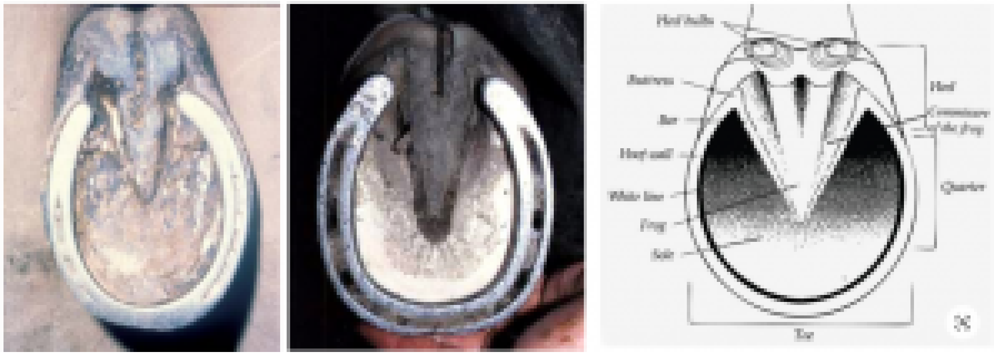
Heels can also be sheared – each at a different height. This tends to be very painful. This can be associated with hoof imbalance.

Therapy : pain relief, larger shoes with wide rim to encourage heel spreading, floating a heel (trimming one side more) to let the heel sink back down to the normal location (controversial).

Shoes

Shoes come in a variety of shapes and sizes. Generally, a shoe needs to be at least as big as the foot. A shoe that is too small will start to cause solar pain and prevent normal hoof expansion.

These shoes are appropriately sized



These shoes are too small (the hoof has grown). Notice how the shoe is seeming to "pinch" the frog? This is likely to create a corn due to constant pressure on the bars

Ensuring the sole is not weight bearing (card stock can slide between shoe and hoof)

A shoe that is oversized tends to come off accidentally as the horse (or another horse) steps on the outside edge. It is tempting to ensure there is no overhang. Shoes do need changing. If left on too long, they will become too small.

> **Key Takeaways**
>
> Lame horses may benefit from a good trim or a more frequent trimming. Check each foot for
>
> - hoof-pastern axis issues (broken back, broken forward)
> - medial-lateral imbalance
> - flat soles (weight bearing on the sole vs the wall)
> - underrun heels
> - sheared heels
> - contracted heels
>
> Check the shoe for uneven wear and fit

Resources

Manual of Clinical Procedures in the Horse Ch 32

Examination of the equine hoof, A Park AAEP- nice explanation of the steps of the hoof exam.

Certified farrier standards

Subsolar (hoof) abscesses

Dr. F Tóth notes

Signalment

Hoof abscesses are common across all ages, sexes and breeds

Etiology

The cause is often unidentified but may be a penetrating wound (including horseshoe nail) or deep bruise. When a horseshoe nail hits the sensitive laminae, this can lead to trauma and infection (hot nail). Horses with chronic laminitis are prone to hoof abscesses as the laminar interdigitation is damaged; this leaves an opening for bacteria. White line disease can also lead to abscesses due to similar structural damage.

Clinical signs

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Horses develop a sudden, severe unilateral limb lameness. The horse is often reluctant to bear weight on the limb or may even refuse to put weight on it. The owner may believe the horse has fracture.

On physical examination, the affected foot is warm and has a bounding digital pulse. The distal limb (pastern area) is often swollen.

When the hoof is pared, a black spot may be visible in an area that is usually not black. For some reason, hoof pus is black.

The horse may develop a draining tract at the coronary band – “gravel” (I have no earthly idea why it is called a gravel). It is easier for an infection in the foot to drain upwards rather than to break through the tough hoof wall or sole.

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Diagnostics

Hoof tester examination

The horse will typically be very sensitive to hoof tester pressure. The entire hoof tends to be sensitive so localizing the abscess is not always possible. In some cases, the hoof testers will squeeze out black goo from the abscess.

Hoof paring

Lightly paring the sole (removing the superficial layer) can help find the abscess. Look for a black spot that doesn't pare off.

https://www.equipodiatry.com/article_hoof_abscess.htm

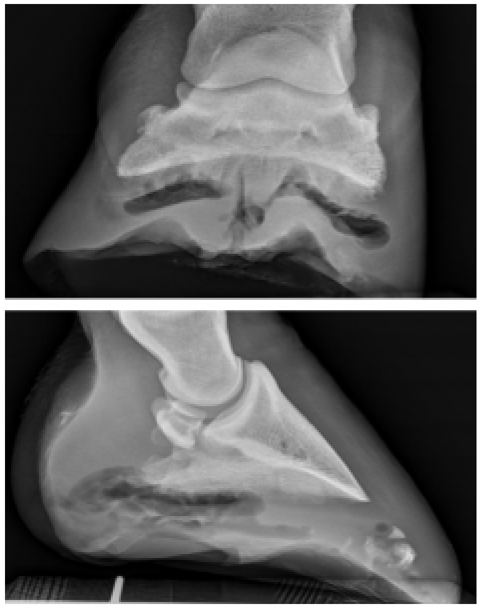
If no spot is identified, it can help to poultice the foot (eg Animalintex bandage) and/or to soak the foot in warm water mixed with Epsom salt. This softens the horn, making paring easier. The epsom salts may also help draw the abscess to the surface.

Nerve block

Pain from the abscess can be hard to totally numb but it should improve at least partially to a local nerve block (lateral or medial PDN or abaxial sesamoid block). This may be necessary to work on the foot.

Radiographs

Radiographs can help rule out a fracture or laminitis. In some cases, the bacteria produce gas which can be seen radiographically. Radiographs can also identify bone involvement (chronic abscesses).



Treatment

The goal of treatment is to create ventral drainage for the infection. This is usually done standing with or without local anesthesia. The tract should be opened just enough to establish drainage. We want to avoid further disrupting the hoof structure. Debridement should be stopped if blood or pink tissue is encountered.

After the abscess is opened, the foot is soaked in warm Epsom salts, treated with a penetrating hoof cleanser, or poulticed to encourage drainage.

The foot is bandaged to minimize contamination until the defect can be filled with granulation tissue or horny sole. If the defect is large, a shoe with a “hospital plate” may be indicated. This is usually a metal or rubber shoe covering that can be removed for treatment and then replaced.

https://therubbercurrycomb.com/2017/01/05/keratoma/

Tetanus prophylaxis is indicated. Antibiotics are not usually needed. NSAIDs can be used as needed for pain. Once the abscess is open, the pain is usually substantially reduced.

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If the distal phalanx is involved (osteitis), then bone must be curetted. This requires general anesthesia and the application of a tourniquet. This is most easily done through a trephine hole in the hoof wall. Regional limb perfusion with antibiotics are recommended.

Prognosis

The prognosis is excellent for uncomplicated solar abscesses. However, the prognosis is guarded to poor if synovial structures or the pedal bone is involved (uncommon).

Key Takeaways

Hoof abscesses can be exquisitely painful (think after-effects of slamming your finger in a door).

- If the horse looks fracture lame but the limb seems okay, think hoof abscess
- It is easy for a shoe nail to cause trauma to sensitive laminae
- Abscesses need drainage – but try to limit damage to the sole or wall

Resources

Horse hoof abscesses, UMN extension

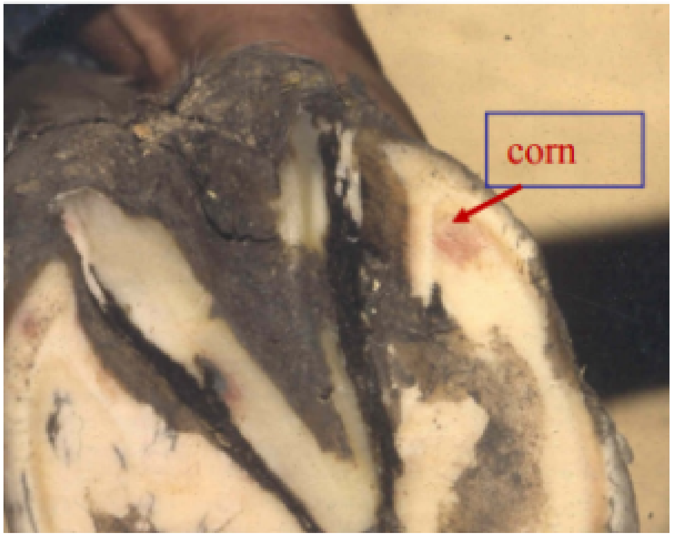
Solar bruising & corns

Dr. F Tóth notes

Definitions

Solar bruising : Contusion caused by impact – results in hemorrhage of the solar corium. Often a “corn”

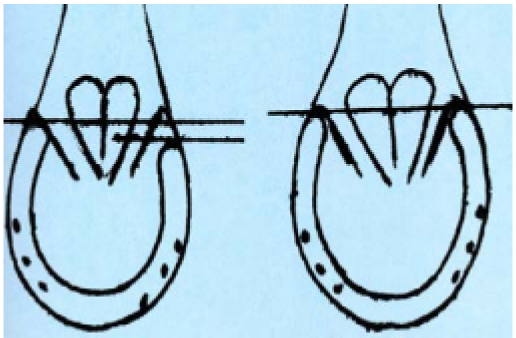
Corn: solar bruising located in the medial angle of the sole



Etiology

Bruising is typically caused by:

- Shoe that is too small or does not extend far enough back under heels (corns)
- Long-toe/low-heel conformation (toe-bruising as horse tends to land on toe)
- Flat and/or thin-soled feet
- Riding on a hard or rocky ground
- Foot that has overgrown its shoe- shoe rides on sole



shoe does not extend far enough back

shoe is too small

Clinical signs and diagnostic tests

Lameness varies. It can be acute and severe or chronic and mild. Bruising often affects several feet. If both front feet are affected, it can resemble laminitis. Lameness may worsen when the shoe is removed.

Increased digital pulses are often present. Discoloration of the sole (bruise) may be evident on unpigmented feet or if the bruise is deep. The horse will typically be positive on hoof tester examination in the bruised area.

Lameness should be improved after palmar digital nerve anesthesia.

Treatment

- Phenylbutazone or other NSAIDs
- Eliminate shoeing problems (replace a small shoe, etc)
- Apply caustic agent to toughen sole, such as iodine, formalin, or phenol (i.e., sole paint)
- Apply a pad until the sole can toughen
- Apply a wide-web shoe to support the foot

Key Takeaways

Corns are sole bruises at the medial angle of the sole.

- These are usually due to a poor fitting shoe (too long between resets).
- Bilateral lesions are common
- Treat with NSAIDs, hoof tougheners and better fitting shoes

Resources

Remedial shoes – Horse and Hound

Corns in Horses– VCA

Thrush

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Dr. F Tóth notes

Definition

Thrush -Degenerative condition of frog & surrounding tissues caused by infection with keratolytic organisms

Etiology

Fusobacterium necrophorum appears to be the most important organism. This opportunistic organism can thrive with poor sanitation or persistent wet conditions. External risk factors include sole pads that keep the sole moist, confinement and muddy paddocks. Horse risk factors include poor conformation with deep frog sulci and/or sheared heels (image below).

Clinical signs

Thrush is characterized by black, necrotic, foul-smelling material in central sulcus or collateral sulci of frog.

Generally the infection is restricted to the frog and sulci but it can involve the digital cushion and skin at the heel bulbs.

The infection leads to deep sulci and eventually an atrophied frog. If the sensitive tissues (beyond the frog) are involved, lameness may be present.

Treatment

Drying agents include formalin, tincture of iodine, phenyl, new methylene blue, and 2% benzoyl peroxide

- Clean feet daily
- Remove necrotic tissue
- Apply drying agent to foot
- Foot soaks in chlorine bleach [30 mL (1 oz) of bleach in 5L water]
- Miconazole (Lotrimin) plus neomycin (50/50 mixture)
- Bandage (if needed for protection)
- Trim foot (if indicated)
- Improve sanitation (if indicated)

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Prognosis

Good for full recovery

Key Takeaways

Wet feet with deep frog crevices get thrush.

- Foul smelling, black gunk in frog
- Occurs due to excessive moisture
- Dry the foot and treat with various compounds

Resources

Thrush in horses, VCA

Definition

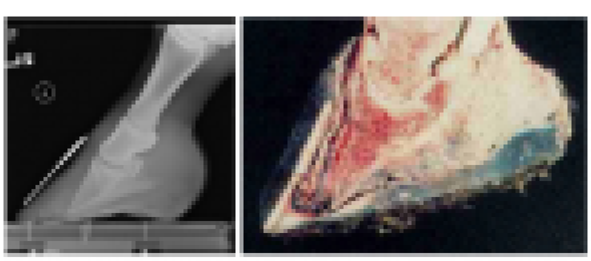
Laminitis is inflammation of the laminae that attach to the coffin bone and interdigitate with insensitive laminae of the hoof wall. It is a painful condition that results from disruption of the dermo-epidermal junction within the hoof. Laminitis = founder.

Pathophysiology

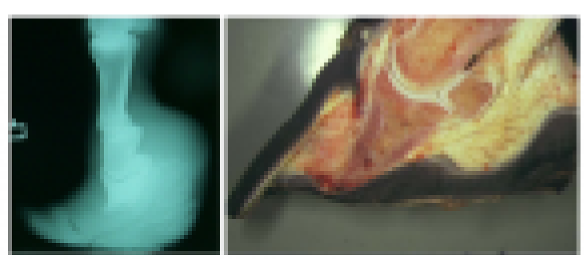
Many different things cause laminitis and they probably don't all cause it the same way (different pathophysiology). One major theory is vascular leakage and secondary swelling within the hoof capsule. Swelling and hoof rotation impair blood flow, leading to more damage via compartment syndrome effects. Other theories to explain laminitis include poor blood flow, vascular thrombosis, and abnormal keratinization.

In general, the toe region is the most damaged due to the limited vascular supply in that region.

Basically the laminae become inflamed, show inflammatory changes such as heat, pain, swelling and "loss of use". Swelling in the foot is bad as there is nowhere for the swelling to go due to the hoof capsule. The capsule leads to compression of the swollen tissues and more damage. With loss of use, the laminae stop holding the coffin bone up in the hoof. The weight of the horse and the pull of the deep flexor tendon battle it out to see if the coffin bone will rotate or sink. Rotation occurs when the laminar inflammation (and loss of use) is primarily dorsal. The deep flexor tendon pulls on the coffin bone and the tip dives toward the ground. The laminae can heal, but are now pulled abnormally. This creates funky hoof growth.

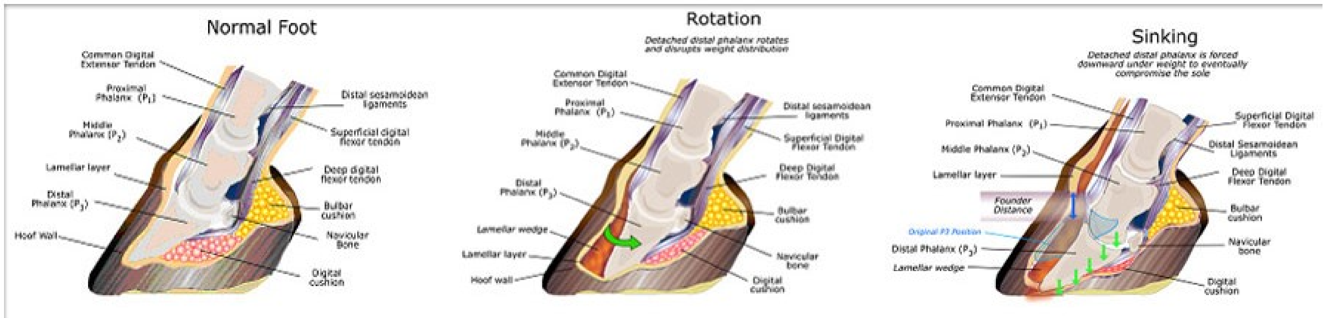


P3 rotation (acute)



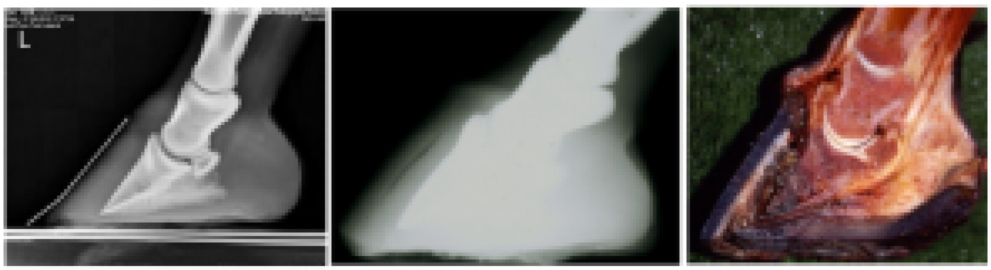
P3 rotation (chronic)

With more severe laminar damage or more weight on the hoof, sinking can occur. Basically the coffin bone is set free and it sinks toward the ground. This is bad.



https://www.onlineequine.co.uk/news/equine-health

Sinking may be missed on radiographs as it is more subtle. Watch for a larger distance from the coronary band, less foot between the coffin bone and the ground, and visible air on radiographs (the laminae should keep air out).



As the coffin bone shifts downward from either rotation or sinking, a half moon shape or the tip of the bone may be visible on the bottom of the foot. This is not good. Survival is poor if the coffin bone is exposed. Saving these horses requires intensive prolonged hospitalization and is usually not successful.

https://trinity-consultants.com/horse-laminitis/

Etiology

About anything can cause laminitis. Laminitis is common following release of endotoxin — GI colic /diarrhea /enteritis, metritis/retained placenta, etc. On the farm, you may see it following exposure to excessive grain intake, a change in diet (especially fresh pastures), black walnut shavings bedding, excessive weight-bearing due to contralateral limb lameness, hormonal changes (PPID, equine metabolic syndrome), coagulopathies, and steroid administration.

The famous racehorse, Barbaro, developed laminitis of his sound hind foot due to shifting weight off his fractured hind limb. This "secondary" laminitis led to euthanasia.

Signalment

Laminitis is a disease of adult horses. Foals do not usually put enough weight on the foot to cause laminitis. It may be more common in older horses, particularly associated with PPID.

Ponies are also more commonly affected by chronic laminitis, likely related to their propensity towards equine metabolic syndrome and insulin resistance.

Clinical signs

Acute laminitis

Signs include increased heat near coronary band, pounding digital pulses, sensitivity to hoof testers around the hoof wall, reluctant to stand on that foot (have the other foot picked up), increased heart rate and signs of pain. Horses develop a "sawhorse" stance due to bilateral forelimb involvement since they are trying to unload weight from the front limbs. Horses may incessently weight shift in the stall. Laminitis leads to a "walking on eggshells" gait.

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Chronic laminitis

These horses will often have a dished foot (the foot starts growing at a different angle due to rotation of the coffin bone), founder rings (rings around hoof wall), widening of the white line on the solar surface, changes in position of the coffin bone on radiographs, broken forward hoof-pastern axis, chronic pain, and chronic abscessation. Chronic laminitis may present as recurrent forelimb lameness.

Founder rings Dished foot Severe hoof overgrowth

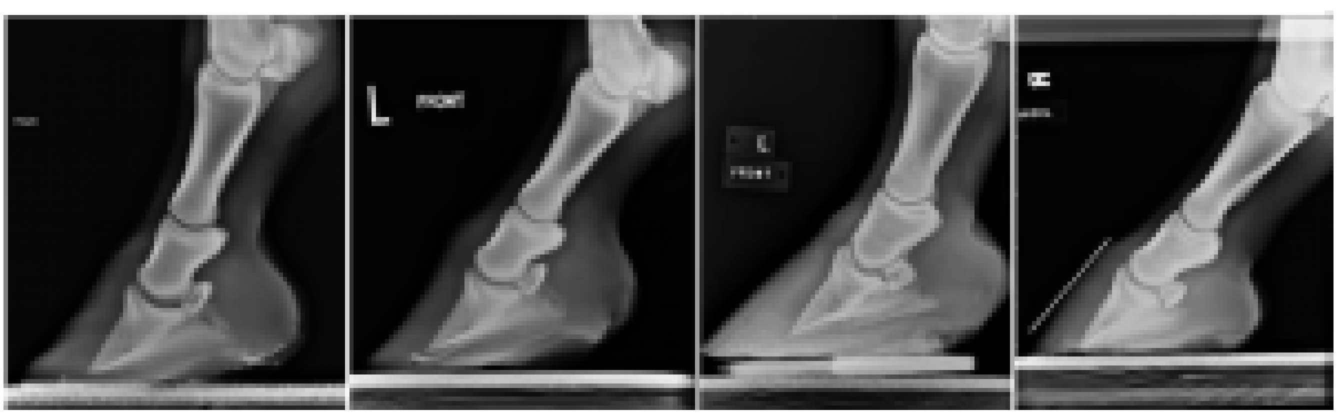
Diagnostics

- Sensitive to hoof testers at the toe
- Should improve with palmar digital or basisesamoid nerve block
- Radiographic changes consistent with rotation, sinking or chronic laminitis (coffin bone remodeling)
- Classic gait (avoid toe pressure)

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=1715#oembed-2

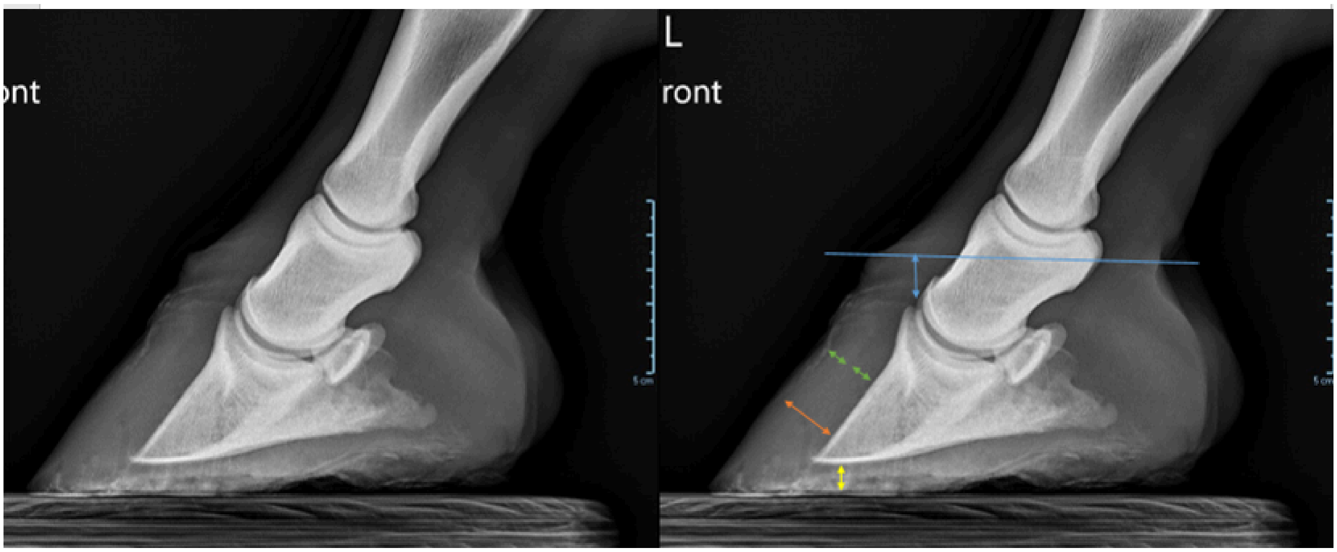
Radiographs

- changes in angle between hoof wall and dorsal surface of the third phalanx (rotation)



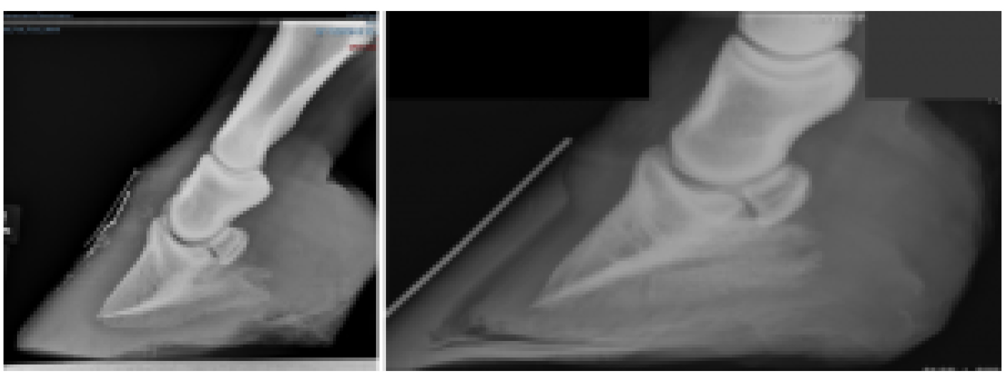
rotation

- changes in distance between dorsal hoof wall and dorsal surface of the third phalanx and for flattening of ledge at top of coronet (sinking)

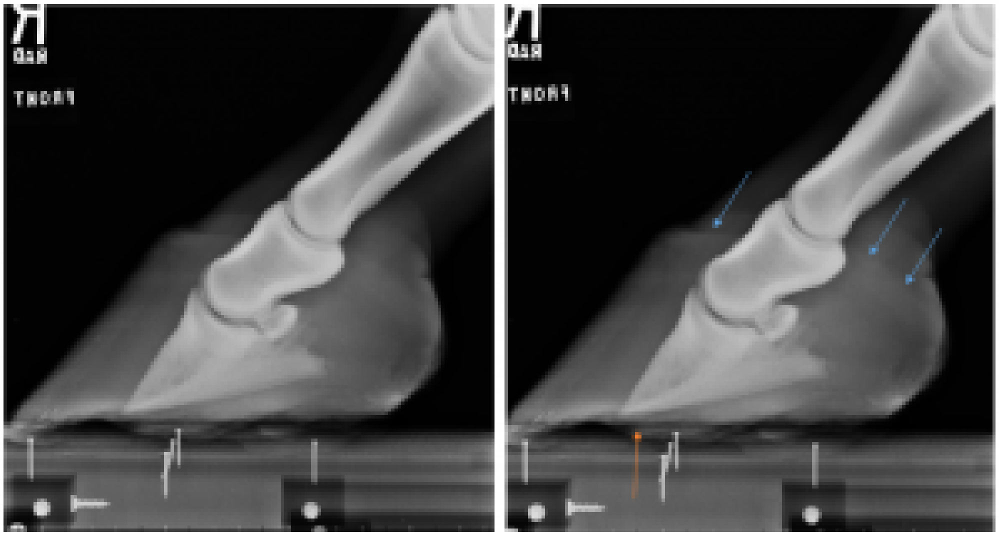


Sinking is indicated by the increased distance between P3 and coronary band (blue), hoof capsule is < 1/2 of total hoof wall (green), total distance from P3 to dorsal wall is greater (orange), sole distance is smaller (yellow)

- These changes are much more subtle. The greater distance from the coronary band and from the dorsal hoof wall are directly related to sinking, as is the decreased sole distance. In some radiographs you can see a darker line between the horny corium (hoof wall) and laminae. When the laminae is more than half of the total distance, that is also related to sinking of the pedal bone.

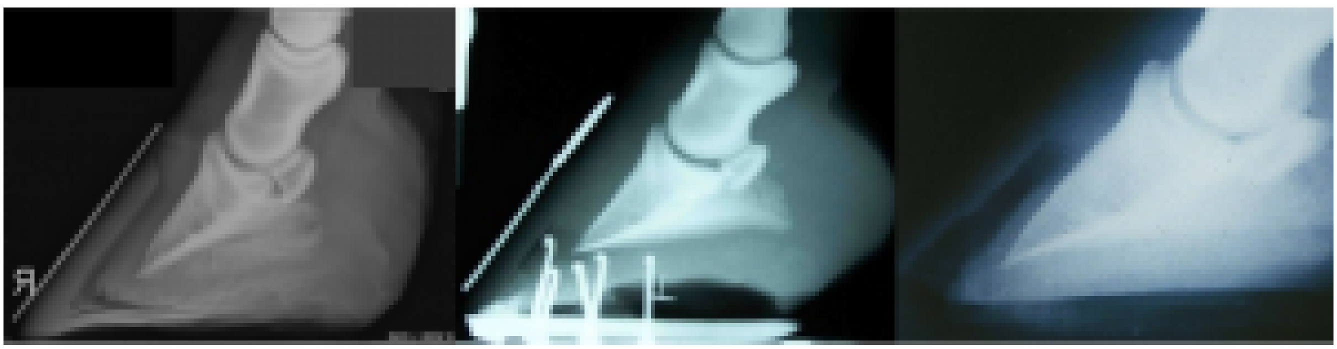

sinking

- limited distance between third phalanx and ground
- halo at coronary band (more prominent due to sinking of collateral cartilages along with coffin bone)



Note halo (blue arrows) and thin sole (orange arrow). Sinking.

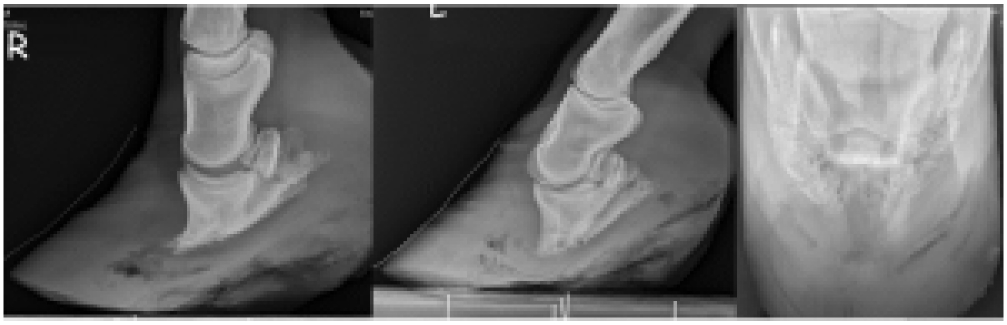
- gas around the third phalanx (infection)



gas lines

- chronic changes- remodeling of the hoof capsule (founder rings, dished shape) and/or the pedal bone ("elf shoe", deformity, lysis)

"Elf shoe" (tip of P3) on left, deformed hoof capsule on right



Remodeling and lysis of P3 along with dished foot and gas within the hoof wall

Treatment

Treatment is focused on the most likely pathophysiology. If swelling is a concern, we try to decrease swelling. If we are concerned about clotting, we try anti-clotting factors. Unfortunately, all of these look the same and we don't yet know enough about what is happening inside the hoof. Therefore, horses tend to get a "shotgun" approach and we treat all possible forms.

Analgesia

All cases are going to require some form of analgesia. This is often NSAIDs but many require additional pain relief. Epidurals may help hindlimb laminitis (less common). Fentanyl patches, gabapentin, iv infusions of narcotics or ketamine, and acupuncture have been used, among others.

Remove the inciting cause

Remove the inciting cause (retained placenta, black walnut shavings, etc). If the horse ingested too much grain or other toxins, mineral oil or activated charcoal may be administered via nasogastric tube to minimize absorption and speed transit. Metabolic syndrome should be addressed by weight loss and any indicated medications or feeding changes. Cushings disease should be treated.

Limit walking

Walking requires laminae to work hard to keep the pedal bone in position. If the laminae are dysfunctional or damaged, walking will only cause more damage. The horses should not be walked more than is absolutely necessary during the acute or inflamed stages.

Decrease swelling/impact of swelling

Swelling inside the hoof capsule leads to more damage. Horses may be given DMSO or other agents to decrease swelling. Ice therapy may also help with swelling. The hoof capsule can also be rasped to allow a bit more swelling. Currently we have moved away from more drastic hoof capsule removal (it used to be removed from the front of the hoof to allow swelling in the most commonly affected area).

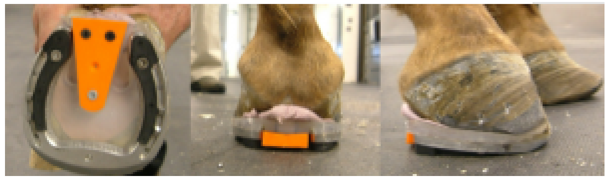
Support the coffin bone

Gravity is pushing the bone downward and the deep flexor tendon is pulling it around. We can relax the pull of the deep flexor tendon by elevating the heel in cases with rotation (this does not help cases of sinking). Counteracting gravity is challenging. In acute cases, builders styrofoam can be used to make a soft support that molds to the horses foot.

Sand or peat moss can work similarly. “Lily pads” are rubber pads designed to support the frog and provide a small amount of heel elevation. In severe cases without financial restrictions, horses can be placed in a sling to minimize weight bearing.

In more chronic cases, the foot is trimmed or shod to enable easy turning or “**breakover**“*. Heartbar shoes are designed to use the frog and heel for more weight bearing, removing some of the stress from the laminae. Shoes may also be applied backward to put more support in the heel and avoid pressure at the toe region. The EDSS (Equine digital support system shoe) is designed to flex based on the horse’s response. Farrier recommendations vary significantly over time!

reverse shoe with pad; heartbar shoe



EDSS shoe

Nailing a shoe on the foot is avoided in acute episodes. Glue on shoes or foot boots can be used to hold pads in place during inflammatory periods.

*breakover is the time from when the horse starts to take a step until the toe leaves the ground. A long toe leads to a longer breakover time.

Encourage blood flow

With sluggish blood flow or constricted capillaries due to external swelling, clotting is involved in many forms of laminitis. Low dose heparin, aspirin (every other day) and other platelet mediators have been tried and are often used.

Acepromazine is used with the goal of vasodilation.

Even though walking would encourage blood flow, it is contraindicated in laminitis due to the related damage.

Surgery

Surgery is considered in more chronic cases with significant rotation. The goal is to realign a rotated coffin bone so that the pull on the laminae is more normalized. Cutting the inferior check ligament may be sufficient in a few cases. In many cases, the deep flexor tendon is transected in the pastern region or in the mid-cannon bone region. This temporarily relieves the pull on the coffin bone. The tendon will heal so the surgery must be accompanied by appropriate farrier work to ensure it heals with the desired conformation.

Minimize further trauma

Chronic cases are prone to hoof abscesses. Abscesses cause inflammation (inflammation = inflamed laminae= laminitis) and add to the damage. Any acute exacerbations should be evaluated to determine if it is recurrent laminitis (often bilateral) or a hoof abscess (often unilateral). Of course that inflammation tends to set off the laminitis in both feet (one is direct since inflammation of the laminae involved, the other foot indirectly due to increased weight bearing).

Other inciting factors should also be avoided (lush pastures, hard surfaces, grain overload) as these horses are at increased risk of recurrent laminitis.

Prevention

Retained placenta, colitis, endotoxemia, excessive weight bearing due to a contralateral limb lameness, and excessive grain intake are all known to cause laminitis and are not uncommon in horses.

Prevention is key if the horse is at risk:

- Ice the lower limb to decrease metabolic requirements
- Support the foot and limb via deep sand or peat moss bedding and/or styrofoam pads
- Administer mineral oi/charcoal through nasogastric tube to bind ingested toxins, minimize toxin absorption and encourage faster movement of any grain or other substance through the GI tract
- Pentoxifylline or polymyxin B to bind endotoxin and prevent its action
- Flunixin meglumine for both its anti-inflammatory and antiendotoxin properties
- Bismuth subsalicylate and/or kaolin for colitis

Prognosis

Prognosis is based on clinical signs, rate of change and amount of sinking (+/- amount of rotation if severe). Sinking is bad.

The prognosis is poor if you can't pick up other foot, the horse needs continued large amounts of analgesics, the pedal bone is sinking or is exposed at the sole, or if you can't get rid of inciting cause.

Sequelae

Pain, rotation of the third phalanx, sinking of the third phalanx, chronic abnormal hoof growth (rings, dished foot), chronic infection (hoof abscesses) due to damage to white line, and recurrent episodes of laminitis are all potential sequelae to a bout of laminitis.

Since horses are prone to recurrent laminitis, it is crucial to take radiographs early on in the diagnosis. The rate and severity of changes can help identify prognosis but you need to know the starting point. Most of these horses will suffer from chronic abscessation since the laminae don't seal well and can't keep bacteria out.

Key Takeaways

Laminitis is bad

- Clinical signs include shifting weight, lying down, hoof tester sensitivity, and "walking on eggshells"
- The coffin bone can rotate or sink. Sinking is worse.
- Ice can help minimize laminitis in high risk cases
- Keep swelling minimal (NSAIDs) and avoid exercise.
- Horses are prone to new bouts of laminitis and to abscesses
- Treatment is supportive and surgery can be used to realign the hoof-pastern axis

Resources

Clinical insights: Treatment of laminitis, EVJ 2019

Diagnosing and treating laminitis in horses, Vet Record In Practice 2018

Pain management for laminitis in the horse, EVE 2019

Radiographic and radiological assessment of laminitis, EVE 2013 – excellent resource for measurements

Equine Emergencies, Chapter 43- Laminitis, Rucker & Orsini, 2014

Hoary Alyssum – UMN extension, 2021

Laminitis cases

Think about what you would do for each of these!

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Other foot conditions

White line disease

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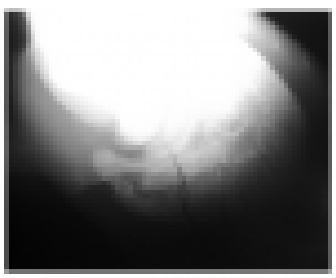
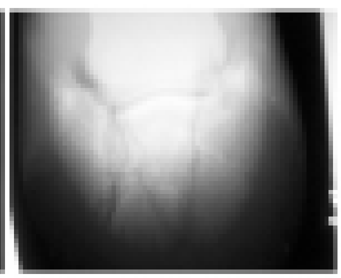
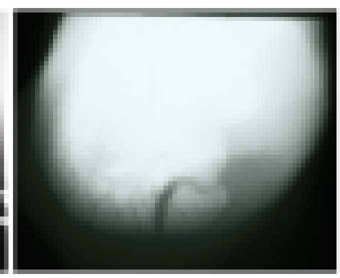
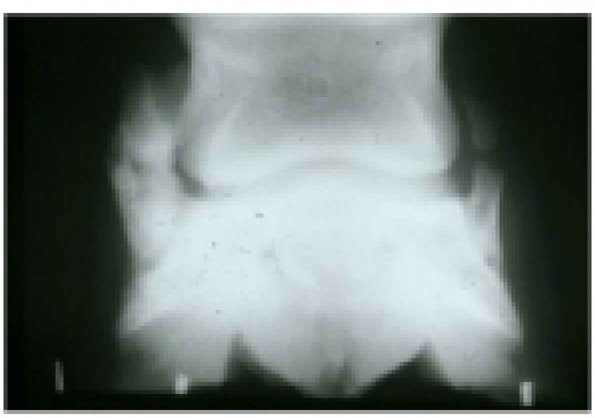
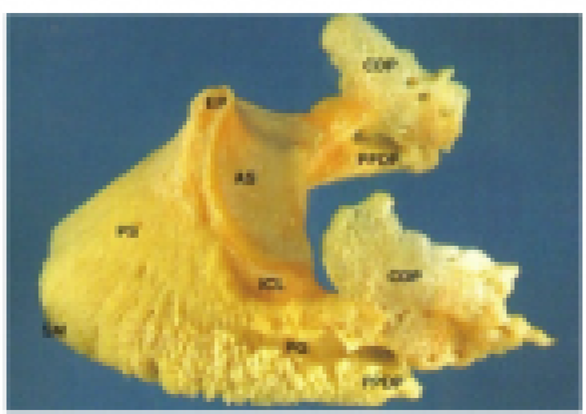
Hoof Disorders and Farriery in the Donkey, VCNA December 2019, Vol.35(3), pp.643-658- includes white line disease section

Coffin bone fractures

Pedal bone fractures, EVE 2011, Vol.23(6), p.314-323

Sidebones

Ossification of the cartilages of the foot, EVE 2010, Vol 19(1), p. 51-56.

Coffin joint arthritis

Evaluation of standing low-field magnetic resonance imaging for diagnosis of advanced distal interphalangeal primary degenerative joint disease in horses:12 cases (2010–2014). JAVMA 15 January 2019, Vol.254(2), pp.257-26 – check the references for more on the disorder

Collateral ligament desmitis

Osseous abnormalities associated with collateral desmopathy of the distal interphalangeal joint: Part 1. EVJ 2009, Vol.41(8), pp.786-793

Osseous abnormalities associated with collateral desmopathy of the distal interphalangeal joint: Part 2. Treatment and outcome. EVJ 2009, Vol.41(8), pp.794-799

Canker


Retrospective study on 30 horses with chronic proliferative pododermatitis (canker). EVE 2011, Vol.23(9), pp.466-471.

Navicular syndrome

Navicular syndrome is a chronic forelimb lameness associated with pain arising from the navicular apparatus. The navicular apparatus is comprised of the distal sesamoid bone (navicular bone) and closely related structures. Multiple different clinical conditions cause pain in the navicular apparatus – these tend to look similar to each other despite different types of damage.

Navicular syndrome is most associated with Quarterhorses and QH types (Paints, Appaloosas, etc). This is probably related to the pounds/square inch on their little feet. It is often bilateral.

Remember, foot pain will often cause the horse to overstress the shoulder due to changes in how the limb is advanced. This might lead owners to be more worried about the shoulder than the foot.

Pathophysiology

Function of the navicular bone

The navicular bone acts as a fulcrum to decrease the work of the deep digital flexor tendon. The fibrocartilage covered flexor surface provides a gliding surface for DDFT. Due to the interplay, the DDFT exerts a major compressive force on the distal 1/3rd of navicular bone and this force is greatest during the propulsion phase of the stride. Furthermore, the force is increased with low heel/long toe conformations.

See Navicular bone mechanics for useful images

Possible forms of navicular syndrome

There are multiple theories and/or possibilities on why navicular bone occurs:

- Exercise : poor blood flow in response to exercise with subsequent pain due to anoxia
- Navicular bone pain : increased intraosseous pressure leads to bone pain
- Navicular bursa/DDFT : damage to the bursa or distal deep flexor tendon leads to adhesions and scarring in the region; pain occurs due to decreased mobility
- Coffin bone/sole/caudal hoof: other palmar heel structures are painful; this includes P3 fractures, sole bruises, and damage to other soft tissues
- Ligamentous injuries : strain/sprain of the impar ligament, collateral ligaments of coffin joint, and/or suspensory ligaments of navicular bone
- Coffin joint pain: arthritis or synovitis leading to pain on movement and with flexion

Pathological changes

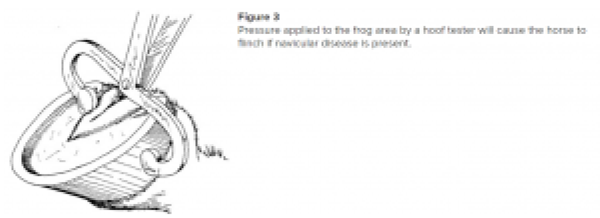
Erosions of fibrocartilage of flexor surface of the navicular bone underlying the DDFT are often the first to occur and are typically seen on the median (sagittal) ridge. Other changes associated with the syndrome include degenerative change of the spongiosa, chip fracture(s) of the distal border of the navicular bone, adhesions between the flexor surface and DDFT, and navicular bursitis (rarely seen alone). Often horses have more then one component.

Diagnostics

Passive exam

Hoof testers

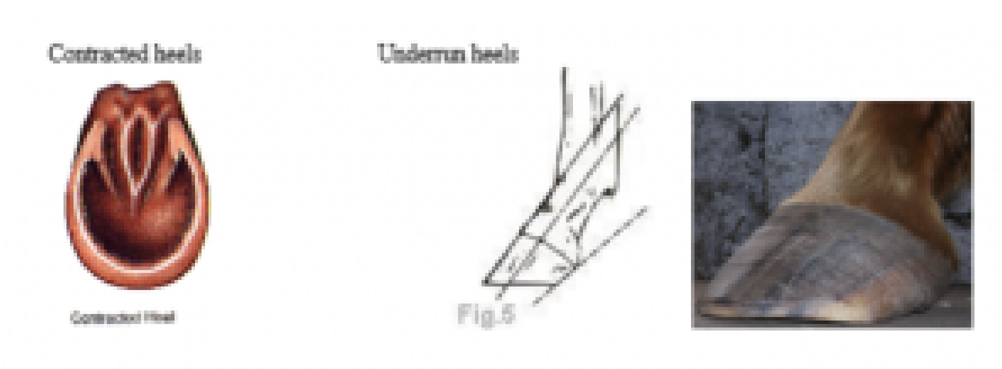
Look for pain along the white line and from the frog to each wall and across the frog. Remember the navicular bone is [deep to the frog.](#)



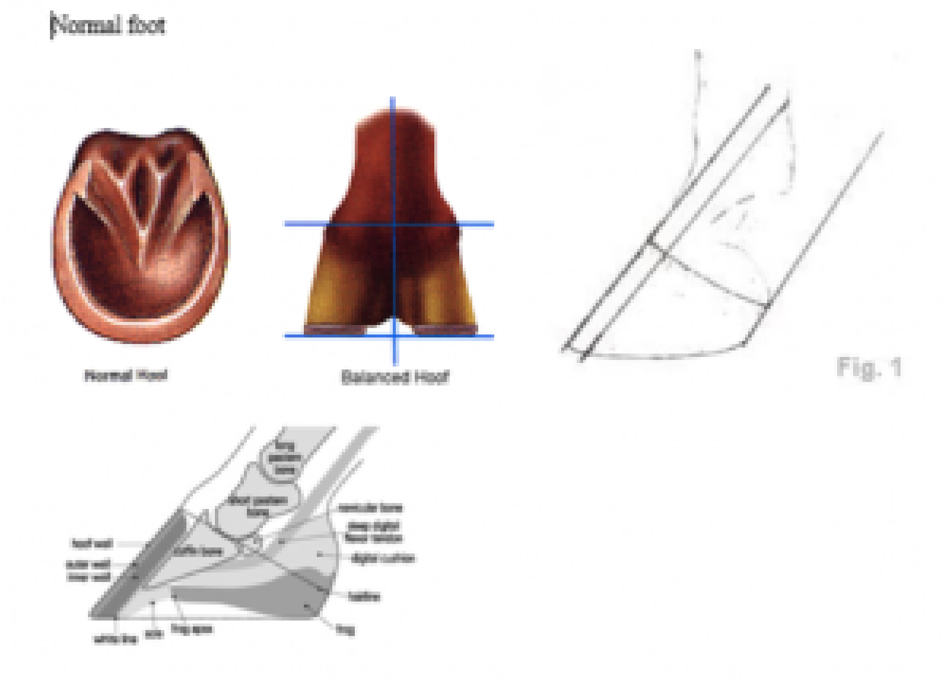
https://extension.missouri.edu/publications/g2743

Associated conformation

Contracted heels are often a consequence of navicular syndrome, while underrun heels and a low heel/long toe conformation can create or exacerbate the problem.



Normal conformation



Active lameness exam

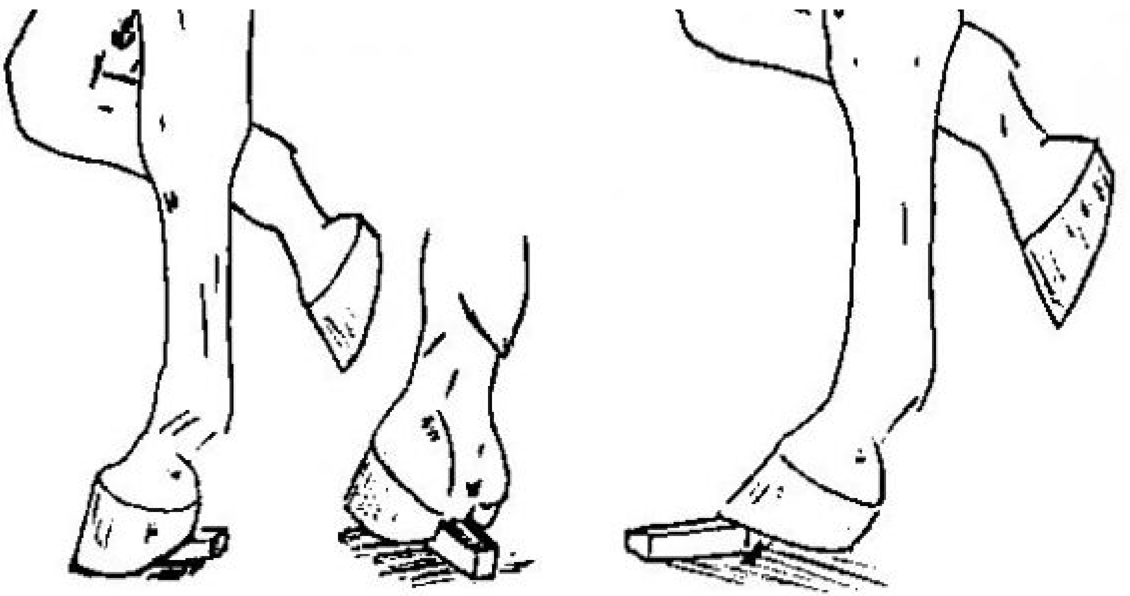
Lameness examination : straight line + lunging

Horses with navicular syndrome usually present with a bilateral forelimb lameness. It can be difficult to see a head nod on a straight line trot since both feet hurt. The gait is described as short and choppy due to the rapid transition between sore feet. Affected horses tend to land toe first (horses should normally land flat footed or slightly heel first) and tend to stumble more. Lameness is accentuated by turning the horse on a hard surface in a tight circle (lunging). Often the inside leg is more lame and the lameness switches between feet depending upon the direction lunged.

Distal limb flexion : if this test is positive, look for coffin joint pain/ligamentous pain/navicular bone pain. Major sources of coffin joint pain include a broken forward hoof axis (mild club foot) and medial-lateral hoof imbalance

Wedge tests

- **Frog wedge** : To do this test, a board or hoof knife is placed under the frog and the horse made to stand on it for 1 minute by lifting the other foot. Consider this test a hoof tester using the horse's entire body. If this is positive, look for pain in the navicular bone or caudal P3.



Tracy Turner, DVM

- **Toe wedge** : To do this test, a board or hoof knife is placed under the toe at the front and the horse made to stand on it for 1 minute by lifting the other foot. This places stress on the deep digital flexor tendon. If this test is positive, look for pain in the navicular bursa, flexor cortex of the navicular bone or flexor tendons.

Circulation test : After 15 minutes of exercise, horses should increase the skin temperature in the heel region by at least 1°F. If they do not, this may indicate poor blood flow to the heel region. This test is subject to outside influences : do not jog the horse prior to doing the test and it may be inaccurate on very cold and very hot days.

Local blocks

Coffin joint block :blocks the coffin joint, collateral ligaments of the coffin joint, bursa and blocks navicular bone pain in many cases. With enough local (>6cc) and time (>5 min) this block also blocks the sole and heel region as the local anesthetic diffuses out of the joint.

Bursal block : blocks the bursa and the heel regions. This is a very low PDN block; it usually numbs the navicular bone but should not numb the coffin joint

Palmar digital nerve block (PDN): blocks the navicular bone, coffin joint, bursa, caudal heel region and sole (all of the foot except for the dorsal laminae and the coronary band)

Test responses	Bursa positive (improves)	Bursa negative
Coffin joint positive	bursa, navicular bone, sole, navicular ligaments/ tendons/heel	coffin joint and coffin joint collateral ligaments
Coffin joint negative	(navicular bone), navicular ligaments /tendons/heel, P3	navicular ligaments /tendons/heel, P3

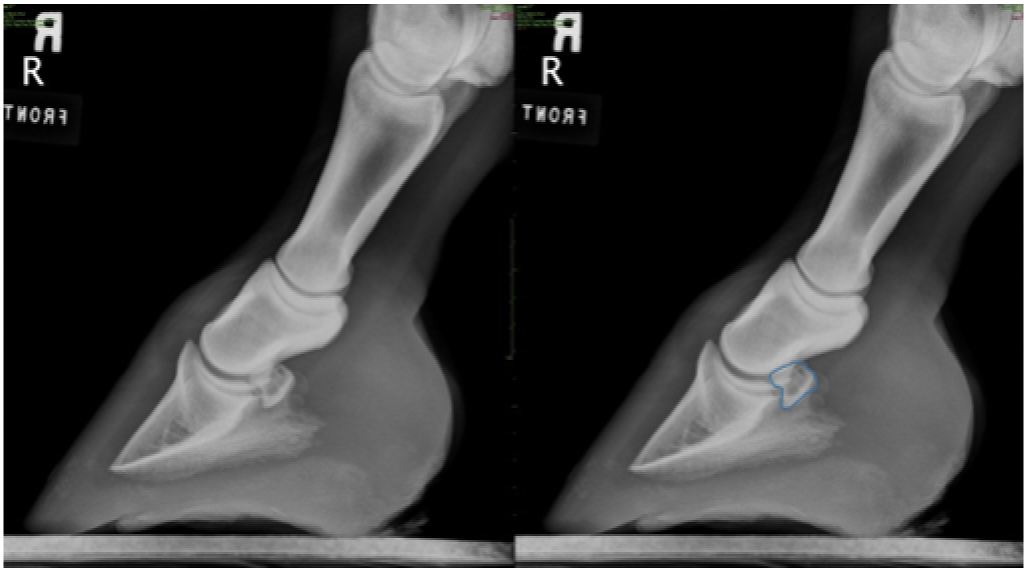
Imaging

MRI is the gold standard. Scintigraphy can also help localize lesions within the foot.

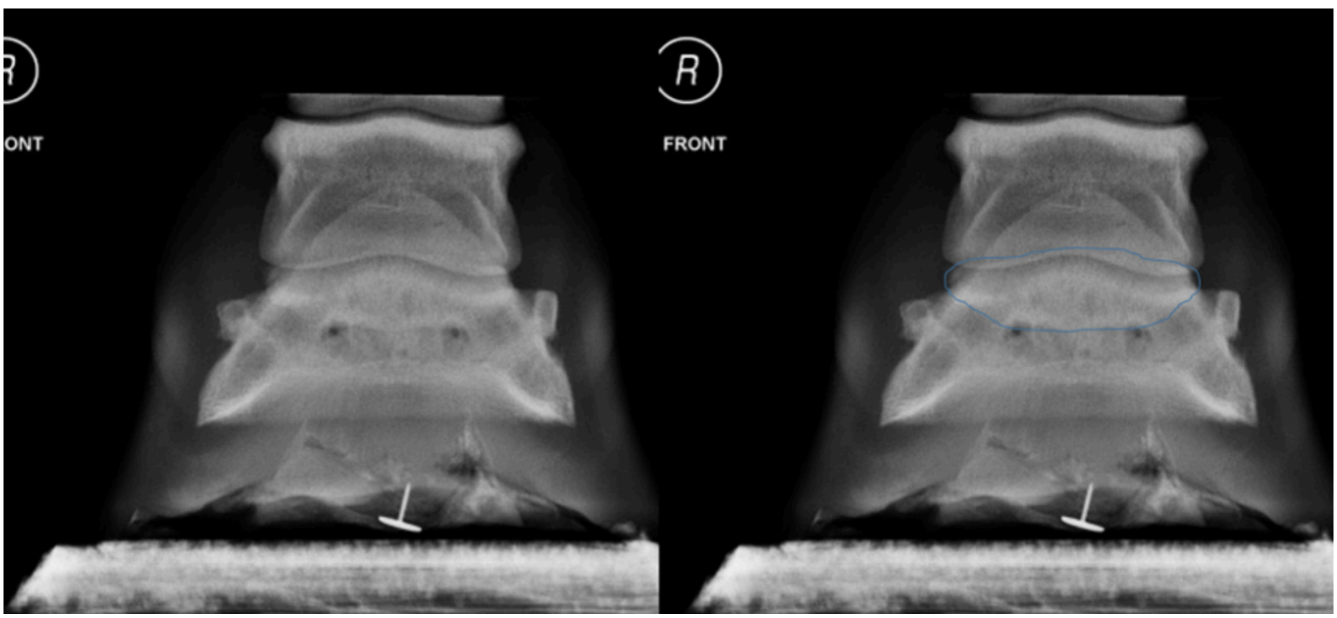
Radiographic changes are not pathognomonic for navicular syndrome (false positive and negative results can both occur). However, radiographs can be performed in the field and are often part of a "prepurchase" exam.

Standard radiographic views

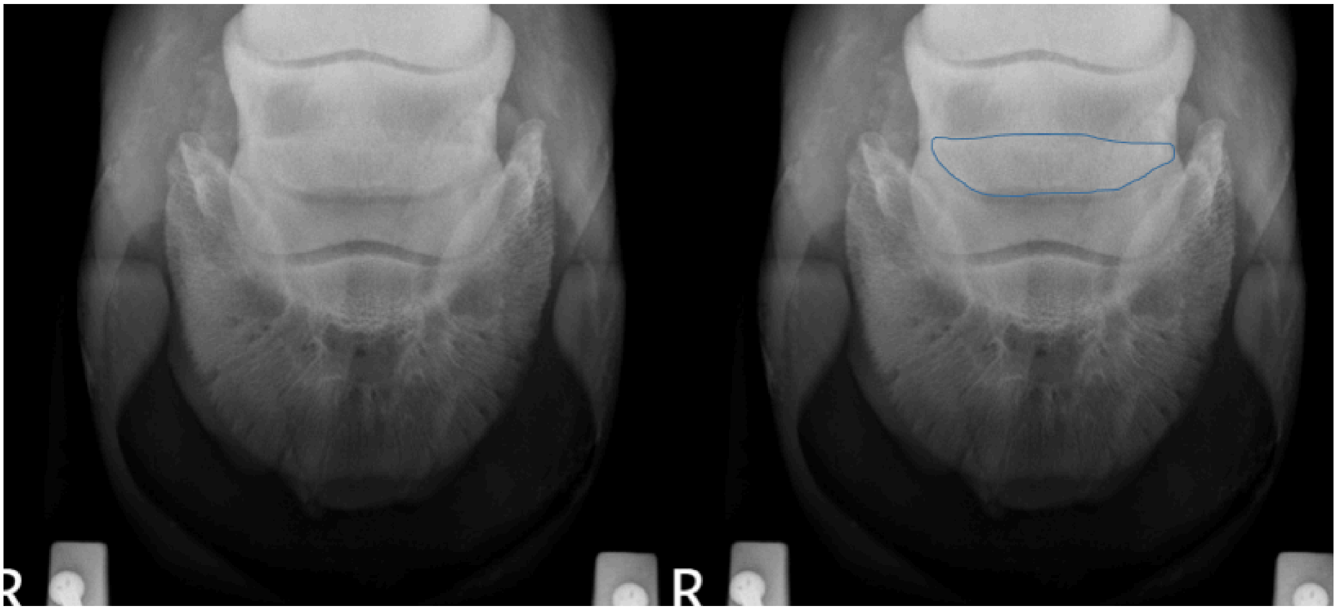
Lateral view – use to check hoof pastern axis, signs of laminitis, toe length, heel angle, soft tissue swelling, fractures, arthritis, shape of navicular bone, sole angle, flat /cupped sole



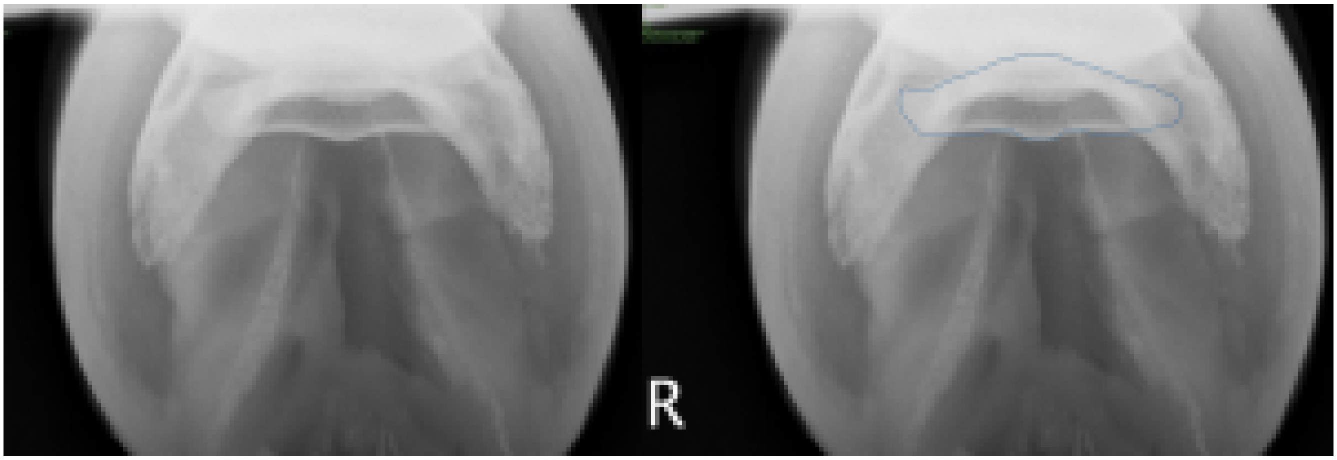
Dorsopalmar view – use to check for medial-lateral imbalance, soft tissue swelling, fractures, arthritis, navicular bone remodeling (wings)



P3 view (60 degree) – use to look for navicular bone fractures, bone asymmetry, cysts, synovial invaginations, and remodeling



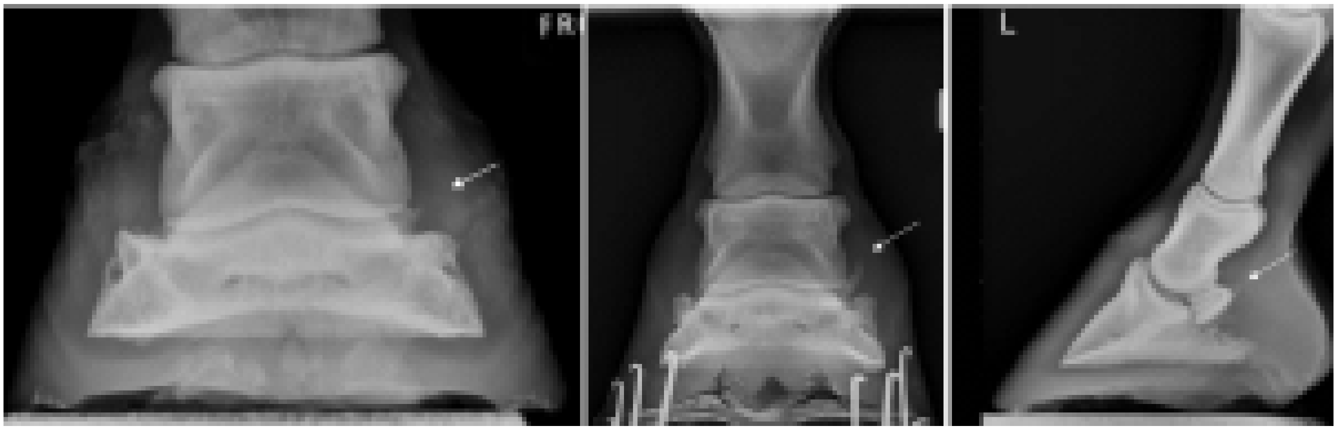
Flexor cortex view- use to evaluate shape of navicular bone, assess for medullary sclerosis



Radiographic changes consistent with navicular syndrome

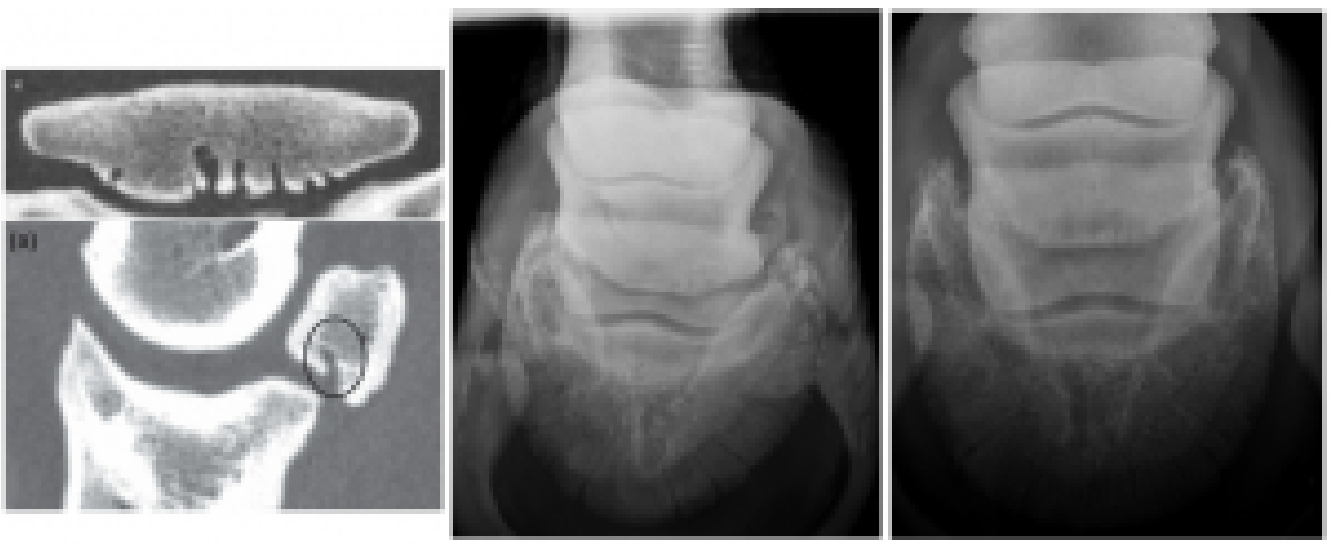
1. Remodeling of the wings and dorsal surface of the navicular bone

- dorsopalmar, P3, and lateral views
- sawtooth borders of the navicular bone, a bump on dorsal surface, and/or spurs on the extremities of the bone



2. Synovial invaginations

- P3 view
- abnormal if many "lollipops" (invaginations shaped like lollipops) evident on the base of the navicular bone or if lollipops on the sides of the bone

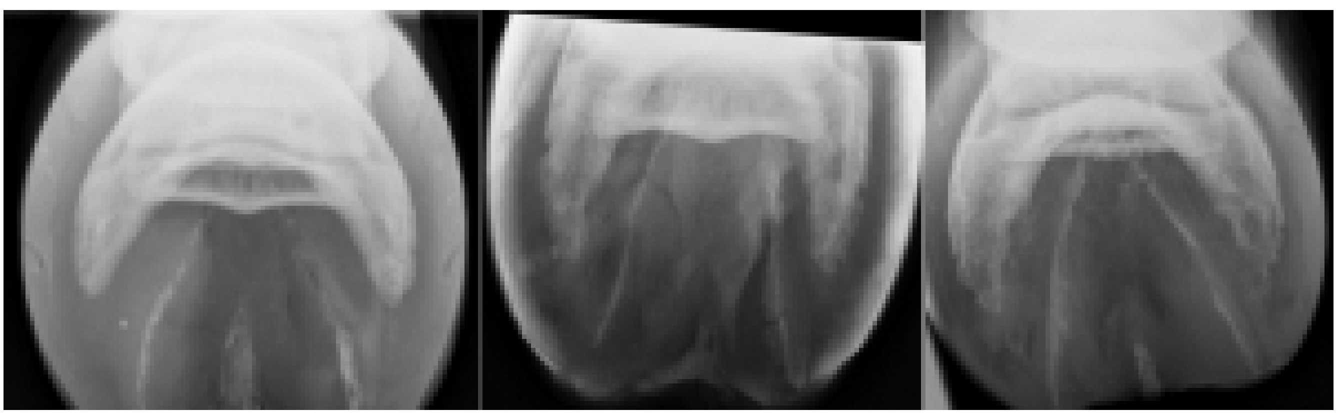


3. Bone cysts

- flexor cortex view, lateral view
- hole in middle of bone

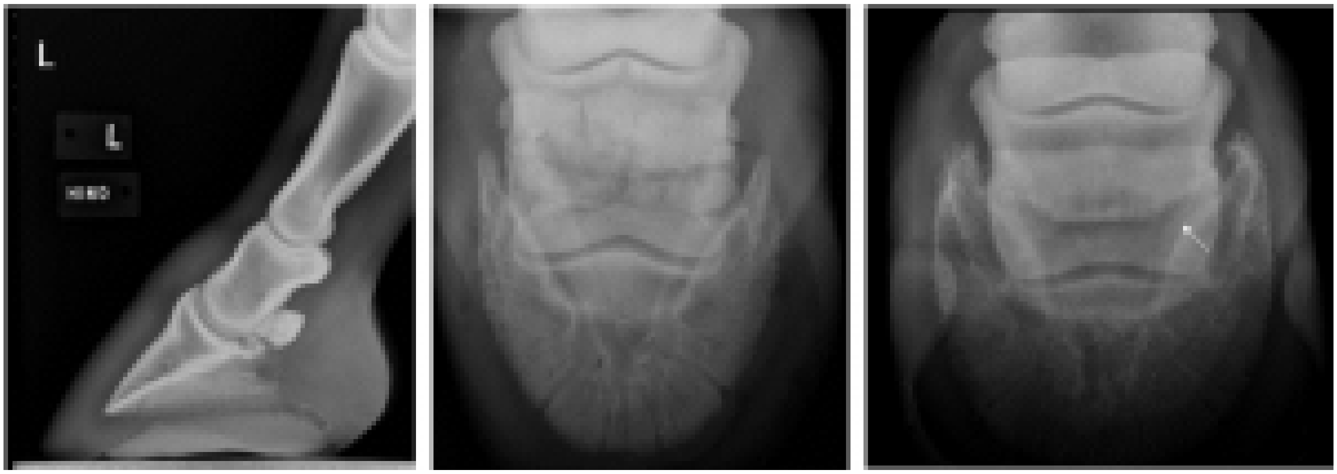
4. Flexor cortex changes

- flexor cortex view
- flattening of flexor cortex, sclerosis of navicular bone
- lysis of cortical surface



5. Navicular bone fractures

- dorsopalmar view, pedal view
- chips or complete fractures



Contrast study : performed to assess cartilage on flexor cortex

Remember to check for other issues:

- medial-lateral hoof balance
- pastern-coffin bone axis (broken back or broken forward)
- heel angle (underrun?)
- toe length/foot balance
- evidence of previous laminitis
- arthritis
- pedal osteitis (increased irregularity to border)

Treatment

- Treat specific lesions – e.g. DDFT tear found in MRI
- Corrective shoeing
    - Encourage horse to land normally rather than on toe
      – Correct long toe, underrun heel
    - Raise the heel to decrease strain on DDFT and forces on navicular bone
    - Roll the toe to ease **breakover**
    - Egg bar shoe to provide support to heel area
- Medical management
  • Systemic NSAIDS
  • Intrasynovial corticosteroids (triamcinolone)
  – Distal interphalangeal joint
  – Navicular bursa (tends to be the most effective)
  • Bisphosphonates – alter bone metabolism by interfering with osteoclasts – controversial
- Keep the horse in regular work
- Surgical management
  • Transection of the proximal suspensory ligament of the navicular bone
  – can be done arthroscopically
  – effects are likely due to transection of sensory nerves to the navicular bone
  • Palmar digital neurectomy
  – Last resort but can be helpful
  – Fraught with complications (e.g., neuroma formation, DDFT rupture)

The neurectomy will NOT improve lameness more than a PDN block. Test the block first. If it doesn't make enough difference in horse comfort, neither will the neurectomy.

Typically, both the medial and lateral PD nerves are transected on each foot. After neurectomy, the foot will be desensitized and needs protection (usually shoe and pad). The horses are NOT more prone to stumbling and will usually stumble less since they land properly (not toe first). Eventually nerve sensation will regrow.

Key Takeaways

Horses with navicular syndrome are often QH types, typically bilaterally lame and present with a short choppy gait. The lameness is worse when circled and they respond to a palmar digital nerve block.

Navicular syndrome does NOT necessarily mean the navicular bone is diseased. It is a very complex disorder.

Treatment is generally to fix the foot conformation (farrier work), keep the horse in work and comfortable (joint injections and NSAIDs). Palmar digital neurectomy is considered when that no longer works.

Supplemental

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Resources

Current concepts of navicular disease, 2011 EVE

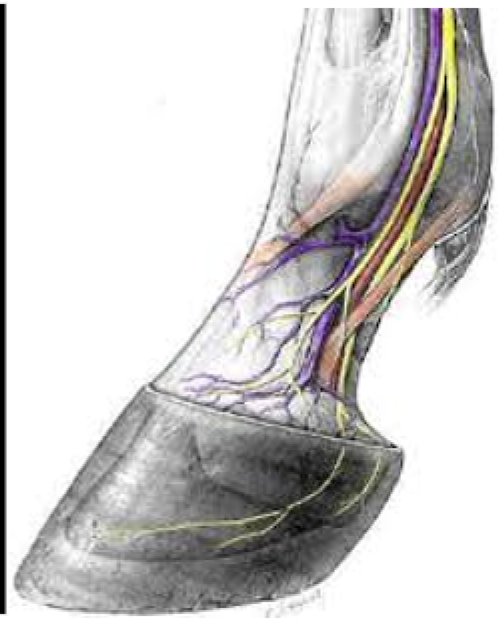
Influence of trimming, hoof angle and shoeing on breakover duration in sound horses examined with hoof-mounted inertial sensors, Vet Rec 2021 – good explanation of ***breakover*** and how shoes impact it

Indications

To relieve pain form navicular disease, fracture of the navicular bone, and select lateral-wing fractures of the distal phalanx. This procedure is not benign and the potential complications should be discussed with the owner prior to surgery.

Relevant anatomy

The palmar digital nerve is transected both medially and laterally in the pastern region. The nerve is typically on the axial aspect of the neurovascular bundle and is closely associated (fused with) the artery. The ligament of the ergot crosses over the nerve and is shiny.



Occasionally, a horse will have an additional branch that innervates the region. If this branch is not transected, the area will continue to have sensation. If the nerve is transected too far proximally, the surgery can alter the vascular tone to the foot and lead to proprioceptive dysfunction.

Preoperative management

Food restrictions: If the surgery is performed under general anesthesia, food should be restricted if possible (2-6 hours)

NSAIDs/analgesics: NSAIDs should be administered preoperatively and postoperatively.

Antibiotics: Not indicated.

Tetanus prophylaxis is recommended.

Local blocks: Local anesthetic injected at the level of the abaxial sesamoid may be used in the standing patient and may make anesthetic maintenance easier under general.

Position/preparation:

Neurectomy may be performed with local anesthesia in the standing patient or under general anesthesia. The area of the surgical incision is clipped, shaved, and prepared for surgery in a routine manner. Unless the hindlimb surgery is completed first, plan on performing your neurectomy on the upper forelimb (or do both).

The hoof should be covered with a sterile drape (towel or sticky drape or large surgery glove). An additional drape should be positioned to minimize suture contamination. This can be on the ground for standing procedures, or the upper limb and below the limb for recumbent procedures.

Surgery Supplies:

- Drape material
- Scalpel blade and handle
- Hemostatic forceps (curved and straight)
- Needle holders
- Suture- 2-0 absorbable
- Suture – 2-0 nonabsorbable
- Bandage supplies

Surgical procedure

The procedure described is called the Guillotine method. An incision 2-cm long is made over the dorsal border of the flexor tendons. By pulling on the ergot the ligament of the ergot is tensed. The incision is extended through this ligament. The nerve is directly under the ligament and is strongly associated with the artery. Both are usually retracted together using hemostats to elevate them to the incision. It is important to keep tissue trauma to a minimum. The nerve is most axial of the three structures. The artery is then dissected off the nerve. The artery is elastic and should bounce back to normal shape when released. The nerve will remain stretched. Fibers should

be palpable on the nerve and not on the artery. The nerve will not bleed if a 25ga needle is inserted. Once the palmar digital nerve is identified the surgeon should look for accessory branches. The nerve is dissected free of the subcutaneous tissue. The nerve is severed at the distal extremity of the incision. Then a hemostat is place on the nerve, which is stretched while being cut with a scalpel at the proximal limit of the incision. Approximately 1-2-cm of nerve should be removed. Make sure you remove nerve not ligament of the ergot or a vessel.
The subcutaneous tissue is closed with 2-0 absorbable material and the skin closed with a nonabsorbable monofilament.

Postoperative care

- A sterile dressing is placed on the incision, and a pressure bandage is maintained on the leg for at 4-6 weeks. Sutures are removed in 10-14 days, and the horse stall confined for 4-6 weeks.
- After healing, the foot needs to be protected from the environment and/or assessed daily for any trauma

Complications

- Painful neuroma formation – generally due to excessive surgical trauma or movement postoperatively
- Rupture of the deep digital flexor tendon – the horse will move more normally and can rupture the tendon if adhesions are stronger than the tendon
- Persistence of sensation – failure to identify and sever accessory branches of the nerve
- Loss of the hoof wall – due to changes in vascular tone

Videos

Resources

Navicular syndrome cases

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Develop a case around the scenarios below. Try this on your own first and then use the articles to check your story and fill in gaps

1. A horse with damage to the collateral ligament of the coffin joint due to medial-lateral imbalance
2. A horse with coffin joint synovitis due to a mild club foot conformation (similar conformation bilaterally)

3. A horse with a vertical split in the deep digital flexor tendon at the level of the navicular bone (and some damage in the other limb, same area)

4. A horse with a fracture of the palmar process of P3 in one foot

What is the signalment ?

> Quarter horse types are more prone to navicular syndrome but other breeds can be affected. Trauma may affect all breeds

Is it unilateral or bilateral?

How long as it been going on?

Has it been getting worse, better, staying the same or it varies?

How does it respond to phenylbutazone? Rest? Exercise?

What are you likely to find on physical examination?

Include hoof conformation, hoof tester responses, palpation results

What is the lameness like on a straight line? In a circle? Going the other way?

What happens if you do the various tests? (wedge tests, flexion tests)

What happens if you do the various blocks (PDN block, coffin joint block, navicular bursal block, others)

Other diagnostics? Eg if you do a bone scan?

Practice

Level A

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NAVLE Prep

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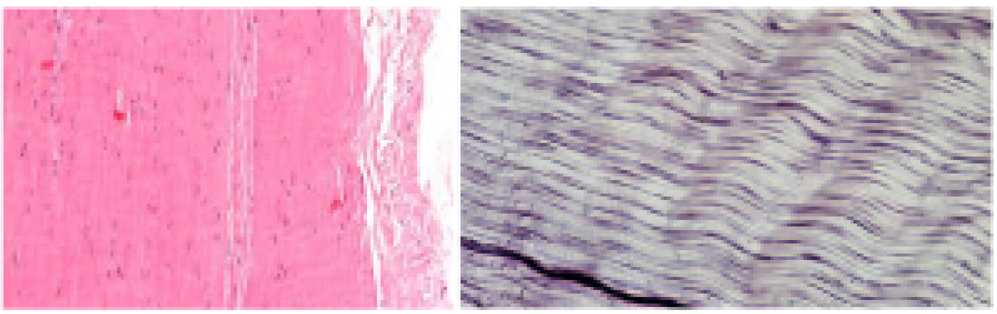
Equine tendons and ligaments

Tendon and ligament disorders

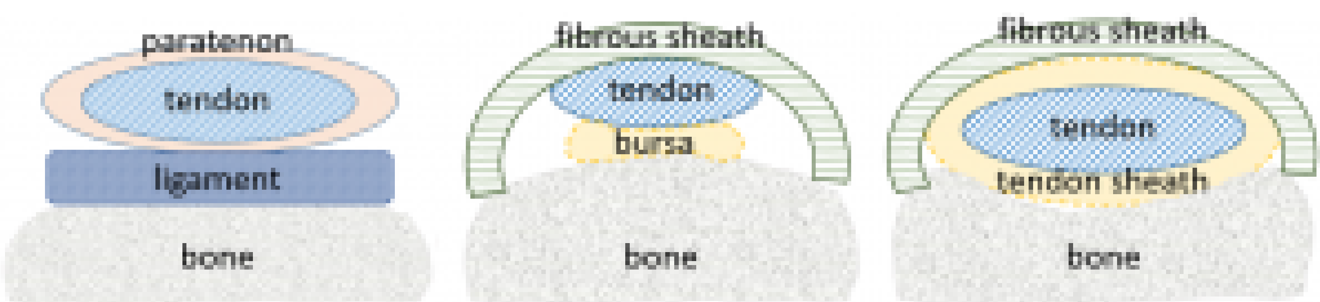
Tendon and ligament structure and function

Structure

Tendons must have high tensile strength and elasticity and be able to glide across other tissues. Tendons are connected to muscle on one end and to bone on the other end. Fibrocatilage regions create zones of increasing stiffness at the tendon-bone junction. Tendons are comprised of an extracellular matrix of collagen, proteoglycans, glycosaminoglycans, and a few tenocytes. To create the high tensile strength, tendons are composed of type I collagen arranged in triple helix (tropocollagen) fibrils oriented parallel to the long axis of the tendon with a large amount of cross-linking. The cross-linking is possible due to the precise arrangement in healthy tendons. The tendons are arranged in bundles with an undulating pattern called crimp. This crimp structure permits stretching without tearing (elasticity).



In areas where the tendon has to make a course change (eg over the fetlock joint) , the tendon is usually surrounded by a tendon sheath. The tendon sheath is lined by synovium and forms a fluid filled cavity for the tendon. A bursa is similar to a tendon sheath except it only covers part of the tendon surface. Bursae are found between tendons and bony prominences (eg bicipital bursa). In other areas, the tendon is surrounded the paratenon, an elastic connective tissue sheath with an excellent vascular supply.



Tendons are relatively acellular. Tenocytes obtain nutrition from penetrating vessels (from tendon sheaths, paratenon, bony attachment) and the synovial fluid if within a tendon sheath.

Compared to tendons, ligaments stretch less and fibers are arranged in less of a parallel fashion and are not crimped. Ligaments may also contain skeletal muscle fibers. Ligaments are attached to bone on both ends or connect bone and tendons (so less stretch overall). Ligaments often function to bind bones together.

Pathology -Tendonitis/Desmitis

Tendons and ligaments respond to injury in the typical fashion with four overlapping phases of injury, inflammation, repair and remodeling. The final result is connective tissue scar.

Inflammation includes heat, pain, swelling and loss of use. Over the first 8 weeks, the tissue is a fibrovascular mass of immature collagen fibers with little strength. During remodeling, these fibers are replaced with type I collagen bundles oriented along the lines of tension. Strength improves 3 fold between weeks 8 and 12. By 24 weeks, the tendon scar is mature with longitudinally oriented fiber bundles. These bundles still contain some immature collagenous tissue; remodeling continues for many more months.

Hint : the number of letters = months of healing. Bone heals in ~ 4 months, tendons in ~ 6 months and ligaments in ~ 8-9 months.

Pathology – Suspensory ligament degeneration

Degenerative suspensory ligament disease seems to be the result of excessive accumulation of proteoglycans that weaken the ligament. The disease is considered heritable and there is no known cure. The proteoglycan accumulation can affect tendons and other connective tissue structures, as well. As the ligament loses strength, the fetlock drops. Horses are typically very lame with abnormal hindlimb conformation (dropped fetlocks).

Key Takeaways

Tendons connect muscle to bone. Ligaments do not connect to muscle and tend to be involved with limiting rather than permitting stretch.

Both tendons and ligaments contain large amounts of type I collagen.

Tendon fibers are crosslinked and aligned with weight bearing; when tendons are injured, they need weight bearing to know how to align.

Tendons are often associated with a tendon sheath or bursa when crossing bendable bits.

Tendons require about 6 months to heal (under good conditions), while ligaments require 8-9 months.

Suspensory ligaments can also degenerate and weaken. The condition is considered heritable.

Tendon and ligament anatomy

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Tendon Notes Vic Cox

1. **Insertions:**

Superficial digital flexor tendon (SDFT) -> proximal on short pastern (P2).

Deep digital flexor tendon (DDFT) -> sole surface of coffin bone = P3

The DDFT will flex the entire digit and the fetlock joint

The SDFT will flex the fetlock and the pastern (PIP) joint but not the coffin (DIP) joint

2. **Downward translation of the fetlock** is prevented by 3 parallel tendons

- suspensory lig. (interosseous tendon) + distal sesamoidean ligaments = suspensory apparatus
- DDFT and its check ligament
- SDFT and its check ligament

But ….. remember that only the suspensory ligament attaches to the sesamoid bones while the flexor tendons slide over them, so the suspensory lig. is the main structure supporting the fetlock. Excessive stretching of these tendons -> inflammation = swelling = bowed tendon. Excessive downward movement of the fetlock (overextension) can cause chip fracture of the proximal dorsal edge of P1 due to being rammed against the distal end of the cannon bone.

3. **Check ligaments** act to check (prevent) downward translation of the fetlock**:**

- proximal = ligamentous radial head of SDF, from medial edge of distal radius

- distal check = accessory ligament of DDFT, a continuation of the palmar carpal ligament.

The distal check ligament is the one most often discussed, hence when just referred to as the check ligament the distal check is what is being referred to. The hind limb lacks significant check ligaments.

4. Distal (inferior) check ligament is cut (check ligament desmotomy) for:

- flexor deformity (contracted tendons) in foals (most common)
- early laminitis case to prevent rotation of P3 (uncommon), DDFT cut more commonly
- to reduce navicular pressure and hence pain (even more uncommon)

5. The suspensory ligament mainly attaches on the abaxial parts of the sesamoid bones and will pull up on them. Therefore, the distal sesamoidean ligaments are needed to pull “down” (distal) on the sesamoid bones. The 2 main distal sesamoidean ligaments are:

- straight = superficial ->short pastern bone (P2) proximal end between insertions of SDFT
- oblique = middle ->triangular area on palmar surface of long pastern bone (P1)

The sesamoid bones are bound to the distal end of the cannon bone by collateral sesamoidean ligaments.

6. Sesamoid fractures are caused by the upward and downward pull on the sesamoid bones may cause them to fracture (fx) as in a “tug of war”. Sesamoid fx can be basal, apical or sagittal.

7. A fibrocartilagenous **intersesamoidean ligament** binds the sesamoid bones together so that the proximal sesamoids form a groove for the flexor tendons. The flexor tendons are held in this groove by the **palmar annular ligament**.

8. At the fetlock the **SDFT** forms a thin sleeve (manica flexorum) around the DDFT. Mainly the SDFT is superficial to the DDFT above the fetlock but distally it inserts on P2 abaxial to the DDFT.

9. The flexor tendons also have **synovial** tendon sheaths (paratendon) that surround them in the fetlock and digital region.

10. In the digital region the flexor tendons are bound down by **proximal** and **distal digital annular ligaments.** The distal digital annular ligament is beyond the SDFT and therefore only covers the DDFT.

11. Tendons have **elastic properties** and can stretch to a certain degree but over stretching will cause damage. Stretching and rebound is a way of storing energy and then releasing it for propulsion. Transducers implanted on tendons of live horses indicate that the degree of elongation is 3% at the walk, 6-8% at the trot, and 12-16% at the gallop. Laboratory testing of isolated tendons indicates that they will rupture in the 12-16% elongation range indicating that the galloping horse is in the danger region but the duration of elongation during locomotion is less than a second which is much less than the time for laboratory strain testing.

12. The tendons most often **damaged** in performance horses are the superficial digital flexor (SDFT) and the suspensory ligament (SL) which is the same as the interosseous tendon. In contrast, the deep digital flexor tendon (DDFT) has a lower incidence of damage. Swelling of the SDFT results in a curvature of the flexor tendons in the

cannon region. This swelling is referred to as a **bowed tendon** because the palmar surface of the tendon "bows" out. SL (interosseous tendon) damage is less obvious but lesions in both sites are best evaluated with ultrasound.

13. Tendons consist of regularly arranged fiber bundles that consist of living cells and an extracellular collagen matrix produced by the cells. The collagen fibers, not the cells, are responsible for the strength and elasticity of the tendon. The collagen fibers have a natural ***wave* or *crimp*** that allows them to stretch as the crimp is straightened out. Flattening of the crimp is not a problem but beyond that other changes due to elongation can be harmful. Mechanical stress that causes cellular or vascular damage will lead to inflammation.

14. Cyclical loading (stretching) and unloading of digital tendons results in recovery of about 90% of the energy that is put into the tendon to stretch it. As mentioned above, this is a process of storing and release of energy. The part of this energy that is lost (10%) is dissipated as heat in the tendon. When **heat** builds up in the tendon faster than it can be removed by radiation and blood circulation, the increase in heat can cause damage to the tendon. Therefore, heat, as well as mechanical strain can lead to tendon injury. During 7-10 minutes of galloping the core temperature of the SDFT can rise to 45-47 degrees Centigrade. This heat would kill fibroblast cells of dermis, but those of tendon are thermal resistant but, in some cases, their limit is exceeded. SDFT lesions often affect the core of the tendon more than the periphery suggesting that heat damage is a factor in the pathogenesis.

Tendonitis and bowed tendons

Overview

Tendonitis is a common debilitating injury seen in all types of performance horses. Tendonitis is referred to as "bowed tendons" due to the change in appearance with localized swelling (looks somewhat like a bow from a bow/arrow). A 'bowed tendon' typically carries a guarded prognosis for return to a high level of athletic performance. The rate of recurrence is considered to be high.

Pathophysiology

There is controversy on whether degenerative changes occur in the tendon and result in tendon weakening before full-blown tendon fiber disruption or whether tendon injuries occur as a result of a single overloading episode. Likely both occur and may vary depending on the horse. Degeneration may be the result of anoxia (lack of oxygen), possibly due to inherent deficiency in blood supply, or constriction due to stretching during exercise. Others have found an increase in temperature in the core of the tendon. This rise in temperature may occur due to the inability of a deficient capillary system to remove generated heat efficiently. This hyperthermia, perhaps combined with mechanical stress, could cause cellular changes that may result in depolymerization of the collagen. This heat could also destroy or interfere with the cross-linking which is required for optimum tendon strength.

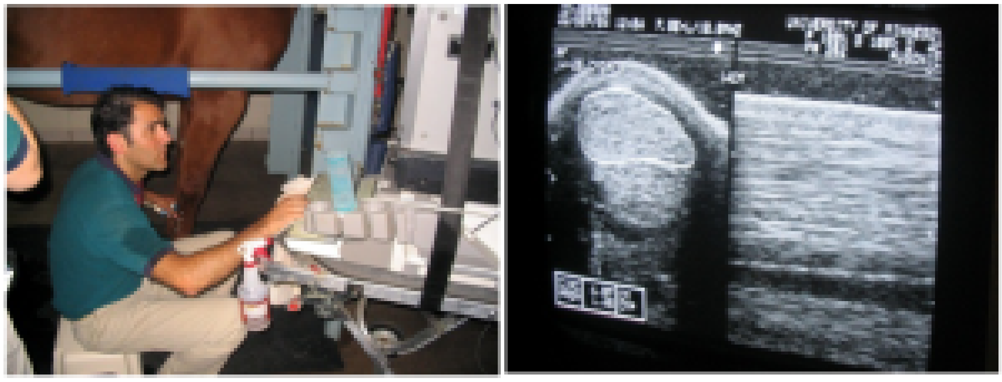
When tendon fibers are torn, capillary hemorrhage and inflammation result at the site of injury. Inflammatory products result in further damage. Healing of tendon injuries requires stopping the inflammation and then restructuring the tendon with normal collagen (type I), with the fibers aligned along the long axis of the tendon and sufficiently cross-linked to provide strength. However, healing tends to occur by forming a knot of scar tissue : fibrous tissue (collagen type III) that is aligned in a variety of directions. Several treatment options may be used to prevent this type of scar tissue.

Chronic injury can lead to calcium deposits in the tendon as the body tries to strengthen the repair.

Clinical signs

The most common site for tendon injury in Thoroughbreds is the superficial digital flexor tendon (SDFT) in the mid-metacarpal region. This region has the smallest cross-sectional area and may be stressed to a greater extent at this point. The deep digital flexor tendon (DDFT) is most often affected near the insertion of the distal check ligament or within the tendon sheath adjacent to or below the fetlock.

Initially, the cardinal signs of inflammation are observed both on physical exam and ultrasongraphically.



Ultrasound of the flexor tendons. Tendons and ligaments are evaluated in cross section (round images) and longitudinally (far right image – this looks more like tendon fibers and it is easier to see alignment). The accessory carpal bone is used as a landmark: eg "enlargement of the SDF 4in below the Ca"

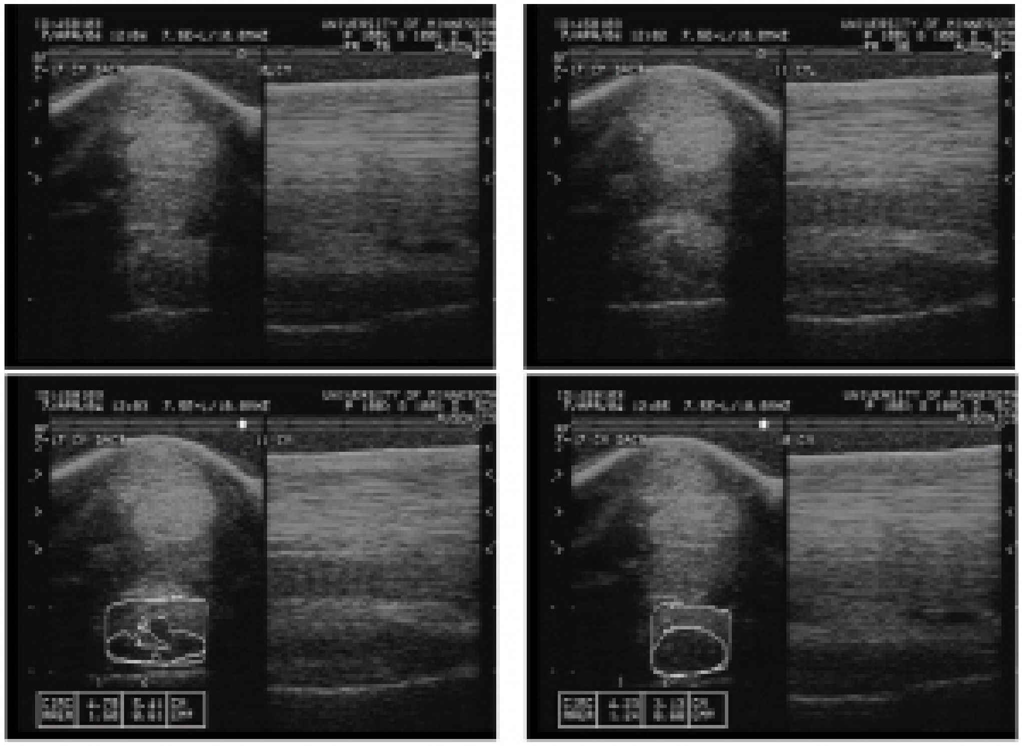
The area is warm, painful and often swollen. The horse is lame initially but this typically improves rapidly.

thickened tendons

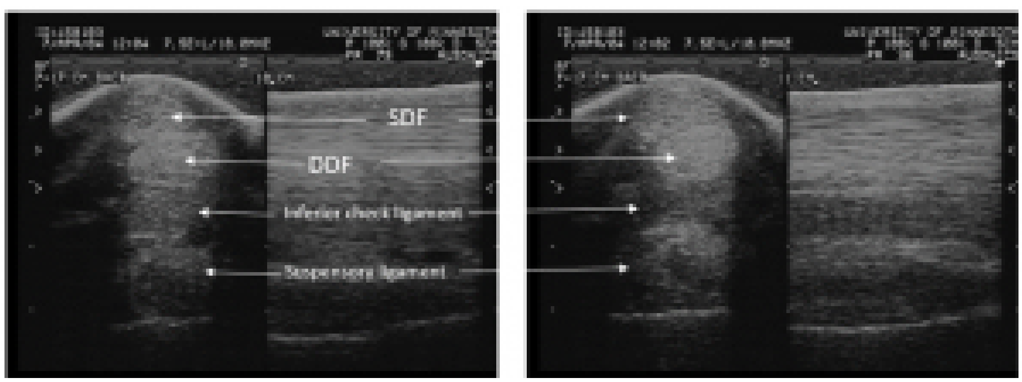
Tenosynovitis generally has obvious effusion (fluid in the sheath). However, some areas are constricted by bands of ligaments (eg annular ligament); this pushes the fluid above and below the band.

Normal Tenosynovitis with annular ligament constriction Annular ligament

On ultrasound, tendon fibers are often disrupted and hemorrhage and/or edema is present (separating the fibers and creating enlargement of the tendon).

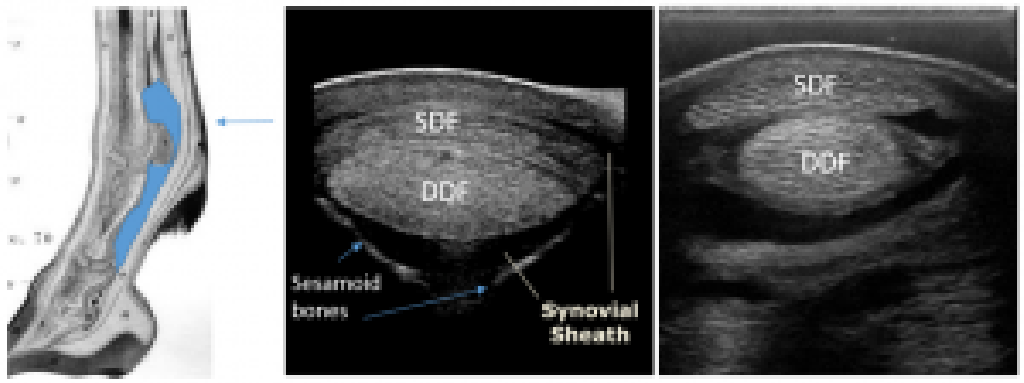


Each top image is repeated below with the damaged area outlined on the cross sectional view. The black areas are damaged fibers (missing) and serum or blood due the trauma.



Same images labeled

Fluid in the tendon sheath is often seen with injury – it may be primary (the tendon sheath is damaged) or secondary (nearby inflammation causes tendon sheath inflammation – aka tenosynovitis).



Ultrasound scan location Tendon sheath in blue

Flexor tendon sheath (level of fetlock) Normal to slightly increased fluid (black)

Moderately increased fluid (black)

Over time, the area stays swollen but the signs of inflammation resolve. The area may no longer be painful on palpation and the horse may be sound at a walk. However, the area is weak and prone to re-injury.

Therapy

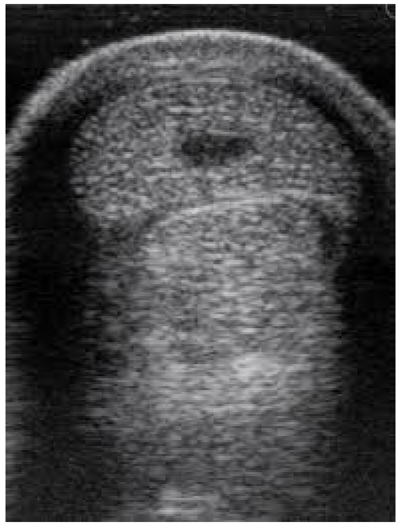
Medical treatment initially includes anti-inflammatory agents, cold therapy, wraps (keep the swelling down) and complete rest until the initial inflammation resolves. Other agents may be given to increase blood supply to the area to speed healing (the rationale behind therapeutic ultrasound and the previous use of 'firing').

For chronic lesions, controlled exercise is the key component of therapy. Controlled exercise is needed to stimulate healing and realignment of fibers along the lines of stress.

Exercise protocols are designed to stimulate fiber alignment without overuse and re-tearing. **Controlled** exercise is key. Horses are NOT turned out as this would immediately result in reinjury. Complete stall rest is contraindicated as this doesn't provide enough force for proper fiber alignment. Once a horse is sound at a walk without NSAID administration, horses are allowed to walk in hand (under control) for increasing amounts of time. If ultrasound reevaluation shows improvement, trotting is started at low levels (2 minutes per day). Exercise is gradually increased as long as the horse stays sound. Ultrasound rechecks are essential to detect early damage. If regression occurs, the training program is backed down and more time taken to move to the next level.

If healing is not progressing, other techniques may be used to minimize scar tissue and maximize collagen structure and alignment. Hyaluronic acid has been injected in the area in an attempt to prevent adhesions but has not been very effective. Polysulfonated glycosaminoglycan (PSGAGs) injections (IM) did help healing in experimental studies. Shockwave therapy is most likely useful at bone-tendon junctions and unlikely to be useful in the middle of a tendon (despite its widespread use). Various stem cells and stem-cell types have been injected in the region with varying results.

Surgical treatment is considered only when horses do not respond to medical therapy and exercise or if they plateau (no further improvement). One option is "tendon splitting". This is used to increase blood supply to the area. It is most useful for core (central) lesions that aren't healing with medical treatment.



Core lesion, SDF tendon

If the tendon is swollen in the area of the fetlock, the palmar annular ligament may be cut to reduce pressure on the tendon as this pressure can even damage normal tendons. Finally, in one study, cutting the proximal check ligament aided in preventing recurrence of the bow, not by increasing strength of the repair but by increasing the elasticity of the entire tendon unit* (and led to more suspensory ligament damage). * Cutting the proximal check releases the pull of the inflexible ligament on the SDFT leaving only the more flexible SDF muscle belly to “pull” on the tendon.

Bandage bow

A bandage bow is damage to the *peritendinous* structures leading to inflammation that looks like a bow. Luckily the tendon itself is not involved. These occur due to a bandage being too tight or too loose (sliding down and constricting). Bandage bows respond to anti-inflammatory treatment (cold therapy and NSAIDs). The horse should be stall rested until ultrasound can be performed to confirm the tendon is okay.

This sort of bandage on a horse is likely to cause damage at the edges -it can be pretty tight and put pressure on the soft tissue structures and tendons.

Key Takeaways

Tendonitis is inflammatory damage within a tendon. The superficial digital flexor tendon is most commonly affected and gives the appearance of a "bowed" tendon. Healing is slow and requires controlled exercise. Ultrasound is used to monitor healing as the initial signs of heat, pain, and lameness fade before the tendon is healed enough for regular work.

Treatment involves rest, cold therapy, wraps and anti-inflammatory agents during the acute stage and stall rest+ controlled exercise after lameness resolves. Other therapies are added if needed due to poor healing.

Controlled exercise is essential. Tendon and ligament fibers require exercise force to align properly. Complete stall rest minimizes those forces resulting in a mishmash of fibers. Pasture turn out is too much exercise and leads to continued damage.

Bandage bows are not truly tendonitis but are swellings around the tendon due to improper bandaging. These heal readily.

Resources

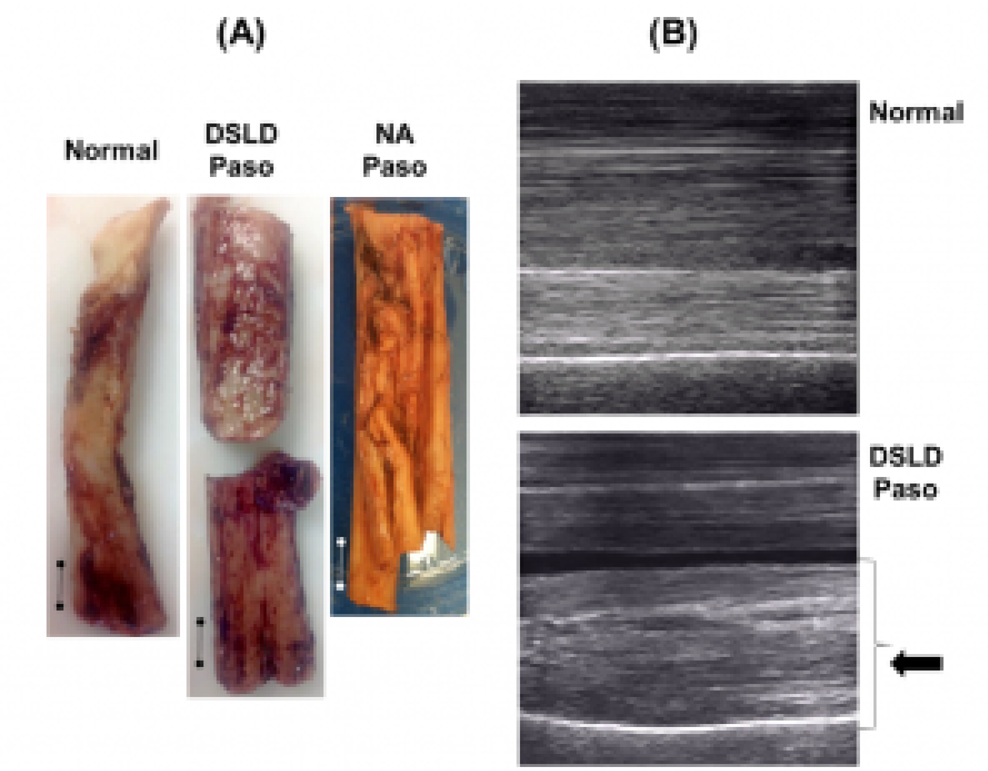
Palmar/plantar tenosynovitis – client education, AEC- nice explanation with images

Suspensory degeneration

Suspensory degeneration is an inherited condition that involves excessive accumulation of proteoglycans in the ligament, weakening it. It has been reported in many breeds; it is most commonly associated with Peruvian Paso horses. Generally this is an aging change in predisposed horses but has been seen with steroid administration and hyperadrenocoriticism, as well.

Degeneration of the suspensory ligament leads to dropped fetlocks and changes in the forces on other structures. The flexor tendons have to assume more concussive force and can become injured secondarily. The other joints become hyperextended as the fetlock drops. The abnormal conformation leads to osteoarthritis in multiple joints.

Ultrasound is typically abnormal due to fiber tearing with the increased stretch.



[Degenerative Suspensory Ligament Desmitis (DSLD) in Peruvian Paso Horses Is Characterized by Altered Expression of TGFβ Signaling Components in Adipose-Derived Stromal Fibroblasts]

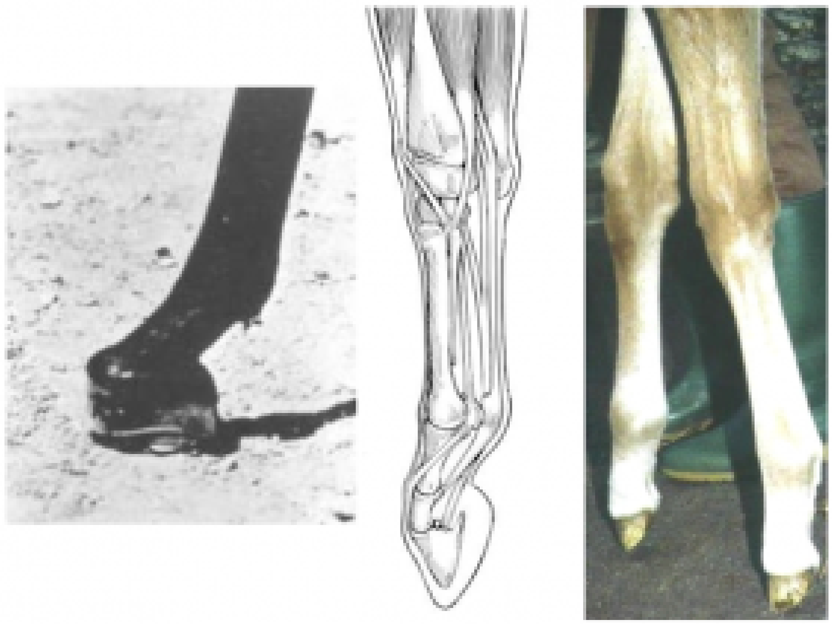
Treatment is supportive and primarily targeted to the effects on other structures (NSAIDs and support shoeing). Some suggest that using polysulfated glycosaminoglycan (Adequan) for osteoarthritis is contraindicated because it may exacerabate the proteoglycan accumulation in the ligaments. Mild to moderate exercise every other day may be beneficial.


Key Takeaways

The suspensory ligament can just start to degenerate (no trauma required). This results in bilateral sinking of the fetlocks and a very painful horse. Prognosis is crappy. Don’t give steroids to these horses.

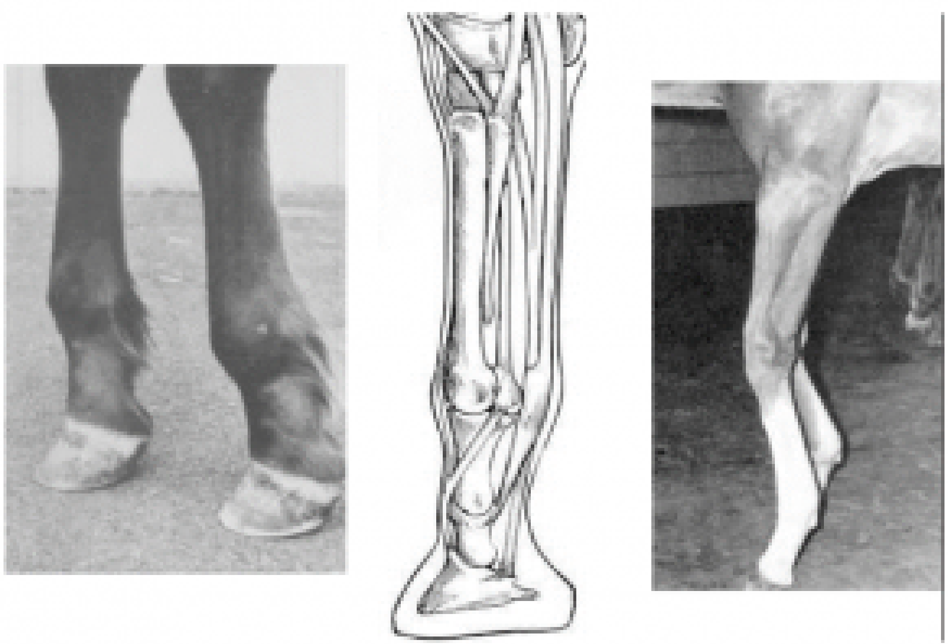
Degenerative suspensory ligament disease in horses. The Horse, 2018

Flexural limb deformities



type 1 club foot

type 2 club foot



fetlock contracture

carpal contracture

Etiology/Appearance

These deformities may be either congenital or acquired and are blamed on “tight tendons”. Contracture of the deep digital flexor tendon pulls on the coffin bone (club foot), while contracture of the superficial flexor tendon pulls on the fetlock (fetlock contracture). Joint capsules may also be tight, leading to all three forms. The pathogenesis of congenital forms is discussed in the next chapter. Acquired deformities are believed to occur secondary to fast growth and high nutrition plane. Most acquired forms occur in older foals and weanlings but can occur in 1-2 year olds. Fetlock contracture is most commonly seen as an acquired form and is the most common acquired form.

Club feet (contracture of deep digital flexor tendon; DIP joint flexion)

- The feet look like clubs because the heels grow toward the ground; this causes long heels and relatively short toes.
- DDFT (deep digital flexor) is the only tendon involved in most cases

Fetlock flexural deformity

- Either the SDF (superficial digital flexor) or both the SDF and DDF may be involved

Carpal contracture

- Likely tight joint capsule

*Many cases will also develop rupture of the common digital extensor tendon. This results in a nonpainful soft tissue swelling below the carpus. The rupture does not worsen the prognosis.

Medical therapy – congenital forms

Limb bandage or splint

> These relax the tendons through the myotactic reflex. The firmer the bandage, the more relaxation achieved. The same response is seen when young animals require a cast. Casted limbs are very relaxed or noodly when the cast is removed. The effect decreases with age.

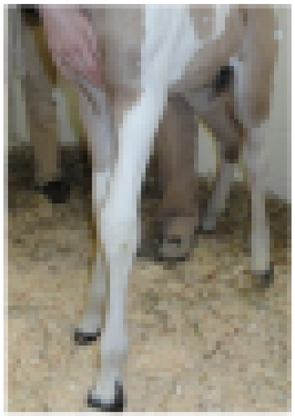
Hoof trimming

> The heel should be rasped or trimmed to allow the heel to drop when the tendons relax.

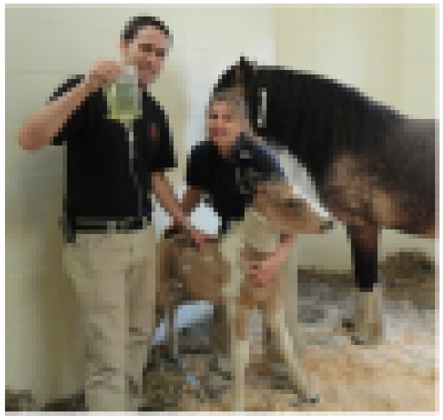
Oxytetracycline

> The tetracycline drugs bind calcium and can relax the muscular part of the tendon. This therapy works in the very young and is typically combined with limb bandaging as the response is time limited. If left unbandaged, the limb will return to its contracted state when the drug wears off. Tetracycline causes

relaxation only in very young animals, rapidly losing efficacy as animals age. Most will respond well at day 1-3 of age and minimally by 14 days of age.



Foal with severe club foot



Getting tetracycline iv

Heel rasped and bandage splint applied

Exercise

Exercise and physical therapy may be enough to stretch structures in mildly affected foals. The exercise encourages normal function. Exercise should be controlled and not overdone. Painful animals will contract the limb, preventing the relaxation needed.

Analgesics

Foals have to walk on these limbs to improve the conformation; if uncomfortable, they won’t walk enough and further tendon contracture may occur due to the withdrawal reflex (aka hot stove reflex)

Medical therapy – acquired forms

Dietary management

Often these foals are on a high plane of nutrition for rapid growth. This results in a mismatch between tendon length and bone length. It is imperative to slow growth rate but without starvation. Starvation results in a compensatory growth spurt once food is reintroduced.

Identify source

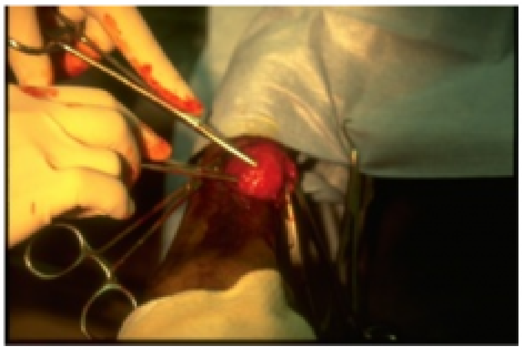
Pain may be a cause of contracture (withdrawal reflex). Check for hoof abscesses and fractures of P3 if the contracture is acquired. If you don’t eliminate the source of pain, no therapy will help

Oxytetracycline and bandaging are usually ineffective in this age group.

Surgical therapy

Club foot

Cut the inferior (distal) check ligament to allow more stretch of the DDF tendon. This is not a tiny ligament (see image below). Cutting it makes a difference.



- Excellent prognosis if not >90 degrees joint flexion.
- This procedure does not impair performance and can be performed in any age horse to improve hoof-pastern angle
- Bandaging and hoof trimming are also required peri-operatively.
- If the contracture is >90 degrees of joint flexion, the deep flexor tendon must be cut. This is a salvage procedure.
- Iodine deficiency in the mare can lead to growth abnormalities in the foal. If the foal has contracted joints, check for an undershot jaw. Those foals have a much more guarded prognosis due to overall lack of response to treatment for the joint contracture.

Fetlock flexural deformity

- Cut the proximal and distal check ligaments
- Poorer prognosis than club feet but should gain some improvement, especially in young foals
- Older horses can have the surgery but get less release and have more scarring (unsightly)

Carpal contracture

- No good surgical options although cutting the ulnaris lateralis and flexor carpi ulnaris muscles has been used occasionally

Prognosis

Prognosis depends on which joint is flexed and how much contracture is present. In general, the more distal the contracture in older horses, the better the prognosis : foot >fetlock > carpus. However, if the foot is flexed so that the angle between P2 and P3 is > 90 degrees, these can be hard to fix.

Key Takeaways

Contracted tendons are generally more readily fixable in babies. After that it gets harder. Not all babies can be fixed.

Club feet are easier to treat than fetlock contracture. Treating carpal contracture in older animals is really hard. There is no good surgery for carpal contracture.

Oxytetracycline and bandaging have magical powers but just in babies.

Foals with contracted tendons and undershot jaws may have dams with iodine deficiency. These foals have a poor prognosis.

Fast growing weanlings and young horses can develop fetlock contracture.

Types of crooked legs in foals

Flexural deformity pathogenesis

Author: Vic Cox

Flexural deformities are the most common congenital defect in foals. In a retrospective study of 608 cases of congenital defects in foals at the University of Kentucky, more than half were flexural deformities. When involving the coffin (DIP) joint, the condition is often referred to as club foot. In a nutshell, the most likely cause is failure to get enough "exercise" in utero. Developing bone (and to a lesser extent adult bone) is very plastic. The shape is determined by the pushes and pulls acting on bones (Wolf's law). These forces are akin to the hands of an artist molding clay. Every mother knows from personal experience how often a fetus moves around and even "kicks" occasionally.

In the early 1950's the embryologist Viktor Hamburger studied these movements using the convenient and inexpensive model system of developing chicks which can be observed thru a window in the egg shell. After thousands of observations he concluded that there was no pattern to the movements; they were totally random. This observation led him to hypothesize that these movements provided a wide variety of stress on bone. In contrast, if the forces on a bone were lopsided, the shape of the bone would be skewed in relation to the forces acting on it. Hamburger tested his hypothesis by applying the neuromuscular blocking agent curarie to chick "embryos". This curtailed movement and when the chicks hatched they had widespread musculoskeletal deformities including joint ankylosis (fusion).

Contracted tendons are common in long legged species such as horses and cattle but uncommon with short legged species such as pigs or dogs. The incidence of tendon contracture is more common in oversized calves of double muscled breeds which presumably is due to insufficient intrauterine space to move. The very long legs of foals may be a predisposing factor as well.

Other factors that may reduce fetal movement are neurological deficits or delayed neurological development. Copper deficiency leads to swayback lambs. In the early 70's three calves were born on a Missouri dairy farm with torticollis (wry neck) and were linked to earlier spraying with a chlorinated hydrocarbon insecticide, a classic neurologic toxin. Fetal positioning occurs late in gestation when a fetus turns around if needed so that the forelimbs and head are ready to exit the uterus first. Failure to do so results in breech birth and may be due to the same factors involved in contracted tendons.

In short, intrauterine "exercise" is needed to stretch out developing tendons. A principle to be learned here is to consider possibilities beyond the obvious. That is, the obvious tendon defect may be due to a hidden neurologic deficit.

Recent work in Minnesota indicates that mare hypothyroidism may be a factor also.

Crowe MW and Swerczek TW, 1985, Equine congenital defects. AJVR **46**,353-358.

How to - Inferior check desmotomy

Indications

Contracture of the deep digital flexor tendon, particularly in the young horse. It may provide a window of security for Cushingoid horses with chronic laminitis and at risk of further rotation.

Relevant anatomy

The check ligament is between the body of the suspensory and the deep flexor tendon in the proximal cannon bone area. The distal or inferior check ligament connects the deep flexor tendon to the fascia on the palmar aspect of MC III. The diameter of the inferior check ligament is very similar to that of the deep and the two structures are merged together grossly. The line of separation is often better identified via palpation than by visualization. Ultrasonographic guidance is useful, particularly in standing surgeries. A large vessel runs along the medial aspect and can be accidentally cut during the surgery.

The check ligament in the hindlimb is vestigial and not usually a problem.

Preoperative management

Food restrictions: If the surgery is performed under general anesthesia, food should be restricted if possible (2-6 hours)

NSAIDs/analgesics: NSAIDs should be administered preoperatively and postoperatively.

Antibiotics: Not indicated

Tetanus prophylaxis is recommended.

Local blocks: Due to the location of the incision, any local block would need to be performed above the carpus (MUM block).

Position/preparation:

Clip from above the carpus to the distal cannon bone on a foreleg. The lateral approach is the easiest (and avoids that very large vessel that tends to be directly in your way). Wrap the foot in a sterile towel to enable manipulation of the toe.

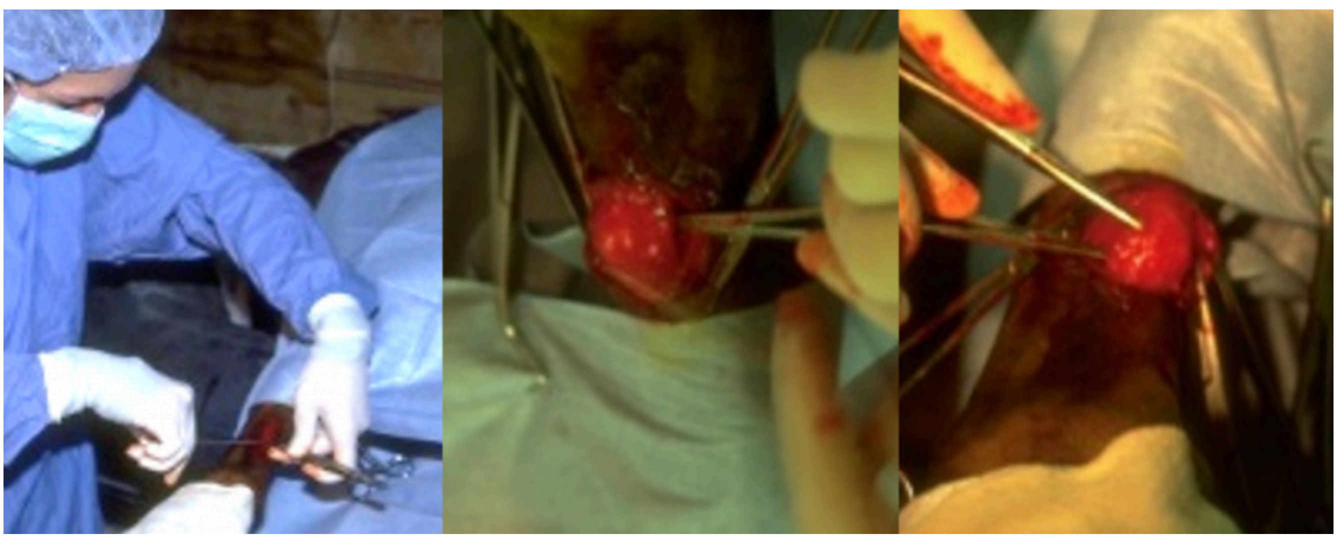
The procedure is done under general anesthesia in young animals but may be done standing is select patients with ultrasound guidance.

Surgery Supplies:

- Drapes or sterile towels
- Scalpel blade and handle
- Hemostatic forceps (curved and straight)
- Bistoury
- Needle holders
- Suture- 3-0 absorbable taper needle
- Suture – 3-0 absorbable cutting needle
- Suture – 3-0 nonabsorbable
- Bandage supplies

Surgical procedure

A 3-cm skin incision is made over the cranial aspect of the deep digital flexor tendon approximately 3-cm distal to the carpus (center over junction of proximal and middle thirds) The incision is continued through the fascia and peritenon (covering over the tendons). The deep digital flexor tendon and the check ligament are isolated by blunt dissection. These at first appear to be one large tendon but there is a plane separating them. The check ligament is about the same size as the deep digital flexor tendon!



Move the toe to see how much tension is on the structures. Once identified a mosquito hemostat is used to bluntly separate the check ligament from the DDF. A second hemostat is then placed between the suspensory ligament and the check ligament. By then turning the points of the hemostats together the check ligament is isolated. Once isolated, the check ligament is sharply transected using a scalpel or bistoury knife. If you are unsure if you have three separate structures, suture material can be passed around the "check ligament" and then the ligament returned to the incision to allow better inspection. The check ligament should gap if all fibers are cut particularly when the toe is extended. The peritenon and fascia are closed with a simple continuous pattern. The skin is closed routinely, often with an intradermal pattern.

Postoperative care

- The incision is covered with gauze and a support bandage applied to the limb.
- To ensure that the ligament does not scar in the original position, farrier work and physical therapy are essential. The foot should be trimmed to a normal angle (lowered heel) and the animal treated with NSAIDs or other analgesics to encourage use of the limb. If the foal cannot tolerate NSAIDs, fentanyl patches are an alternative.

Complications

- incomplete transection of the ligament
- damage to the medial vessel
- damage to the deep flexor tendon and/or suspensory ligament
- limited response due to lack of farrier work and exercise

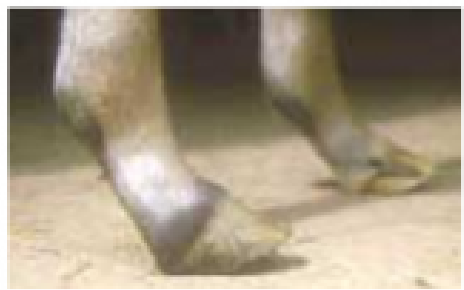
Videos

Resources

Flexural deformity of the distal interphalangeal joint, VCNA 33(2):315-330

Tendon laxity

In premature and neonatal foals, tendons and ligaments may be too relaxed instead of too contracted. As weight bearing is not always balanced, this can lead to abnormal limb and foot angulation. The foal may tip back on its heel with an elevated toe. This is not a deep flexor tendon injury but is too much tendon stretch.

The foal may have angular limb deformities due to lack of joint control by weak ligaments. Often these are the “windswept” foals (look like the wind is blowing hard from one direction).

Tendons and ligaments strengthen as the foal matures and exercises lightly. Meanwhile it is imperative that foals not overexercise as abnormal forces on the physes could lead to secondary problems.

Bandaging is often attempted to “support” the limb. Due to the myotactic reflex in babies, this actually makes it worse. Band-aids (light bandages) can be applied to prevent trauma on flooring but heavy wraps should be avoided. Tongue depressors or similar structures can be glued to the foot to help minimize weight shifts backwards.

The prognosis is good if the rest of the foal is mature. It is always good to radiograph the cuboidal bones before exercising the baby (see angular limb deformities).

Key Takeaways

Tendon laxity is a sign of immaturity. Mild exercise should help strengthen the tendons.Avoid heavy bandages!

If the cuboidal bones are normal, these carry a good prognosis. Incompletely ossified cuboidal bones can lead to angular limb deformities.

Types of crooked legs in foals

Practice

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https://open.lib.umn.edu/largeanimalsurgery/?p=2310#h5p-94

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https://open.lib.umn.edu/largeanimalsurgery/?p=2310#h5p-113

Equine joint disorders

Joints can be affected primarily by :

trauma – fractures or chips

arthritis = DJD (degenerative joint disease) = OA (osteoarthritis)

sepsis – infected due to hematogenous spread, local extension, or direct trauma

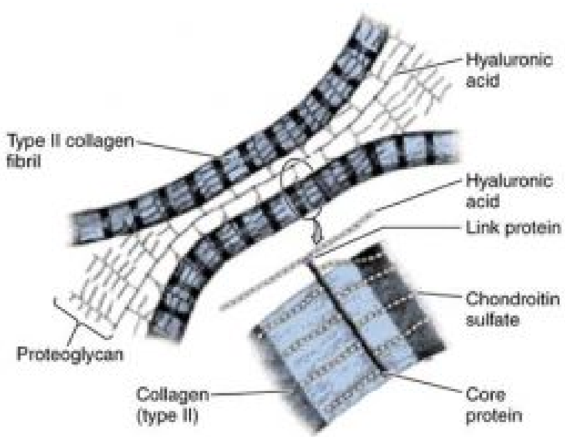
osteochondrosis – developmental abnormalities in bone/cartilage

Joint anatomy and function

Structure

The main components of a joint include the articular cartilage (hyaline) sitting on a layer of subchondral bone, coated by synovial fluid and surrounded by a synovial lining and joint capsule. The cartilage is composed of chondrocytes and an extracellular matrix of precisely arranged type II collagen and proteoglycans. This structure traps water, creating a resilient cushion in a healthy joint. Cartilage contains no vessels, no lymphatics and no nerves. Nutrition has to migrate from the synovial fluid and through the matrix. Chondrocytes have different densities and orientation depending on the distance from the articular surface. The joint capsule maintains the joint stability (prevents motion in unintended directions) while the synovium produces lubricants, manages inflammation/phagocytosis and provides nutrition.

Extracellular matrix



- Type II collagen – triple helix of amino acid chains, organized in fibrils. Provides tensile strength. Produced by chondrocytes. Very limited turnover of fibrils in adults.
- Aggrecan – proteoglycan; protein strand with glycosaminoglycan chains of chondroitin sulfate and keratan sulfate attached
- Aggrecans are attached to hyaluronan strands by link proteins
- The GAGs attract water creating compressive

stiffness of cartilage

Synovial fluid contains nutrients and boundary lubricants. The lubricants are necessary to minimize friction between components. The main components are hyaluronate and lubricin.

Matrix metalloproteinases (MMPs) are synthesized by synoviocytes and chondrocytes. They can digest all components of the extracellular matrix and are responsible for removing damaged components. MMPs are released in zymogen form to minimize damage. Tissue inhibitors of MMPs (TIMPS) are also synthesized by the synoviocytes and chondrocytes.

Pathology

Three main pathogenic mechanisms of osteoarthritis are proposed:

1. Defective cartilage – flawed matrix fails under normal loading
2. Normal forces damage healthy cartilage – injured chondrocytes release enzymes which cause cartilage damage and breakdown the proteoglycan network
3. Increased stiffness of subchondral bone – microfractures heal with increased bone density; this leads to limited ability to absorb shock, pushing more load onto the cartilage

Synovitis contributes. Synovial inflammation leads to increased levels of inflammatory mediators. Synovitis can develop from trauma (eg a floating osteochondral fragment or direct trauma), release of inflammatory mediators from the cartilage, and infection.

Immune related changes (rheumatoid arthritis) are not seen in horses.

Clinical signs

1. Reduced range of motion – pain, synovial effusion, synovial edema and periarticular fibrosis
2. Effusion – increased levels of synovial fluid due to protein leakage
3. Synovial fluid changes – high protein, low viscosity due to lower HA (hyaluronate) content
4. Pain -due to synovial effusion, periosteal disruption from osteophytes, and potentially subchondral bone changes.

Key Takeaways

Cartilage helps absorb energy through creating a hydrated layer on top of the bone. Type II collagen, proteins and sugars create an environment that holds water (until it is damaged). Matrix metalloproteinases help clean up debris but create damage. Cartilage has very poor healing ability. Inflammation of the joint environment leads to arthritis – typically this is typically due to wear and tear and trauma.

Pathophysiology

Osteochondrosis dissecans (OCD) refers to joint lesions that occur when the cartilage becomes separated from the underlying bone. Further separation continues until pieces of cartilage or cartilage+bone are floating free in the joint. Common sites of OCD in the horse include the lateral trochlear ridge of the distal femur, cranial intermediate ridge of the distal tibia (DIRT lesions), lateral trochlea of the talus, and caudal aspect of the humeral head.

Subchondral bone cysts are another form of osteochondrosis. However, instead of the overlying articular cartilage becoming detached from the subchondral bone, the cartilage becomes infolded. Cysts may also occur secondary to trauma. Common sites for developmental cysts include the medial femoral condyle, glenoid fossa, and distal cannon bone.

Histologically, osteochondrosis is characterized by abnormal chondrocyte differentiation and formation of defective intracellular matrix. The process of ossification is interrupted and abnormally thick cartilage develops. Associated poor vascular supply to the thickened cartilage results in inadequate chondrocyte nutrition. The abnormal cartilage is an area of focal weakness and can separate or infold. This is referred to as abnormal endochondral ossification.

Etiology

Several factors have been proposed as the inciting factor for osteochondrosis. These include genetic predisposition, rapid growth, nutritional mismanagement, and trauma. None of these factors can be identified as most important.

Osteochondrosis often affects rapidly growing animals; however, it appears to be more closely related to a high energy diet than to rapid growth. Controlled diet studies strongly implicate excess digestible energy (often excessive carbohydrates) as a factor in the development of osteochondrosis. Excess protein did not seem to make a difference. Diets high in calcium and phosphorus may induce osteochondrosis, as can abnormal copper (low) and zinc (high) levels. In another study, mares with wobbler syndrome (probably cervical OCD) were bred to similarly affected stallions. Offspring were not wobblers but had a high incidence of developmental orthopedic disease. In Standardbreds, tarsocrural OCD has a heritability rate of 0.52 (high). Finally, trauma may precipitate disease when biomechanical forces act on structurally abnormal cartilage. This correlates with the identification of clinical signs in horses just starting training.

Older horses can develop osteochondral cysts and fragments due to wear and tear on joints and related changes in bone and cartilage structure.

Diagnosis

Osteochondrosis is most commonly diagnosed in young horses being put into work. This timing is more likely related to closer examination of the horse than to development at this stage of life. Joint effusion is the most common presenting complaint. Lameness may or may not be apparent but is more typically seen with cysts due to the weight bearing locations. Diagnosis is confirmed by radiographs. As this is a developmental disorder, both joints (eg both stifles or both hocks) should be radiographed as should any other joints (particularly fetlocks) with effusion. Radiographs may not show lesions in mild cases; ultrasound and/or arthroscopy may be needed to fully evaluate the joints.

Therapy

Nonsurgical treatment includes rest, controlled exercise, and minimizing joint inflammation. It may be successful depending upon the site of the lesion and the intended use of the horse. As fragments can lead to osteoarthritis due to synovial damage, surgical removal is recommended. Surgical treatment has become the treatment of choice and involves removing loose pieces of cartilage and debriding defective subchondral bone. Cysts may be injected with steroids using ultrasonographic guidance. Prognosis is favorable for hock and stifle joints, depending upon the amount of cartilage damage at the time of surgery (up to 70-80% success rates). Prognosis is less favorable for shoulder, pastern, and fetlock joint lesions. These areas tend to develop progressive osteoarthritis.

Key Takeaways

Osteochondrosis is abnormal cartilage development (failure of endochondral ossification) leading to osteochondral fragments (joint mice) or cysts. Fragments occur in non-weight bearing areas but lead to local inflammation and joint changes. Cysts occur in weight bearing areas. The primary presenting complaint is often synovial effusion (fluid in the joint). Lameness is more likely to be associated with cysts; many horse with osteochondral fragments have joint effusion but are not lame. Lesions are frequently bilateral.

Resources

Pathogenesis of osteochondrosis dissecans: How does this translate to management of the clinical case? Equine vet. Educ. (2016) 28 (3) 155-166

Workshop Report. Third International Workshop on Equine Osteochondrosis, Stockholm, 29–30th May 2008, Equine vet. J. (2009) 41 (5) 504-507

Osteoarthritis

Pathophysiology

Osteoarthritis (OA) is a noninflammatory disorder of joints characterized by degeneration and loss of articular cartilage and development of new bone on joint surfaces and margins. It can also involve sclerosis of the subchondral bone. OA is a common response of joints to a variety of insults. In general, it is seen as a "wear and tear" phenomenon but can also occur secondary to osteochondrosis and sepsis. Once cartilage starts to break down, several factors are released into the synovial fluid that cause further inflammation and further cartilage breakdown.

Diagnosis

Clinical signs associated with OA include pain on movement, reduced range of motion, increased joint fluid (effusion), and changes in the synovial fluid (less viscous, lower hyaluronan content). Generally, OA affects older horses, horses with a heavy work background, those with osteochondrosis, and those with previously septic joints. Diagnosis is based upon localized lameness (joint blocks) combined with radiographs and/or arthroscopy. Because OA starts as a cartilage disorder, not all lesions will be apparent radiographically.

Therapy

Cartilage does not heal well due to limited vascularity and potential for new cartilage growth.

At the present time we cannot resurface joints with normal cartilage. (Research is ongoing, funded by the NFL…). Treatment is aimed at slowing the rate of cartilage breakdown.

Surgical therapy

Arthroscopy is used not only as a diagnostic and prognostic tool but is also useful in treatment of OA. It is used to remove fragments of new bone and to clean up cartilage lesions and synovial proliferation (inflammatory response).

If the joint is unstable, it must be stabilized for any treatment to be successful. Remove or stabilize any loose fragments, debride any cysts. Without surgery in these cases, medications won't help.

Pastern and lower hock joints may also be "arthrodesed" or fused. This prevents motion and therefore much of the pain associated. The pastern and lower hock are low motion joints so movement is limited already; decreasing movement is easier to obtain and does not affect other joints too severely. Fetlock and carpal joints are also occasionally arthrodesed. These are high motion joints so the fusion is much more complex and the complications greater.

Joint replacement is not commonly done in horses.

Medical management

Medical management is more often used due to the cost of arthroscopy and arthrodesis. Choices depend on many factors, including value of the horse, current performance and future performance expectations and the horse's mental status (particularly if stall rest if recommened).

- **NSAIDs** are used to inhibit the inflammatory reaction; however, they may also interfere with the healing process and should be used judiciously until their full effects are understood. Motion is good for joints so NSAIDs do help with encouraging horses to move around.
- **Corticosteroids** may be injected into joints to relieve inflammation. At low concentrations they may be chondroprotective; however, prolonged use or high concentrations will cause cartilage degeneration. Methylprednisolone is typically used in low motion joints while triamcinolone is used in high motion joints.
- **Hyaluronan (HA)**is frequently used in an attempt to provide cartilage structural materials, to increase the viscosity of the synovial fluid, and as a mild anti-inflammatory agent. An intravenous form *(Legend®)* is now available and there is some experimental data to support its use. It is probably most effective in cases of acute synovitis. It may need to be given weekly for optimum effects.
- **Polysulfonated glycosaminoglycan (PSGAG/** ***Adequan®*****)** is composed principally of chondroitin sulfate, a component of cartilage. It is anti-inflammatory and is reported to stimulate the production of HA and to interfere with degradative enzymes. It may be given into the joint but greatly increases the risk of sepsis by decreasing the number of bacteria required to overwhelm the immune system. It is more often given im, with a manufacturer's recommendation of treatment every 4 days for 7 treatments.
- **Oral supplements** have also been developed; chondroitin sulfate and glucosamine are the two most common components. Chondroitin sulfate is similar to PSGAGs in its activity; however, many (all?) forms of chondroitin sulfate are not biologically available. Glucosamine is a precursor of cartilage proteoglycans and may have a number of antiinflammatory activities. Experimental studies on these oral products are limited. The most convincing results have been with *Cosequin®*. Other common and perhaps useful brands are *FlexFree®*, *Synoflex®*, and *MSM®*(oral form of DMSO). Tetracyclines are inhibitors of MMPs but use may compound drug resistance issues. Neutraceuticals are NOT regulated by the FDA.

- **IRAP** (interleukin receptor antagonist protein) competes with interleukin 1 for receptor binding in an attempt to decreased inflammation. Duration of binding is unknown.
- **Free choice exercise** helps keep joints mobile. Forced exercise can speed cartilage breakdown. Stall rest (if needed due to a particular therapy) can be very challenging for both horse and owner.
- **Frequent trimming** helps to keep the **toes short** (best **breakover**) and to keep the foot balanced.
- **Rehabilitation/physical therapies** may be recommended. Not all are scientifically proven. These therapies include hydrotherapy, ice, swimming, acupuncture, chiropractic, laser, electrical stimulation, therapeutic ultrasound, counterirritants, radiation, shockwave, massage, and heat.
- **Nutrition/weight management.** Weight control can be important. Supplements containing fatty acids may help decrease inflammation. Other supplements have variably shown anti-inflammatory and/or analgesic properties
-

Key Takeaways

Arthritis is common in horses and is usually due to wear and tear along with cartilage damage. Therapy is supportive

- NSAIDs
- Free choice exercise
- Frequent hoof trimming
- Supplements

Cartilage does not heal well. Joint supplements may be useful to prevent damage but quality varies.

Horse owners love fancy toys and “new” stuff (therapies).

Resources

Clinical insights: Recent developments in equine articular disease (2016–2018), Equine Veterinary Journal 50 (2018) 705–707

Pathophysiology of Osteoarthritis, CCE Jan/Feb 2009, pp 28-40

Management and Rehabilitation of Joint Disease in Sport Horses, Vet Clin Equine 34 (2018) 345–358

Evaluation of polysulfated glycosaminoglycan or sodium hyaluronan administered intra-articularly for treatment of horses with experimentally induced osteoarthritis. AJVR, 2009. DOI:10.2460/ajvr.70.2.203

Influence of trimming, hoof angle and shoeing on breakover duration in sound horses examined with hoof-mounted inertial sensors, Vet Rec 2021 – good explanation of ***breakover*** and how shoes impact it

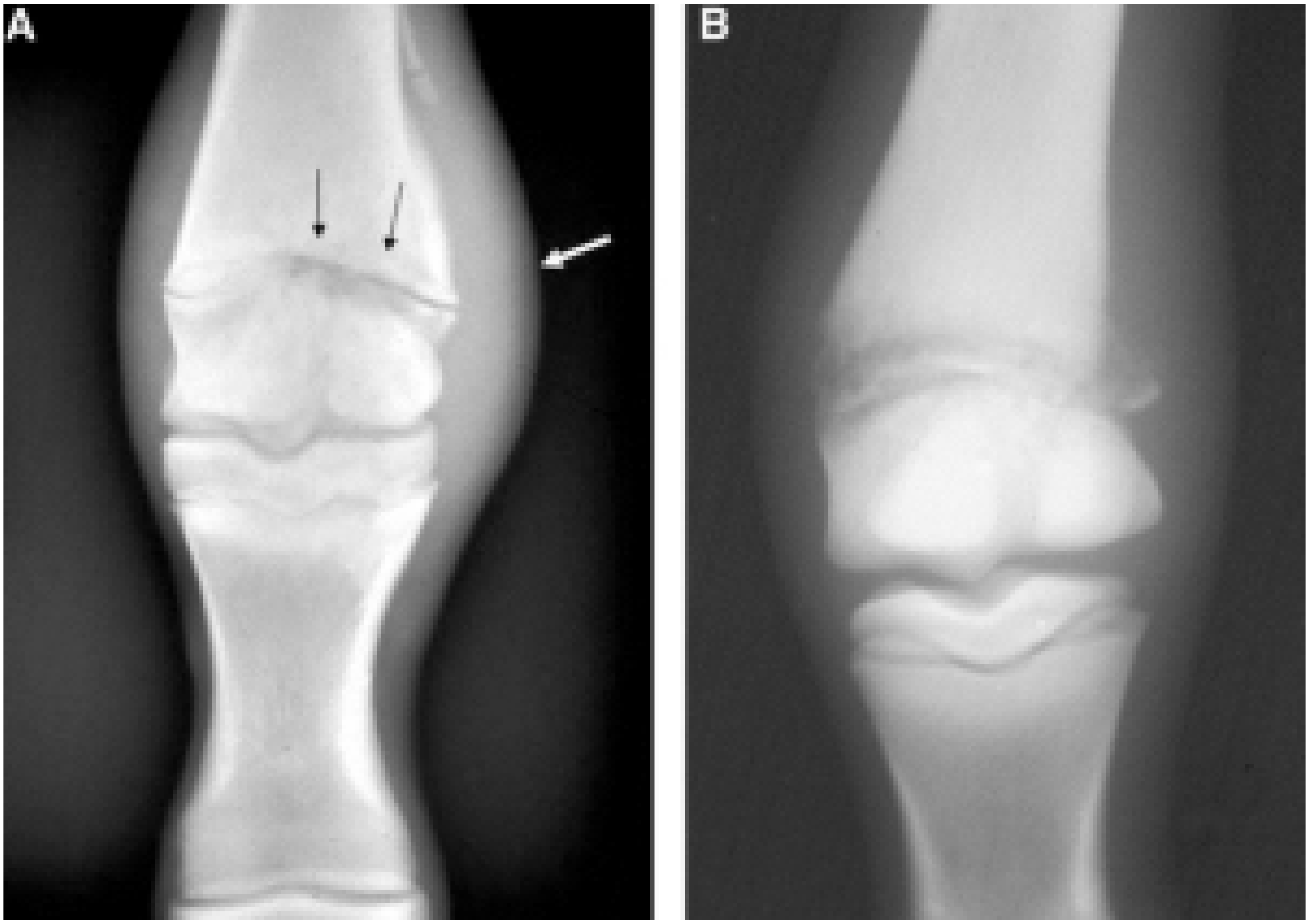
Etiology

Joint sepsis can occur due to trauma (puncture wounds and iatrogenic), extension from nearby infection and hematogenous spread. Hematogenous spread is unusual in adults; in foals it is usually related to umbilical, GI or respiratory infections. A variety of organisms can be identified with wounds, including anaerobes. Iatrogenic infections are often Staphylococcus aureus; these are associated with joint blocks and therapeutic joint injections. Systemic infections in foals are often gram negative coliforms. Rhodococcus equi can seed joints in older foals.

Diagnosis

Early identification and aggressive treatment is required for soundness and often for life. Joint effusion and lameness are common. Foals may have a limited inflammatory response , lie down a lot, with lameness not always apparent. All joints should be carefully palpated in foals (multiple joints may be involved) and the umbilicus ultrasounded. Joint fluid is sampled and submitted for culture and cytology. A healthy joint will have viscous fluid with low protein and low cell count. An infected joint will have high protein, a high cell count and low viscosity as inflammatory cells and mediators leak into the fluid and destroy the hyaluronan components and other proteins. The joint fluid and/or blood should be cultured to determine the causative agent and appropriate antimicrobial treatment.

Radiographs are recommended as many cases of juvenile septic arthritis occur due to extension from an infected physis or metaphysis.



[Etiology, Diagnosis, and Treatment of Septic Arthritis, Osteitis, and Osteomyelitis in Foals]

Treatment

Any underlying infection should be treated and infected umbilical stalks removed surgically if indicated. Systemic iv antibiotics are indicated.

The joint is treated via lavage. Through and through needle lavage (two needles are put into the joint and fluid flushed into and out of the joint) is effective in foals and in very early cases of traumatic infection. If available, arthroscopic lavage is considered more effective in adults and in more chronic infections.

Local (intra-articular) antibiotic infusion of amikacin or other high powered antibiotic is usually combined with systemic administration of more broad spectrum and first line antibiotics such as penicillin/gentamicin or a cephalopsorin until culture results are available. (Amikacin is often used systemically in foals). Antibiotics alone are not effective.

Synovial resection may be required to remove deep seated bacteria and damaged synovium.

Management

Joint samples are take every other day to determine if repeated flushing or injection is required and to ensure improvement.

If the infection cannot be controlled, the horse should be euthanized for humane reasons.

Key Takeaways

Foals can develop septic arthritis due to hematogenous spread. Adults develop septic arthritis due to wounds and injections.

Septic arthritis can result in euthanasia

Treat with lavage and antibiotics (local +/- systemic)

Resources

Haematogenous septic arthritis, physitis and osteomyelitis in foals: A tutorial review. Part 1. Equine vet. Educ. (2021) 33 (12) 659-672

Haematogenous septic arthritis, physitis and osteomyelitis in foals: A tutorial review. Part II. Equine vet. Educ. (2022) 34 (1) 37-48

Septic Arthritis, Physitis, and Osteomyelitis in Foals, VCNA August 2017, Vol.33(2), pp.299-314

Antimicrobial selection for the equine practitioner, VCNA 2021, Vol 37, pp 461-494. Includes specific recommendations for musculoskeletal infections

Effect of arthroscopic lavage and repeated intra-articular administrations of antibiotic in adult horses and foals with septic arthritis. Veterinary Surgery. 2017;46:1008–1016.

Hock joint problems

Older horses get arthritis; osteochondrosis is more likely to be diagnosed in a young horse.

Anatomy

The tarsal joint is really a collection of four joints, some of which communicate with each other but there are horse to horse differences.

Tarsocrural = tibiotarsal joint

This is the big joint and is where all movement occurs. It always communicates with proximal intertarsal joint. Effusion of this joint is known as bog spavin.

To tap or inject this joint : Inject slightly distal to medial malleolus and more dorsal so the needle does not pass thru the medial collateral ligaments which come off the distal end of the medial maleolus. Needle should pass into the large joint space between the medial collateral ligament and the cranial branch of the medial saphenous vein.

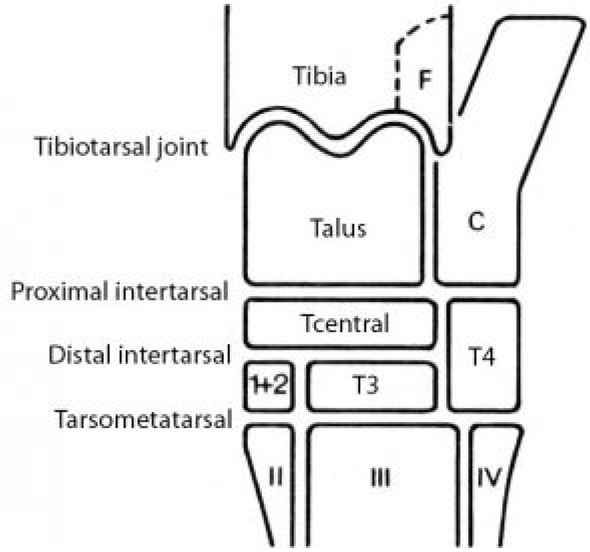
Proximal intertarsal joint

This is a low motion joint between the talus/calcaneus and the central tarsal bone + T4. This joint always communicates with the tibiotarsal joint so separate injection is unnecessary. Inflammatory mediators within this joint will also affect the tibiotarsal joint.

Distal intertarsal joint

This is a low motion joint. Arthritis in this joint is called bone spavin.

Injection of the distal intertarsal joint is the most difficult due to narrow space and heavy covering with the medial collateral ligaments. An imaginary line is found between the distal (medial) tubercle of the talus and the groove between medial splint and the cannon bone. The injection point is on this line and just distal or thru the cunean tendon distal edge. The goal is to pass the needle tip into the intersection of Tc with T3 and T1+2.



Tarsometatarsal joint

This is a low motion joint. Arthritis in this joint is also called bone spavin. In 10-40% of hocks this joint will communicate with the distal intertarsal joint. Some drugs may also diffuse across these joints.

To inject this joint, pass the needle tip on the lateral side between T4 and edge of the head of lateral splint (Mt 4).

Normal radiographic anatomy

The tarsal joint has more complex ligaments than other joints. It has long and short collateral ligaments. **Long collateral** ligaments extend from the tibia to the metatarsus and are superficial to the short collateral ligaments. **Short collateral** ligaments extend from the tibia to the talus or calaneus or both. Superficial, middle and deep short collateral ligaments have been described. Additionally there is a large **dorsal tarsal** ligament running from the distal (medial) tubercle of the talus to the cannon bone (Mt3), Tc and T3. The **long plantar** ligament runs from the plantar aspect of the calaneus to the head of the lateral splint bone (Mt 4). It is torn in curb. Other ligaments bind together individual tarsal bones.

Osteoarthritis

Bone spavin is arthritis of the distal hock joints (tarsometatarsal and distal intertarsal joints). These are low motion joints but are affected by normal wear and tear due to gliding, stopping, and turning. Most older horses that have been in any degree of work will have changes in these joints. Some younger horses may also have changes, despite not being in work. The changes in younger horses are suspected of being due to cartilage abnormalities (form of osteochondrosis).

Hock joint arthritis is common in many performance horses.

- Standardbreds (harness horses): while a rider will shift the center of gravity towards the forelimbs, a rider in a sulky (cart) will shift the center of gravity towards the hind limbs and thereby increase stress on the tarsal joints.
- Rodeo horses that turn quickly stress their tarsal joints with rotary motion under a load.
- Jumpers stress their tarsal joints when they rear up and then propel themselves with their hind limbs. Poor conformation as in “cow hocked” individuals is another contributing factor

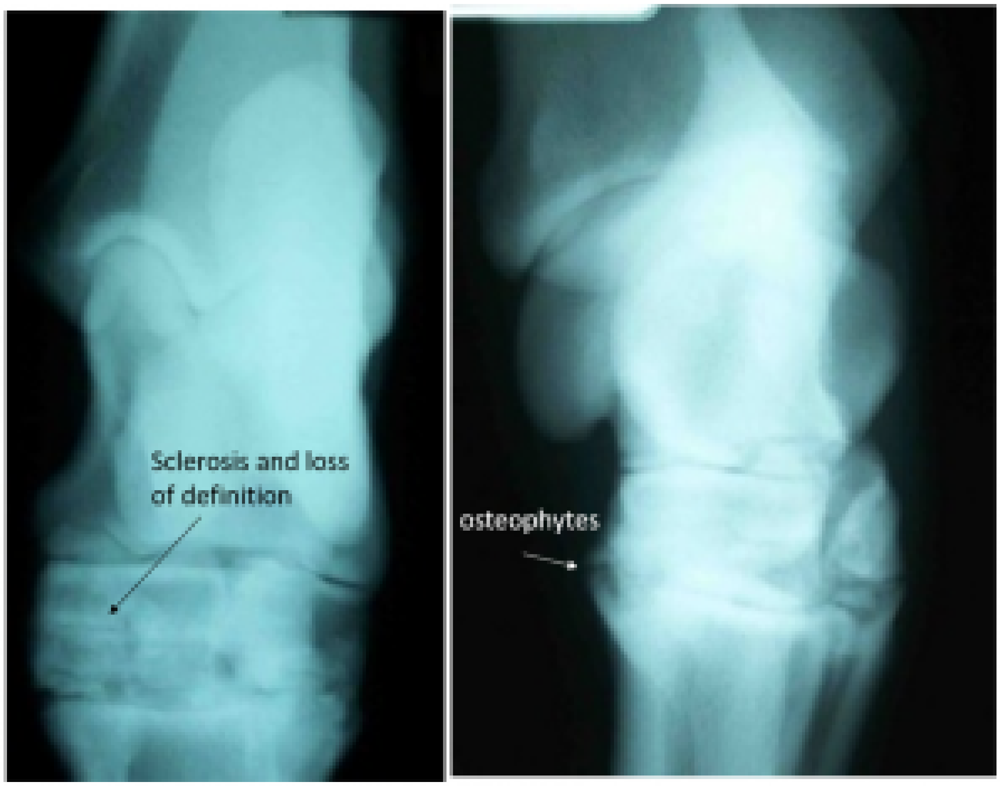
Diagnosis

Horses with bone spavin will have an abnormal gait with a low foot flight because tarsal flexion is painful. Upper limb flexion will make the lameness worse.

Relief of pain after anesthetic injection of the cunean bursa or distal intertarsal joints. The injection sites are as follows:

- Distal intertarsal – at T-shaped junction of Tc, T3 and T1+2
- Tarsometatarsal – at junction of T3, T4 and Mt3. Remember that the collateral ligaments cover over the joints and make injection difficult.

Radiographic lesions include osteophytes (new bone at the edges of joints) which make the bone edges sharp or appear to have spikes, loss of joint definition (lack of a sharp line) due to cartilage loss and bone formation in the space, and mild remodeling of the boney shapes – the joint may look fuzzy.



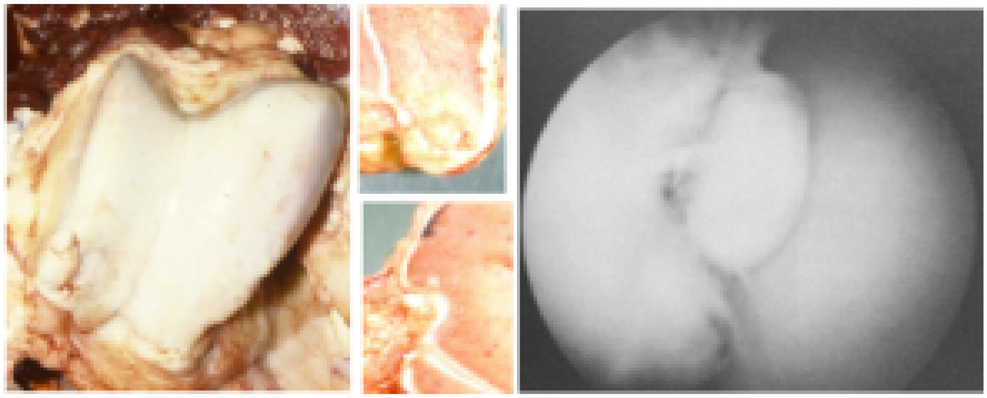
OA affecting DIT and TMT joints

Therapy

Because these are low motion joints, treatment is aimed at fusing the joints so that motion (and therefore pain) no longer occur. This can be done by keeping the horse in work (and on analgesics); however, it may take some time for natural fusion to occur. The process can be speeded by injecting the lower joints with steroids, injecting them with a compound that destroys cartilage (monoiodoacetate or MIA; no longer in favor), or by removing the cartilage with a drill while the horse is anesthetized. Historically, cunean tendinectomy was performed to relieve pressure on the remodeled bone. Prognosis is favorable as long as only the lower two joints are affected. Since the proximal intertarsal joint communicates with the high motion tibiotarsal joint, changes in that joint are more serious and can lead to arthritis in the tibiotarsal joint.

Osteochondrosis

Osteochondrosis dissecans is a developmental disorder whereby pieces of cartilage +/- bone break off.

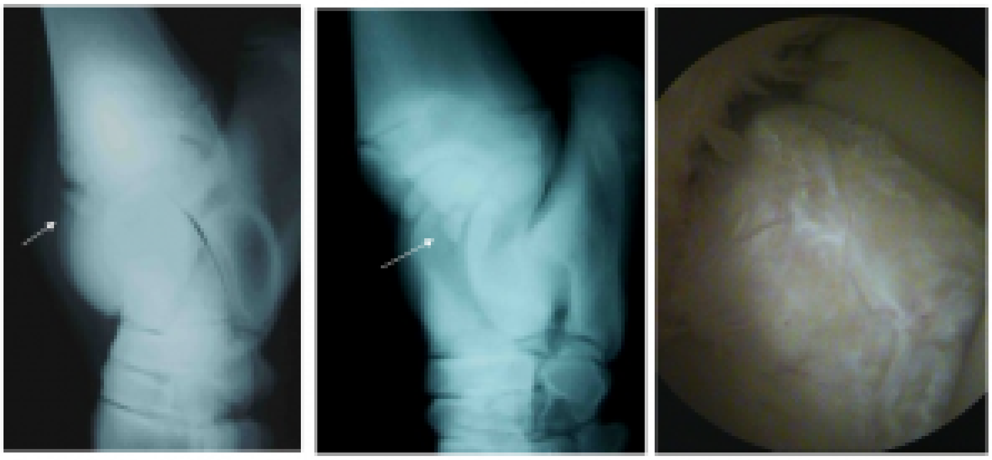


OC lesions of the trochlear ridge

Clinical signs include joint effusion with minimal lameness. Young horses just being put into work are most commonly affected.

tibiotarsal joint effusion (bog spavin)

The predominant sites in the hock are the distal intermediate ridge of the tibia (known as DIRT lesions) and the lateral trochlear ridge of the talus. The medial malleolus can also be affected.



DIRT lesion and irritated synovium due to fragment

OCD is often a bilateral condition so both hocks should be radiographed. Fragments of bone may be apparent in the joint. Arthroscopic surgery may be necessary to find cartilage fragments and is the treatment of choice. Once the fragments are removed, horses with hock OCD have a very good prognosis for future performance.

Capped hocks

capped hocks in a mule

Capped hocks are due to bursitis and are generally related to trauma. Note the swelling is more localized to the point of the hock.

Other lesions include infections, fractures of the cuboidal bones and hock luxations.

Key Takeaways

Young horses get joint effusion from osteochondrosis. The most common site is the tibiotarsal joint with a fragment off the distal intermediate ridge (DIRT lesion)

Older horses are painful due to arthritis. Arthritis most typically affects the lower joints: tarsometatarsal and distal intertarsal joints. This is referred to as bone spavin.

Resources

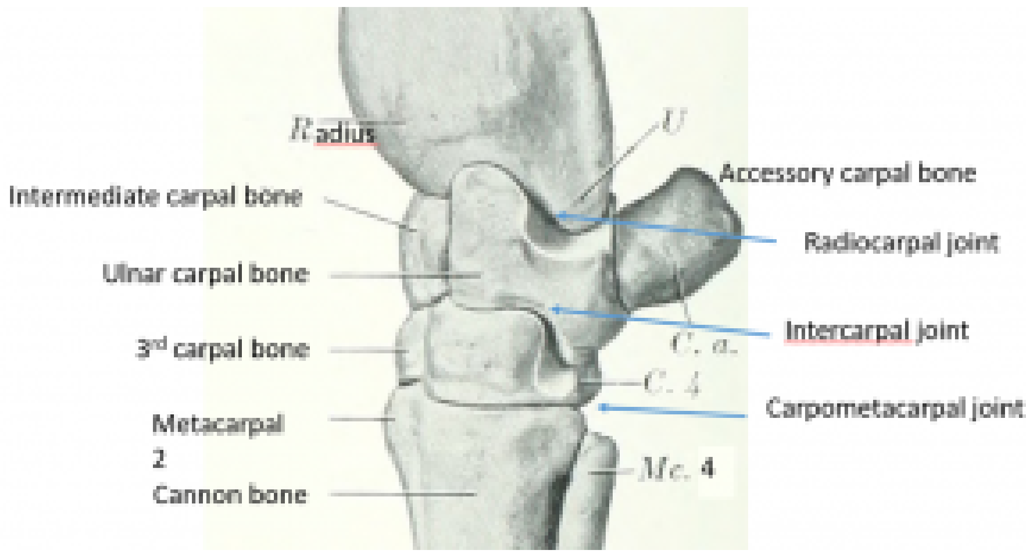
Review of equine distal hock inflammation and arthritis, AAEP 2006

Diagnosing lameness in the tarsus and proximal suspensory region, FAEP 2017

Carpal joint problems

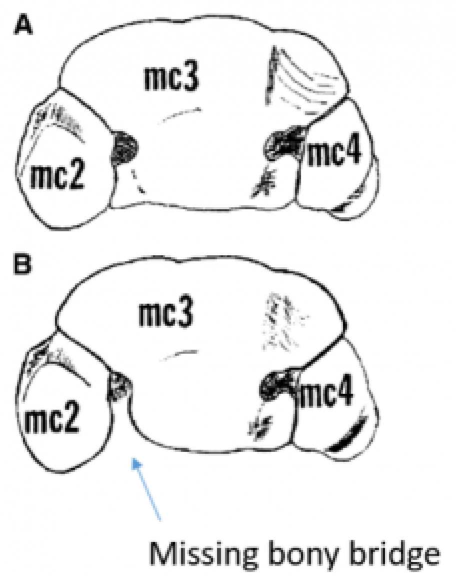
Anatomy

There are 3 joints in the carpus : the antebrachiocarpal (radiocarpal), the intercarpal (middle carpal) and carpometacarpal joint. The antebrachiocarpal and intercarpal joints are high motion joints while the carpometacarpal joint is low motion. The intercarpal and carpometacarpal joints communicate in all horses.



Weight bearing is asymmetrical with the axial aspect of the limb bearing more weight and enduring more trauma over time.

Many Arabs of Polish and Russian ancestry have less bony support on the medial aspect of the limb due to a different conformation and are prone to more osteoarthritis at the carpometacarpal joint.



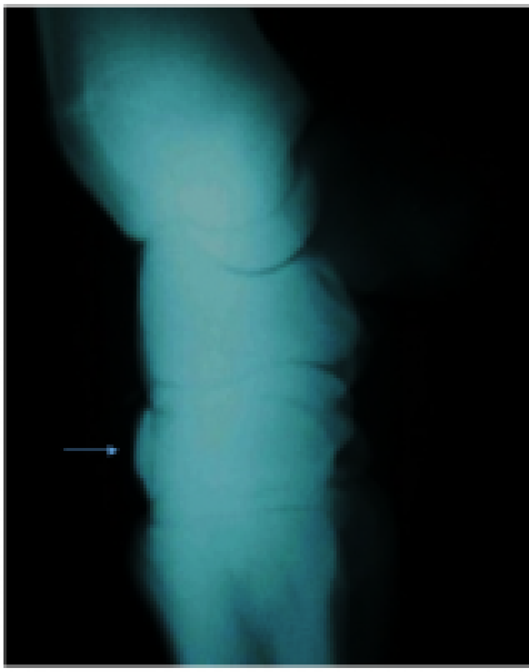
Osteoarthritis

The main problem affecting the carpus (besides sepsis) is trauma and arthritis. Racing horses, in particular, are at significant risk of developing chips or slab fractures.

Diagnosis

Common signs include pain on flexion, bony remodeling of the carpus, and carpal distension.

Radiographs are useful. The most common sites for chips include the distal dorsomedial aspect of the radial carpal bone, the proximal dorsomedial aspect of C3, and the distal radius. Slab fractures (front of bone fractured off) are also found on C3 (third carpal bone) and may be preceded by sclerosis (increased bone) of C3 and/or lysis of C3. Lesions are often bilateral. Radiographs will show small spicules of bone at the joint margins or sharp corners to the bones. The flexed lateral view is useful for determining whether the intermediate carpal bone or radial carpal bone is affected since “radial drops” and “I goes high”.



Slab fracture, 3rd carpal bone

Chip fracture, radial carpal bone

Arabians with CMC (carpometacarpal) syndrome show an exaggerated, callus-like response

More typical CMC OA

Arab CMC OA

Therapy

Treatment includes removing any chips and treating the joints for any cartilage damage.

Arabian carpometacarpal syndrome is treated with arthrodesis of the intercarpal and carpometacarpal joints if identified prior to changes in the radiocarpal joint. Most of these horses are treated supportively until retirement (usually within months of diagnosis). Pasture turn out, NSAIDs, and frequent trimming are used to maintain comfort.

Key Takeaways

Carpal joint arthritis is most common in

- older Arabs – due to instability of the joint after injury
- race horses – due to chip and slab fractures when the carpus is hyperextended (super straightened) during speed work

Resources

Severe carpometacarpal arthritis in older Arabian horses, Vet Surg 2003

Practice

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Equine bone disorders

Bone disorders involving bony remodeling and fractures of smaller bones

Bone remodeling and healing

Wolff's Law – bone adapts to the load applied to it. More load -> bone strengthening. Less load -> bone atrophy. Generally loading is good. The bone remodels to fit the load as long as the forces are physiologic (not too much too soon).

This is the useful one

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Note the appearance of Barnes dehorners in The Office video clip…

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mesmerizing

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Bone is one tissue that will return to its original structure after damaged. But it doesn't have to.

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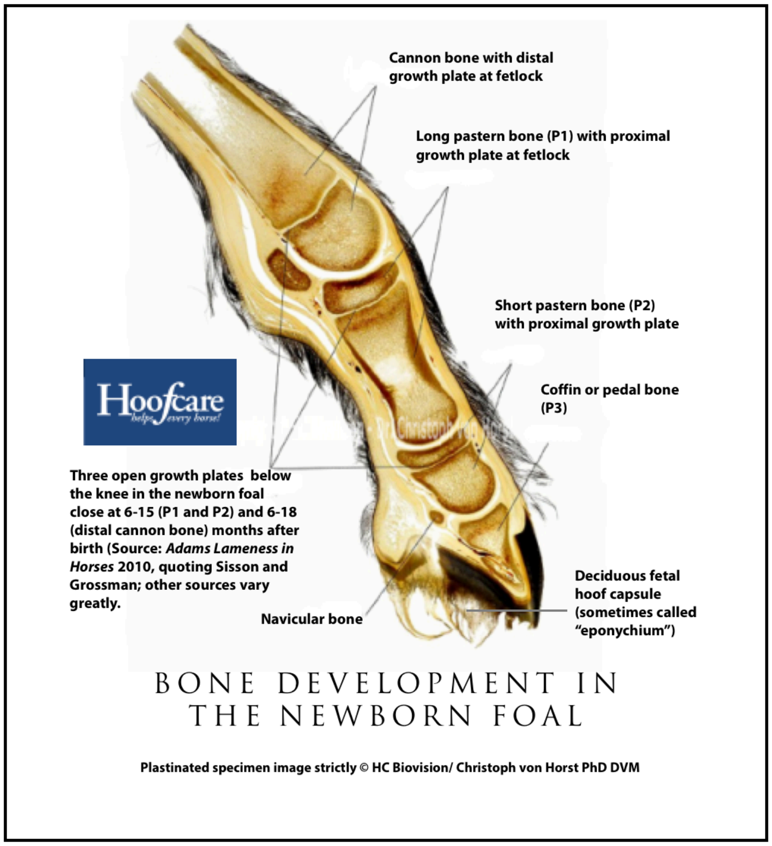
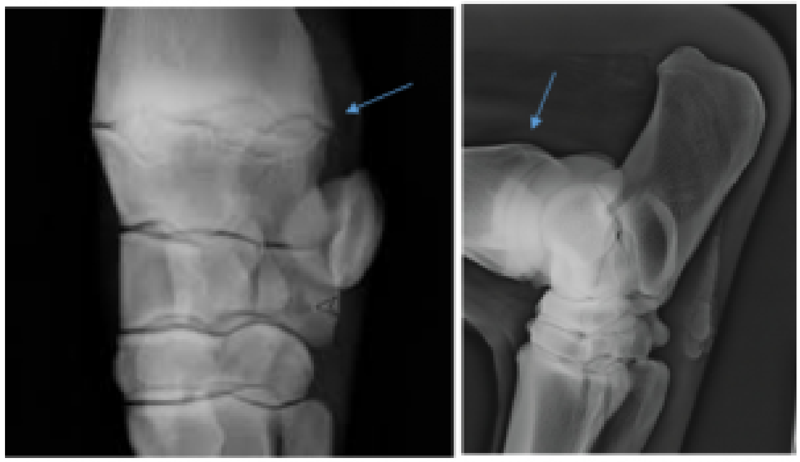
The periosteum is not as forgiving and will usually respond to trauma with reactive changes (see reaction around splint bone below).

Physeal disorders

Most, but not all bones have both a proximal and distal physis. Growth of the long bone occurs in the physis as most of the cells in the physis are cartilage. Physeal growth also adds to the width of the bone.



https://hoofcare.blogspot.com/2011/06/video-fix-my-crooked-foal-reality-time.html



Radial physis Tibial physis

Growth plate trauma (overload) can lead to fractures but more often impacts growth. If the physis is traumatized, it doesn't grow as well. Often the trauma is not uniformly distributed. If one side of the physis grows well but the other doesn't, the limb grows crookedly (angular limb deformities).

In young animals, rapid growth and exuberant exercise can be enough to damage the physis. If the physis is evenly damaged, the limb is just shorter but straight. This is rare. Generally one side of the physis is affected more than the other. The leg then deviates toward the compressed side, creating an angular limb deformity. [Note: ALDs can develop through other pathways too.]

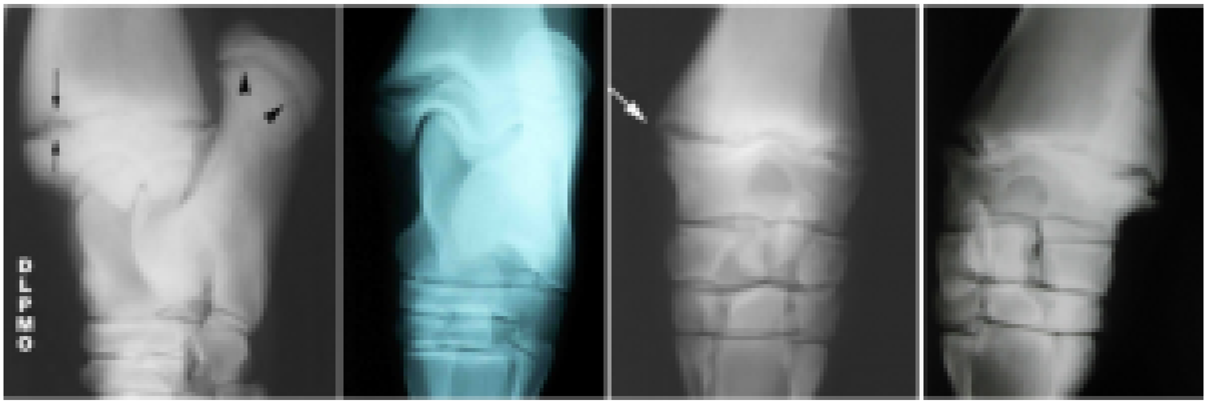
Physitis

Physitis= inflammation of the physis.

Physitis can occur due to excessive trauma on a normal physis or to normal trauma on an abnormal physis. Causes include rapid growth due to genetics and/or diet, excessive exercise, uneven weight due to an angular limb deformity (ALD), or abnormal cartilage. If the cause is exercise or growth, the physitis is usually symmetrical. If the physitis is asymmetrical, look for ALDs.

Affected animals show signs of pain – recumbency, knuckling, shaking. The physeal area is swollen and painful on palpation.

Radiographs show mixed density in the physis – a combination of sclerosis and increased lucency.



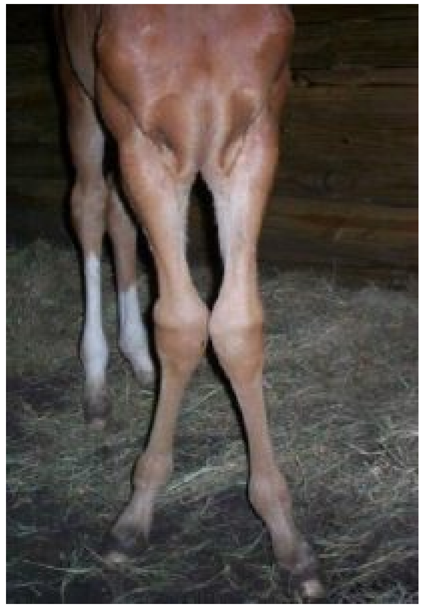
Physitis is treated with NSAIDs and removing the risk factors (decreased exercise, adjust diet, fix any angular limb deformity).

Angular limb deformities (ALDs)

Angular limb deformities are changes in the frontal plane. Angular limb deformities (ALDs) are named according to the joint that is deviated and describe how the distal limb is moving compared to the proximal limb. (Stand at the shoulder or hock and look down to see what joint is deviating).

- Valgus = deviation to the **l**ateral side (note both “L”s)

- Varus = deviation to the medial side



both forelimbs deviate at the carpus and move laterally = carpal valgus

bilateral carpal varus

Windswept foals have both a valgus and varus deformity:

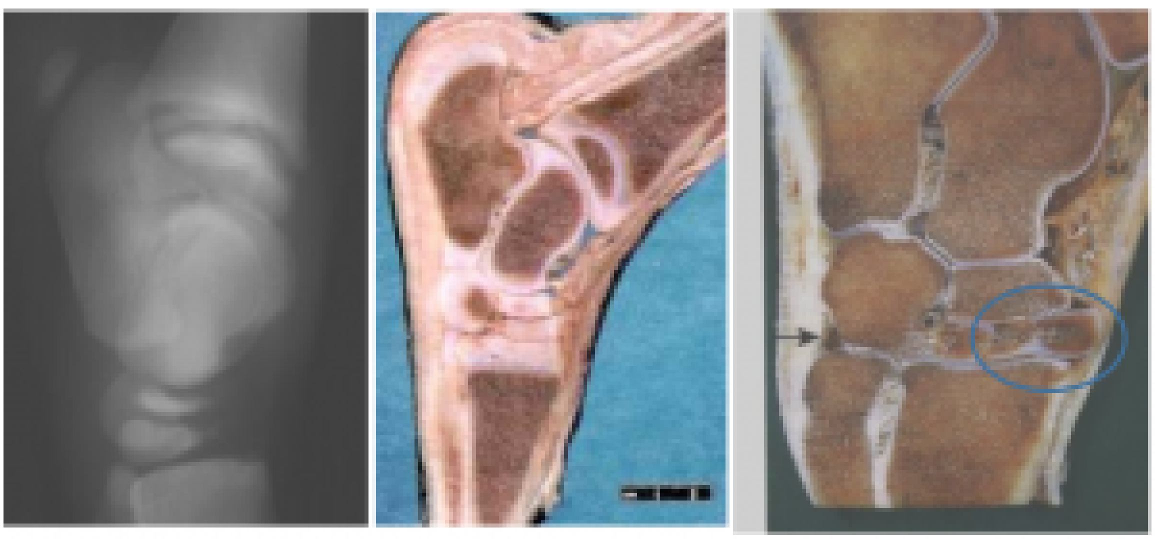
The most common versions are carpal valgus, tarsal valgus and fetlock varus. Mild carpal valgus can be protective; <5 degrees in a foal is considered normal. Varus is problematic and needs correction.

Many foals have **external rotation** of the forelimbs. The toes point outward. However, the limb is straight but is rotated from the shoulder.

This will correct as the horse develops a broader chest. It is important to not diagnose or misdiagnose an ALD if the limb is rotated but straight. Line up with the foot and/or look down from the shoulder.

Not all ALDs come from a physeal abnormality. Other causes include ligamentous laxity and cuboidal bone abnormalities. Newborn foals can just have weak ligaments. These limbs can be straightened manually and you may be able to see changes as they move. These foals should not be lame.

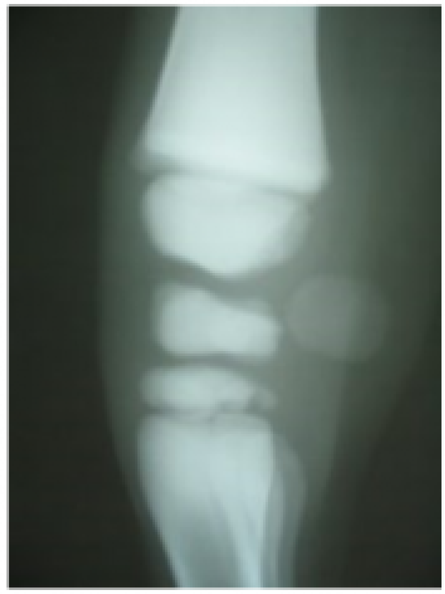
Premature foals often have immature cuboidal bones (the carpal and tarsal bones are still mostly cartilage). Immature bones squash and then ossify in an abnormal shape.



note how the third tarsal bone squished out the front and ossified that way in the far right image

Diagnosis

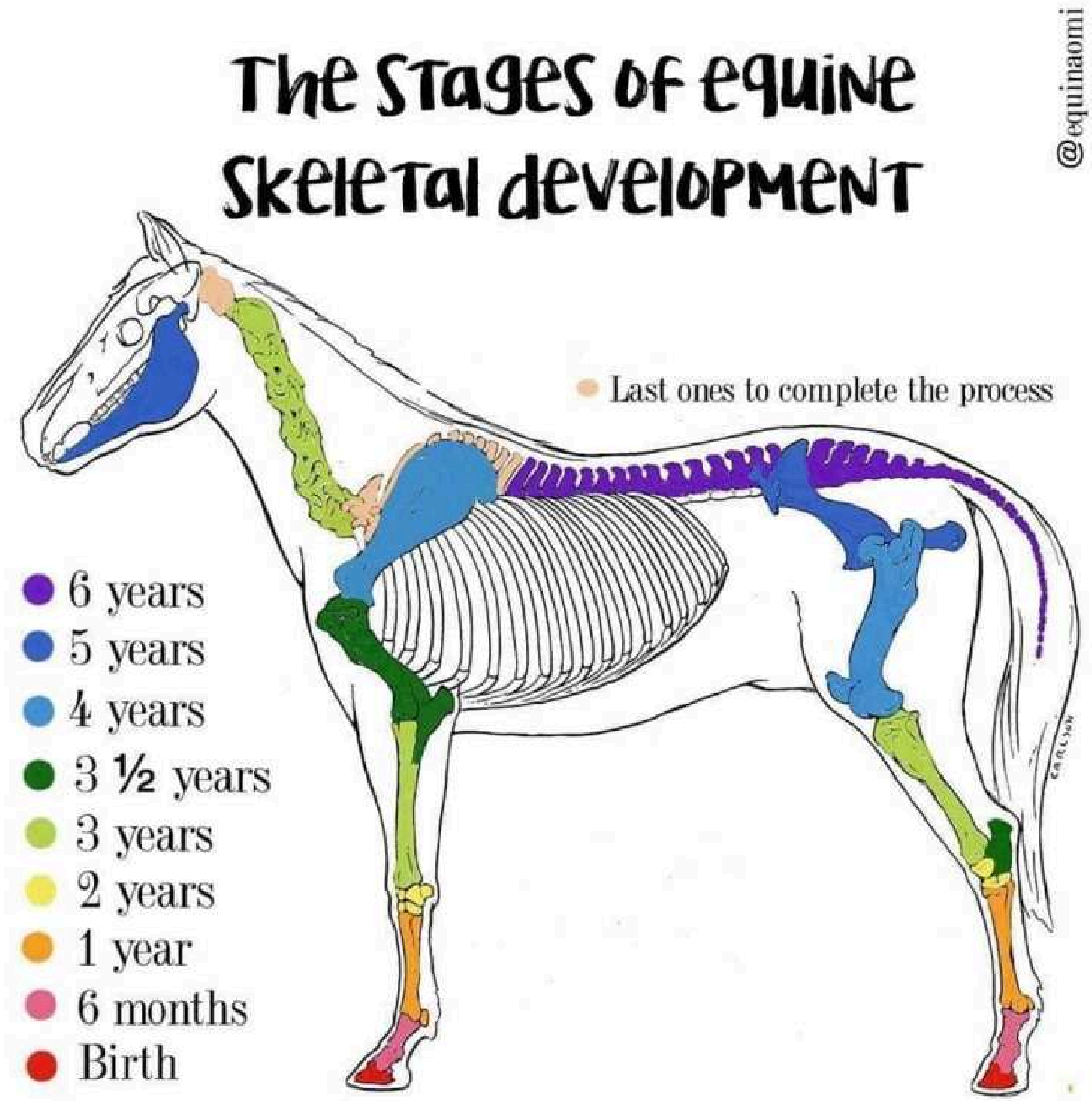
To determine the cause of the ALD, radiographs are taken using long plates. Draw a line down the middle of each long bone. Where they intersect is typically the cause of the problem (joint or physis). Radiographs also let you assess the cuboidal bone development.



Treatment

Different physes grow at different rates and for different times. For correction to work, the physis still needs to be growing. Monitor the more distal joints closely as you have a smaller window of growth.

- Distal radial physis – most growth by 6 months; closes at 3.5 years.
- Distal tibia – most growth by 4 months; closes at 2 years
- Distal MC III/MTIII – most growth by 2 months; closes at 1.5 years



- *https://equineink.com/2019/08/10/the-stages-of-equine-skeletal-development/*

Medical management *requires active growth!*

- control exercise
  - Some weight bearing is fine but more exercise is more trauma. Stall rest is generally indicated.
- adjust the load on the foot through trimming or hoof wall extensions
  - varus – trim medial aspect or add lateral extension
  - valgus – trim lateral aspect or add medial extension
  - trim to the side of the deformity or put extension on the opposite side
  - increase load on the affected side so increases bone growth
  - more effective for fetlock (whether you want it to be or not)

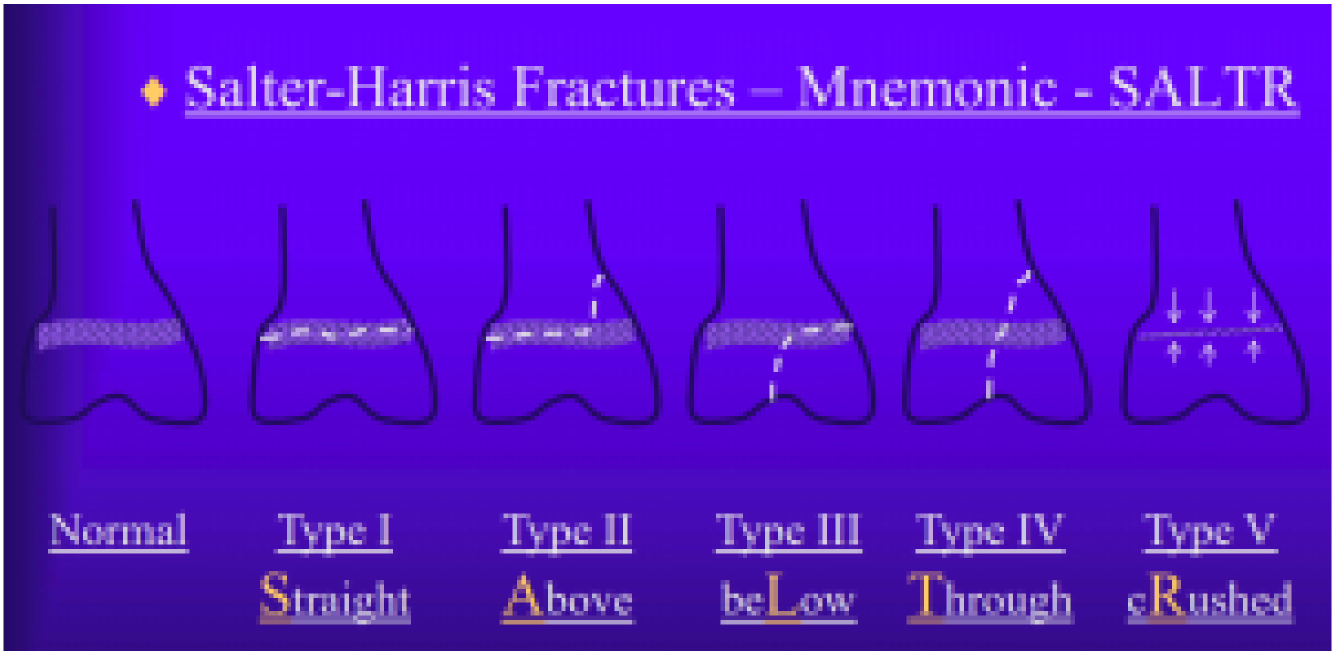
Surgery is needed if

- severe angulation (>15 degrees)
- not enough growth potential left
- foal is developing a secondary conformational abnormality (carpus valgus is developing a fetlock varus)
- economically important

Implants are put on the faster growing side to slow it's growth and let the other side "catch up". It is possible to overcorrect so implants need to be removed. Historically we performed periosteal stripping to stimulate the slower growing side. These may or may not have done anything (mother nature fixed them?) but overcorrection was not an issue. Implants may be a combination of screws and wire as seen in this image (transphyseal bridging) or a single screw placed across the physis (transphyseal screw).

These implants need to be removed if the limb becomes straight *and* the foal is still growing as the limb can overcorrect.

Physeal fractures



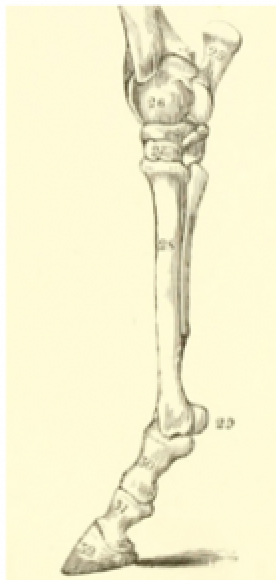
Key Takeaways

Angular limb deformities can occur due to tendon laxity in newborn foals, due to crushed cuboidal bones (due to prematurity and poor ossification), or due to trauma and/or inflammation of the growth plate. Mother nature will fix some of these but success depends on the physis involved and due to the degree of angulation. If the fetlock is involved, surgery is indicated earlier rather than later as this physis closes very early in life. Newborn foals with ALDs should be radiographed to assess cuboidal bone maturity.

Growth plate fusion chart

Splint bone disorders

Splint bones bear at least partial weight from the upper body and are easily traumatized due to their location.




Lateral splint bones are at risk from other horses and firm objects. Medial splint bones can be hit by the opposite limb. Medial splint bones articulate fully with MC/MT II while the lateral splint bones have much less weight directed on them. Medial splints can be affected by arthritis at the carpometacarpal joint due to the extra weight bearing.

Splint bone exostoses

The most common abnormality is a lumpy splint bone due to periosteal damage. These are called “splints” in lay terminology. Owners may not have observed the trauma or even detected these at the stage of inflammation. Many are identified as incidental findings after the inflammation has resolved.

If detected early, the area will be warm and painful on palpation. The horse may be lame. The lameness and inflammation respond well to stall rest and NSAIDs for 3-5 days.

If detected later, the area will be cool, nonpainful and firm. No treatment is advised at this stage.

Occasionally the exostoses will form more deeply and axially, and will rub on the suspensory ligament, creating lameness from suspensory desmitis. These exostoses need surgical removal.

Splint bone fractures

Splint bone fractures will usually heal if there is no associated wound. Many are comminuted and the blunt trauma or contamination associated can lead to avascularity and sequestration.

If the fracture is in the proximal 1/3 of the bone, the head of the splint may pop outward due to pull of proximal ligaments. These will usually require bone plate repair; however, MTIV (lateral hindlimb splint) has minimal function and can be removed.

May not require treatment

Needs stabilization or removal

Key Takeaways

“Splints” are periosteal reaction secondary to trauma. These rarely need much treatment.

Splint bone fractures may or may not need surgery; proximal fractures need attention.

Dorsal cortical fractures (Bucked shins)

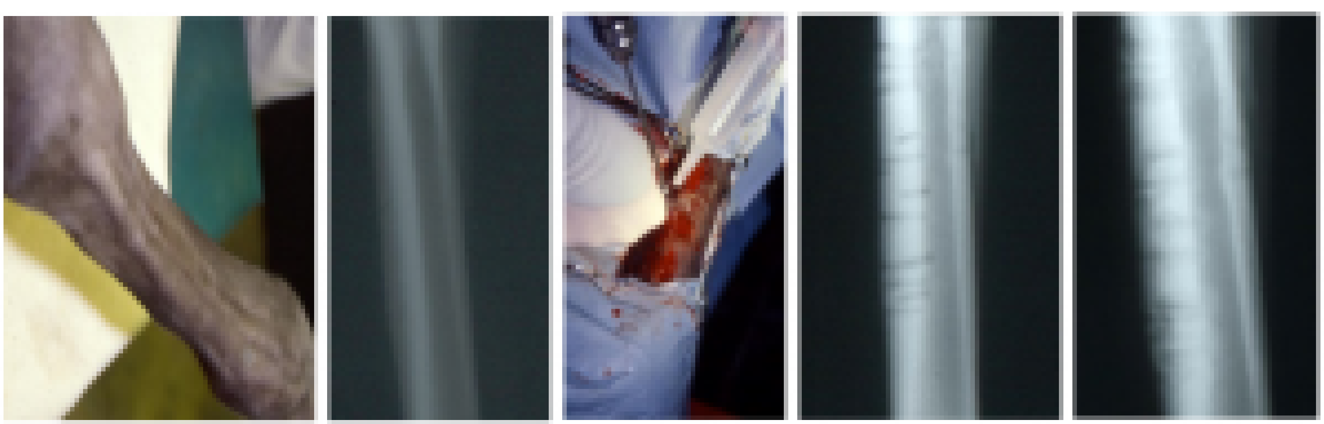
Bucked shins are actually remodeling from dorsal cortical fractures of the cannon bone (only in the cortex, not across the entire bone). This disorder is almost exclusively seen in young Thoroughbreds in race training.

Clinical signs include lameness and pain on palpation of the dorsal cannon bone.

Radiographically the dorsal cortex of MC III is thickened.

Most horses will not have obvious fractures on radiographs but some will have 1 or more radiolucent lines in the dorsal cortex identified as "stress fractures". These are usually seen in 3 year olds that experienced bucked shins as 2 year olds. Occasionally the fracture line will curve back to the surface, creating a true saucer fracture.

Treatment includes a revised training regimen and NSAIDs unless stress fractures are evident. If fracture lines are evident, the horse is stall rested until periosteal callus bridges the fracture line. This is most likely to occur in the distal or proximal metaphyseal regions. Osteostixis or osteostixis plus screw placement is used when the fracture isn't healing and for saucer fractures. Osteostixis involves drilling through the cortex to stimulate local bone repair mechanisms. The horse is stall rested for 4-6 weeks. Screws are removed and light work is maintained for another 60 days and before return to race training.



Key Takeaways

Bucked shins are seen in racehorses in training. Dorsal cortical fractures occur due to overloading of the cannon bone. Radiographically the dorsal cortex is thickened. Cases without stress fractures are treated by a revised training regimen and NSAIDs. Osteostixis can be performed to encourage healing if needed.

Equine muscle trauma

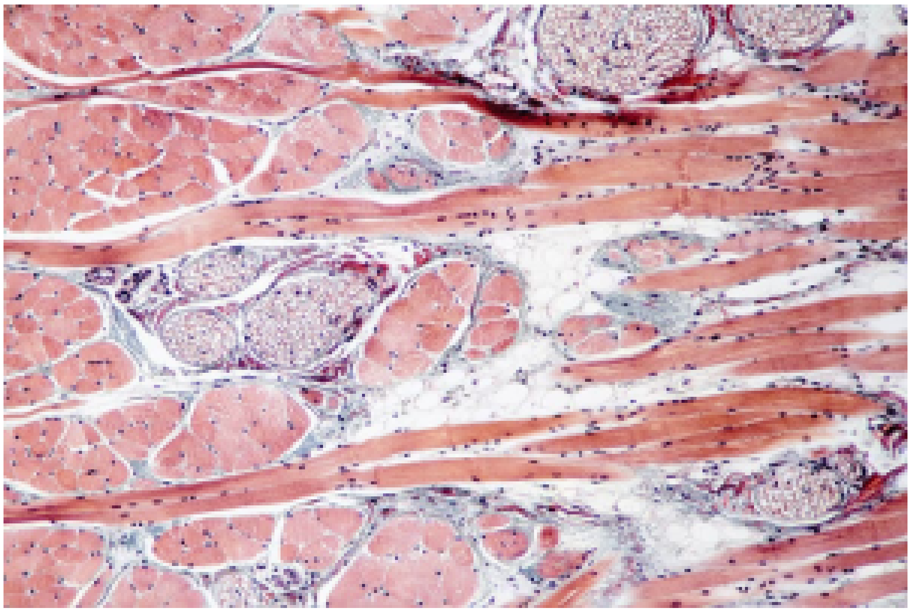
Muscle tears and trauma

Also see gait abnormalities

Muscle structure and function

Muscle generates force by contraction. To create movement, muscles contract across joints. Calcium and ATP are key factors.

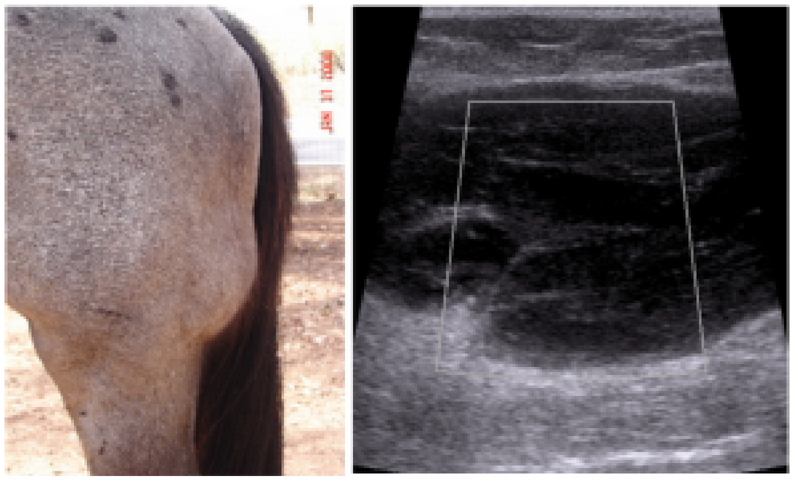
Muscle consists of bundles of muscle fibers surrounded by endomysium. Bundles of fibers, called fasciculi, are surrounded by the perimysium. The entire muscle is covered with the tough epimysium.



Muscle tears and trauma

Muscle is fairly easy to tear and has minimal capacity for regeneration. Repair occurs by replacement of muscle fibers with scar tissue.

Muscle tearing results in hematoma formation and mild signs of inflammation. In horses, the hematoma typically resolves into a seroma and then is absorbed by the body.



Scar tissue replaces the torn muscle and can restrict motion. As scar tissue doesn't stretch, recurrent tearing is common.

Healing is usually rapid unless a large hematoma forms. Hematomas can take months to resolve.

Therapy involves careful stretching during the healing process to minimize scarring to other structures. Therapeutic ultrasound is often used when available.

Practice

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https://open.lib.umn.edu/largeanimalsurgery/?p=6547#h5p-217

LA Orthopedic Emergencies

Limb instability – fractures, tendon lacerations, soft tissue breakdown injuries

Infected synovial structures

Hemorrhage

Arterial damage

Arterial bleeding can be life threatening. Most arterial lacerations are caused by external trauma; fractures can also lacerate arteries and cause severe bleeding without an external wound.

As with most arterial bleeding, compression, ligation or vascular repair is typically needed. In large animal species, collateral circulation is generally sufficient to provide blood flow to an area; rarely is vascular anastomosis required or performed.

Blunt force or stretching of an artery can lead to clotting and lack of blood flow without laceration or hemorrhage due to damage of the wall and release of tissue factors.

Bleeding secondary to artery laceration

Pastern lacerations are one of the more common causes of arterial injury due to the limited soft tissue covering of vessels in that region. Accidental artery trauma can occur in surgery, as well.

Bleeding can be controlled through

- tight bandages
- temporary tourniquets
- ligation of the artery
- clamping of the artery
- patient death (obviously not ideal)

Horses may not tolerate tourniquets and tight bandages on hindlimbs (these are painful) and will often require sedation. Cattle and small ruminants are more amenable to treatment. Animals can be sedated and/or anesthetized if needed; fluid support is often indicated due to blood loss. Anesthesia often seems dangerous in animals with blood loss; however, short duration anesthesia that results in hemorrhage control is generally preferable to ongoing blood loss.

Bleeding secondary to bone fracture

Femoral fractures and radial fractures are the most likely causes; pastern fractures can also lacerate the digital artery. For the femur and radial fractures, damaged arteries are deep and not accessible without significant surgical trauma. Significant bleeding can also occur from the bone itself. Compression can be almost impossible due to the large muscle mass. Keeping the patient quiet and calm (lowered blood pressure) is essential. Various therapies to activate clotting and/or slow bleeding are usually attempted:

- iv formalin (11-50 ml 10% neutral buffered formalin/ liter LRS)
- EDTA
- ice packing
- yunnan baiyao

In many cases, a blood transfusion will be required. Once the bleeding has stopped and the patient stabilized, referral to a hospital with transfusion capability is indicated.

Arterial spasm/ arterial blockage

When arteries are stretched too far or are traumatized, they tend to spasm shut. If this spasm lasts long enough for clotting to occur or causes endothelial damage, eventual loss of distal blood flow is very possible. In these situations, all blood supply to a region tends to be impacted. Without blood supply, the extremity becomes necrotic. Such injuries end in amputation or loss of life.

The most common causes of this type of injury are racetrack breakdown injuries, limb entrapments, and cannon bone fractures due to dystocia management in neonatal calves. In the latter two cases, the vessels are compressed by outside forces (whatever is entrapping the limb and the calving chains).

Breakdown injuries (suspensory breakdown or fetlock breakdown) injuries occur when the fetlock is hyperextended. This can be due to rupture of both suspensory branches, fracture of both sesamoid bones or fracture of a pastern bone. With breakdown injuries, the fetlock drops so low that the vessels are stretched almost to the breaking point.

In all of these situations, the blood flow damage is not immediately obvious. However, within 6-12 hours, the limb is noticeably cooler and the prognosis is very poor. Healing does not occur without blood supply. Larger animals do not tolerate limb amputation and should be euthanized unless some sort of prosthesis is available (and this is rare). Small ruminants and alpacas can tolerate limb amputation and this is an option.

Occasionally, infections and endotoxemia lead to systemic clotting. Distal limbs are affected first. This can result in hoof sloughing as one of the early signs, due to the limited blood supply to the hoof as well as the small diameter vasculature.

References

Intravenous formalin for treatment of haemorrhage in horses. Moreno, C. R ; Delph, K. M ; Beard, W. L. Equine veterinary education, 2021-03-08

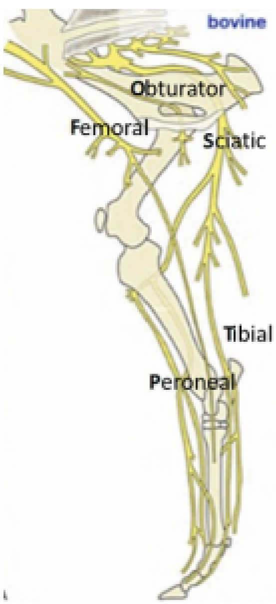
Fetlock breakdown injuries. WestVets.com

Nerve damage

Nerve damage may occur with direct trauma such as by a laceration, indirect trauma such as by the sharp end of a fractured bone, pinching by a fracture callus or scar tissue, or overstretching as when a leg it caught under a trailer or over a fence.

General treatment principles for nerve injuries include stall confinement with deep bedding. Sand is a good base as it is soft but provides stable footing. Steroids or NSAIDs are administered: dexamethasone @ 0.05 mg/kg, IM, every 1-2 days or flunixin meglumine @ 1 mg/kg, IM, q 12 h.

Hindlimb nerve injury



Many hindlimb nerve injuries are due to dystocia, particularly in cattle with oversized calves. Many result in “downer cows” or cattle unable to stand voluntarily.

Obturator paralysis

Seem immediately after calving and is often related to calf hip lock. Adductors are affected. The animal will have a base wide stance or may not be able to stand without assistance. When the limb is placed properly, the animal can weight bear. The fetlocks may knuckle. Affected animals are prone to limb abduction, particularly on slippery surfaces. When sitting, the hindlimbs are often extended forward. Obturator paralysis can lead to hip dislocation.

https://www.vetstream.com/treat/bovis/diseases/obturator-paralysis

The animal should be moved to an area with good footing. Treatment may include hobbling the back legs to prevent splits (use hobbles placed above the fetlocks). There is a high risk of permanent damage due to ongoing damage to muscles and nerves.

Ischiatic paralysis/sciatic nerve damage

Primarily seen immediately after calving but can be seen with hip fractures or injections. Persistent knuckling of fetlock and slight “dropping” of the hock is observed as the sciatic nerve innervates the muscles of the lower limb and is important in proprioception. Weight bearing is variably affected and may be due to other issues vs directly related to the sciatic nerve damage.

https://www.vetstream.com/treat/bovis/diseases/sciatic-injury

Tibial/peroneal nerve paralysis

Seen primarily in cattle immediately after parturition or prolonged recumbency and is due to pressure ischemia over lateral stifle region. The fetlocks are hyperflexed with some animals walking on the dorsum of the fetlock. The animal can bear weight on the limb but the hock is overextended and the digit cannot be extended. Both hindlimbs are typically involved when it is related to prolonged labor. A slightly milder version of sciatic nerve damage.

Treatment includes bandaging/splinting to straighten the fetlock. Differentials include gastrocnemius rupture (larger hock drop present with gastrocnemius rupture). Recovery takes 2-3 months

Femoral nerve damage

The femoral nerve may be damaged during dystocia; this is again most likely with hip lock but now the calf's nerve is damaged. Due to loss of quadriceps function, the baby cannot extend the limb for weight bearing. The patella is slack. Differentials to consider include hip fracture (femoral capital epiphyseal fracture) and hip luxation.

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Prognosis is fair (depends on severity) but colostrum management is essential. Muscles will atrophy rapidly. NSAIDs may be helpful.

Forelimb nerve injury

Sweeney is damaged to the nerve(s) around the scapula. Damage usually occurs due to pressure on the nerve or damage by fracture.

Radial nerve/brachial plexus injury

The brachial plexus or radial nerve is damaged when an animal or its forelimb is restrained and the animal struggles. It can also be seen with prolonged lateral recumbency. With damage, the elbow drops and the carpus and fetlock are maintained in partial flexion. Animals are unable to flex the shoulder or extend the lower part of the limb. Severe to non-weight bearing lameness with toe dragging may be seen. The animal can bear weight if the limb is splinted into a straight position. Differentials include humeral or olecranon fractures.

https://www.researchgate.net/publication/327499696_FULL_LENGTH_ARTICLE_OPEN_ACCESS_Physiotherapeutic_Treatment_Of_Radial_Nerve_Paralysis_By_Infrared_Radiation_In_A_Stallion/figures

Treatment includes bandaging, splinting, or casting the leg (including carpal joint) to prevent fetlock abrasion.

Most forelimb nerve injuries will improve rapidly. Nerves regenerate slowly at ~1 inch/month. The closer the injury to the muscle it innervates, the better the prognosis. Muscles without nerve supply rapidly undergo atrophy so will need rehabilitation. It can take two years for full return to work.

If skin sensation is totally lost the prognosis is guarded. If the condition persists for more than 2 weeks, the damage is likely permanent.

Resources

Peripheral neuropathy of a forelimb in horses: 27 cases (2000–2013). November 2016. Journal of the American Veterinary Medical Association 249(10):1187-1195

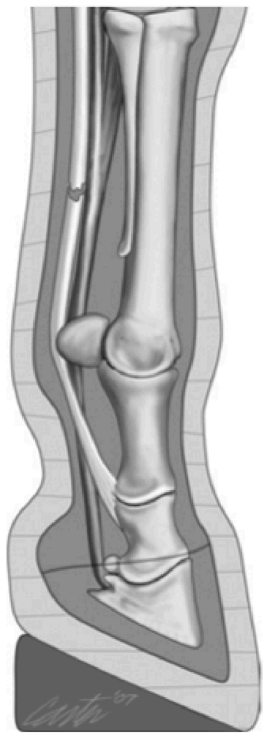
Diagnosing and treating downer cattle (Proceedings) July 31, 2011 Peter D. Constable

Tendon and ligament lacerations

Extensor tendon lacerations heal well without significant intervention.

Flexor tendon lacerations can be career ending due to poor healing. Tendons do not return to normal structure but maintain variable amounts of scar tissue within the injured area. Scar tissue is unable to stretch properly and often tears, leading to reinjury. Chronic injury may also lead to calcification of the tendon, further minimizing stretch.

Partial lacerations carry the best prognosis. It is important to keep these from becoming complete tendon lacerations. This requires immediate support to prevent full weight bearing. As the flexor tendons are most stretched with weight bearing, the animal is splinted so that it is standing on its toe and with the dorsal cortices aligned. This resembles a ballet dancer on their toes.



http://www.randwickequine.com.au/sites/default/files/publications/injuries_of_the_flexor_tendons_focus_on_the_superficial_digital_flexor_tendon.pdf and https://www.sciencedirect.com/science/article/abs/pii/S1534751604000459

This position can be stabilized with a dorsal splint, casting material or Kimzey leg saver splint.

Complete lacerations should be similarly stabilized for animal comfort. Surgical repair has not been found to change success rates. Suture repair is difficult and results in significant foreign body reaction. Healing is slow and often regresses as the horse uses the limb. Special shoeing and bandaging are required. In a large retrospective study, only 55% or horses with tendon lacerations were able to return to intended use and 18% were euthanized. Lacerations within the tendon sheath seem to heal particularly poorly, likely related to the poor vascularity.

Resources

Tendon and ligament injury chapter

Outcome after Lacerations of the Superficial and Deep Digital Flexor Tendons, Suspensory Ligament and/or Distal Sesamoidean Ligaments in 106 Horses. Jordana M et al. 2011 Veterinary Surgery 40(3):277 – 283

Healing Characteristics of Deep Digital Flexor Tenorrhaphy Within the Digital Sheath of Horses. Jann H et al. 2003 Veterinary Surgery 32(5):421-30.

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Lacerations Involving Synovial Structures

A soft tissue laceration that is located over or near a synovial structure (joint, bursa, tendon sheath) can have potential synovial structure involvement. These lacerations are considered emergencies and should be examined and treated as quickly as possible.

On arrival

- Full physical exam (heart rate, respiratory rate, mucous membranes, etc.) to assess the systemic health of the horse. Think about why the horse could have gotten the laceration in the first place. There could be an underlying issue, such as colic, that can be noticed on a physical exam.
- Administer a tetanus toxoid if the horse has an unknown tetanus vaccination history or if the horse has not been vaccinated for tetanus in the last 6 months.
- The horse will likely need to be sedated. Similar drugs and protocols from the "Limb Fracture" chapter can be used, however, these horses are generally not in as much pain as horses with fractures, so keep that in mind when selecting sedation protocols.
- Wounds on the limb with or without synovial involvement are a great time to use nerve blocks. This will increase the duration of your sedation and make the horse much more comfortable when you are assessing and treating the wound. Nerve blocks can also increase your safety while working on the wound, especially on a hind limb. *Equine Joint Injection and Regional Anesthesia* is an excellent resource for regional anesthesia techniques (see reference section).
- Clip the area around the wound. This will make the area cleaner and much easier to work with. You can place sterile lube in the wound and around the edges to prevent excessive hair and debris from entering the wound, but not every practitioner does this because it could also be a way to trap debris in the wound and make it more difficult to lavage everything out.

- Lavage the wound with sterile saline. “The solution to pollution is dilution”

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- Aseptically clean the laceration. Never clean with chlorhexidine scrub or solution when there is potential for synovial involvement because it is toxic to joints. Sterile saline is an excellent option for these situations (as well as other sensitive areas like around the eyes). Dilute iodine solution can also be used to clean, but remember that iodine is inactivated by debris in the wound.
- Using a **sterile** glove +/- sterile probes or other surgical instruments, perform an examination of the wound. Try to determine the margins of the wound, how close it potentially is to synovial structures, and the depth of the wound. The sterile probe can even be used when taking radiographs to get a better idea of depth and direction of the wound.

Always offer referral when there is a horse with a wound with potential synovial structure involvement

Clinical signs

If the injury is acute, the horse may or may not be lame. There is no way of determining whether or not there is synovial structure involvement just based on degree of lameness.

If the injury has occurred a few days prior to examination, the horse may become suddenly non-weight bearing lame. This is generally because inflammation starts accumulating in the joint, thus increasing the pressure and pain.

Synovial fluid could possibly be seen coming from the wound, but this is not always the case. This is more likely in an acute wound, rather than a chronic one.

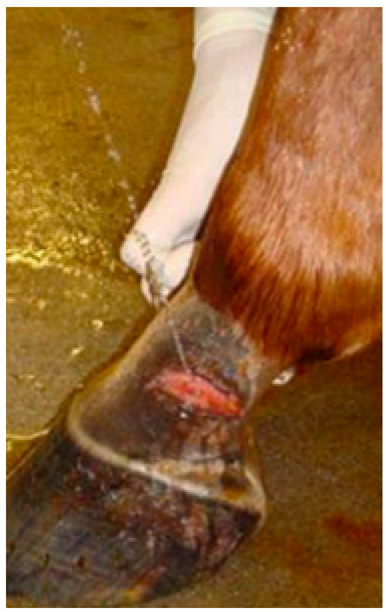
Physical exam parameters are usually within normal limits, but tachycardia or tachypnea may be present, depending on the amount of pain the horse is in.

Joint integrity assessment

- Radiographs
    - Look for gas near or in the joint space. Radiographs are not the most sensitive way to assess for joint involvement, however, they are quick and easy to do in the field. They can also help assess for any bone involvement or fractures that may have occurred during the trauma.
    - You can also inject sterile contrast media into the joint of concern (at a site distant from the wound) and then take radiographs. **This is one reason why it is important to be aware of and comfortable with different sites to inject each joint. The previously mentioned Equine Joint Injection and Regional Anesthesia book is also a great resource for learning about multiple different approaches and techniques for arthrocentesis of each joint.

- Ultrasonography
    - Ultrasonography is another quick and non-invasive way to assess a wound and can also be done in the field. Place a sterile glove or sterile rectal sleeve on the ultrasound probe, which will enable you to use the ultrasound directly in the wound without contaminating the wound or your ultrasound probe.
    - Ultrasound can be used to assess the depth and direction of the wound.
    - Some indications of joint involvement include: increased synovial fluid within the joint, gas or fibrin present in the joint, and/or a thickened synovial membrane.

- Arthrocentesis
    - Local anesthetic can be really useful.
    - Clip and aseptically scrub a site on the joint that is distant from the wound. Insert a needle into the prepared area and always start by taking a sample for culture and cytology. This fluid can be analyzed for evidence of joint contamination immediately after retrieval, either microscopically or grossly (especially in the case of chronic joint infection).
    - Using the same prepared area, the joint can be distended using sterile saline, and the wound observed for “leaking” of the sterile saline. It is also necessary to flex and extend the joint following the distension to fully assess.



    - It is helpful to be aware of the normal amount of fluid that is supposed to be in a particular joint so you know if you are effectively distending it or not.
    - **Never perform arthrocentesis on a joint through the wound or through cellulitis. This will drag bacteria into the joint.**

Follow up care

- Even if no joint involvement is suspected, after distending the joint or examining the cytology sample, antibiotics should still be injected directly into the joint as prophylaxis.

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- If there is joint involvement:

1. Start the horse on systemic antibiotics as quickly as possible or perform a regional limb perfusion, depending on where the wound is located.
2. Thoroughly lavage the joint. This can be done standing or under general anesthesia, depending on the case. This can be done by inserting a large gauge (14 g) needle into a site distant from the wound. This will likely be the same location that was prepared for the diagnostic arthrocentesis. Lavage with at least 1-2 L of sterile saline. Do not forget local anesthesia!

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3. Following lavage, administer intra-articular antibiotics.
4. If the wound and joint are severely contaminated (usually chronic wounds), do not suture the wound closed. This allows for maximum drainage and enables you to lavage the wound and joint thoroughly every day until there is no sign of infection cytologically or from culture results.
5. If the wound is acute and not severely contaminated, the wound can be sutured closed, but leave a small opening to allow for fluid drainage.
6. Regardless if the wound is sutured closed or not, apply a topical antimicrobial agent and a sterile bandage

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References

Moyer, W., Schumacher, J., & Schumacher, J. (2011). *Equine Joint Injection and Regional Anesthesia*. Chadds Ford, PA: Academic Veterinary Solutions, LLC

Murray, S. J. (2012). How to Manage Penetrating Injuries of Synovial Structures in the Field. AAEP Proceedings, 58, 221–227.

Orsini, J. A., & Divers, T. J. (2014). *Equine Emergencies: Treatment and Procedures*. St. Louis, MO: Elsevier/ Saunders.

Limb Fractures

Limb fractures: a cause of non-weight bearing lameness. Limb fractures are considered an emergency and should be evaluated as soon as possible.

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Some things that the owner can do while you are on your way include:

- Keeping the horse calm (offering hay, treats, a buddy, etc.)
- Try to reduce movement of the horse
- Hook up the trailer to prepare for a potential referral
- Try to apply compression if there is hemorrhage

Supplies that you will potentially need in your truck:

- Sedatives, analgesics, and tranquilizers
- Bandage and splinting supplies → we will get into that later
- NSAIDs
- Laceration repair supplies
- X-ray machine
- IV catheter supplies
- Euthanasia solution

When you arrive at the farm

If the horse is in stable condition and calm, complete a full physical exam (heart rate, respiratory rate, temperature, mucous membranes) to ensure that the horse is systemically well. Be mindful for signs of shock or colic.

If the horse is down / thrashing, sedate then reassess the situation. Additionally, you will likely need to sedate before starting manipulation or assessment of the traumatized limb. The sedation will also assist with analgesia, depending on the drugs used.

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Potentially Useful Drugs for a Fracture Emergency	
Xylazine	Sedation + Analgesia
Detomidine	Sedation + Analgesia
Acepromazine	Tranquilization
Butorphanol	Analgesia
Phenylbutazone	Analgesia
Flunixin Meglumine	Analgesia
Morphine (epidural)	Analgesia
Lidocaine (CRI)	Analgesia
Ketamine (CRI)	Analgesia

**The goal of sedation is that you should be able to complete an exam, manipulation, and stabilization of the affected limb without causing ataxia and increased risk of further injury. Physical restraint, such as a twitch or stocks, can also be useful, depending on the case.

Continued assessment

Determine where the fracture is likely located and if there is any instability or laxity within the limb. If there is a wound over the fracture location, it is considered an open fracture until proven otherwise, and should be treated as such.

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Fracture stabilization

Stabilization as quickly as possible is very important so the horse does not cause further injury to itself. Stabilization can help protect neuromuscular structures, prevent a closed fracture from becoming open, protect an open fracture from continued contamination, prevent further luxation, and prevent additional damage to the bones, cartilage, and surrounding tissues that will be needed for healing.

The goal of splinting is to prevent movement of the fracture in the medial-lateral direction and in the dorso-palmar or dorso-plantar direction. Splints should be placed perpendicularly. Additionally, the proximal limb will act like a pile driver and distract lower limb fractures. This is minimized by supporting the limb with the dorsal cortices aligned.

Splints: get creative! Broom or pitchfork handles, PVC pipes, metal pipes, pieces of wood, etc. are all reasonable options as long as they are safe and sturdy. There are also manufactured splints, such as the Kimzey splint, that is easy to use.

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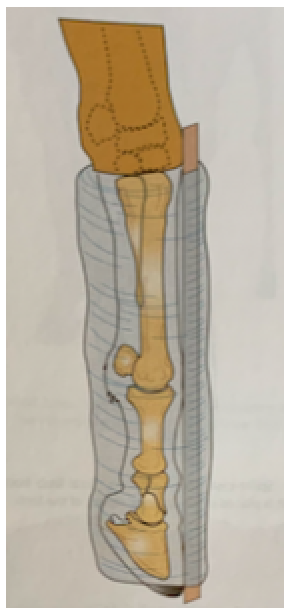
Robert-Jones Bandage

- Many layers of cotton with brown gauze over each layer → leg should be at least 3 times the original diameter when you are done
- Each layer is tighter than the previous one
- Vet wrap as the final layer
- +/- splint (can attach with duct tape)

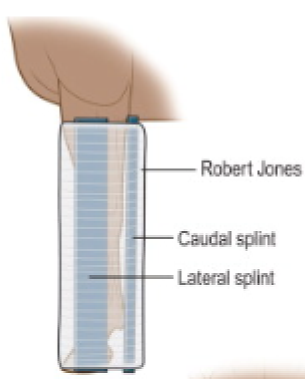
You can apply a cast, but that is more tedious, the horse must be completely still, and it will likely be removed immediately by the referral center. However, cast material is easy to carry in the truck and a bandage cast may be easier than splinting.

For fracture stabilization, the location of the fracture matters.

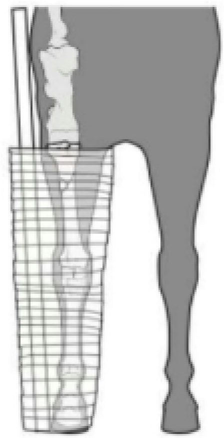
- Fracture anywhere distal to the fetlock, including the fetlock and distal metacarpus (forelimb)
    - Bandage and splint must extend from the ground to the carpus
    - You want the bony column in the leg to be in alignment with the toe pointed
    - Apply the splint dorsally
        - Or apply a Kimzey splint in the same fashion (with the toe pointed)
    - **If you suspect lateral/medial instability, you can apply splints on the lateral and/or medial aspects of the bandage as well



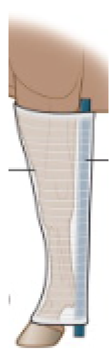
- Fracture from distal metacarpus to proximal carpus
    - Don't point the toe in this case, just let them stand normally
    - Robert-Jones bandage with lateral and palmar splints extending from the ground, past the elbow



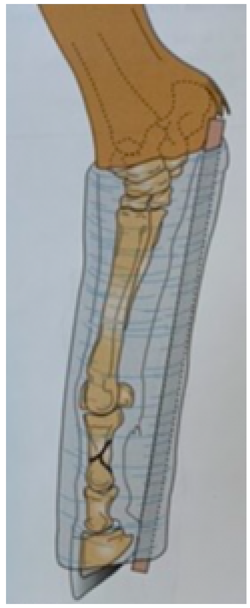
- Fracture of the radius
    - Robert-Jones bandage from the ground to the elbow with a palmar splint to the elbow and a lateral splint to the withers



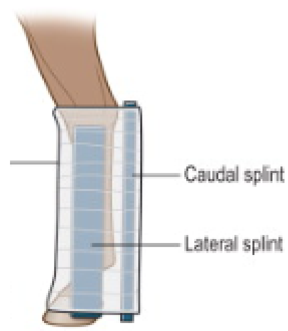
- Fracture of olecranon or humorous (dropped elbow with a flexed carpus → looks like radial nerve paralysis)
    - A light bandage from the ground, up to as high as possible past the elbow, with a palmar/ caudal splint
        - This gives the limb stability so the horse can balance better
        - Lock the carpus in extension



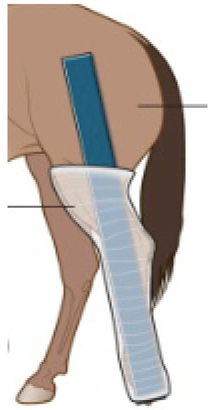
- Fracture anywhere distal to the fetlock, including the fetlock and distal metatarsus (hindlimb)
    - Bandage and splint must extend from the ground to the tarsus
    - You want the bony column in the leg to be in alignment with the toe pointed
    - Apply the splint on plantar aspect
        - Or apply a Kimzey splint in the same fashion (with the toe pointed)



- Fracture of the metatarsus
    - Allow the horse to stand normally and do not point the toe
    - Robert-Jones bandage with lateral splint extending past the tarsus and plantar splint to the calcaneus



- Fracture of tarsus or tibia
    - Rare fractures and hard to stabilize
    - Robert-Jones bandage from the ground to the stifle with a lateral splint extended at least to the hip



- Fracture proximal to the stifle
    - Cannot be stabilized
    - The good news is there is a lot of musculature in that region to stabilize itself

Once the fracture is stabilized, radiographs can be taken and/or the horse can get trailered to a referral hospital. If the horse has a fractured forelimb, face them backwards in the trailer. If the horse has a fractured hindlimb, face them forwards in the trailer. Allow the horse to have the use of its head to balance in the trailer, but do not allow them to turn around.

Treatment and Prognosis for Return to Former Use

Fracture Location	Fracture Type	Treatment	Prognosis
Distal phalanx	Articular	Medical or surgical	Guarded
Distal phalanx	Nonarticular	Medical	Good → very good
Middle phalanx	Comminuted	Medical or surgical	Guarded
Proximal phalanx	Comminuted	Surgical	Guarded → poor
Proximal phalanx	Noncomminuted	Medical or surgical	Good
Metacarpal or metatarsal III	Various types	Surgical	Poor → good (depending on the fracture type)
Olecranon	Various types	Surgical	Guarded → good, depending on fracture type and age of the horse
Radius	Open	Surgical	Poor
Radius	Closed	Surgical	Fair to good for lighter horses, poor for heavier horses
Tibia	Physeal	Surgical	Good
Tibia	Diaphyseal	Surgical	Guarded → poor
Humorous	Complete	Medical	Poor
Femur	Physeal	Medical or surgical	Guarded → poor
Femur	Diaphyseal	Surgical	Guarded → poor

Resources

Orsini, J. A., & Divers, T. J. (2014). *Equine Emergencies: Treatment and Procedures*. St. Louis, MO: Elsevier/ Saunders.

Smith, J. J. (2006). Emergency Fracture Stabilization. *Clinical Techniques in Equine Practice*, *5*(2), 154–160. doi: 10.1053/j.ctep.2006.03.009

Palmer S.E. (2012). How to Stabilize Equine Fractures in the Field. AAEP Proceedings

Joint and tendon luxations

Joint luxations

Joint luxations usually occur when the limb is held in place (e.g. gopher hole) and the animal keeps moving. Collateral ligaments may rupture or be disrupted by avulsion injury. Diagnosis may be apparent via angulation of the limb or may require manipulation and radiographs, including stress views. Animals are usually acutely and severely lame. Casting (3 months duration with cast changes as needed) or internal fixation is used to stabilize the limb. Arthrodesis is often attempted as the amount of joint damage is usually extensive, resulting in severe arthritis.

Joint luxations are relatively rare in large animal species. The exception is hip luxation in cattle.

Coxofemoral luxations in cattle

Cattle develop coxofemoral (hip) luxations with falls, by being ridden by other cattle when in heat, and subsequent to neurogenic injury (obturator paralysis). The hip can luxate craniodorsally or caudoventrally. Animals with a craniodorsal luxation can often stand; those with a cranioventral luxation cannot. The luxation can be identified by asymmetry of the bony prominences or via rectal palpation (cranioventral luxation). With a dorsal luxation, the limb is shortened, the hock turned inward and the toe drags

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Cropped from https://www.youtube.com/watch?v=t-sR1bHhzKQ

Acute craniodorsal luxations are more successfully treated than more chronic or ventral luxations but only if there is no damage to the acetabulum. Traction is required. The cow is cast into recumbency with the affected limb uppermost. A rope is looped around the groin and secured to a fixed object (tree). Traction is applied to the limb to forcibly extend it, usually with a calf jack. Once the limb is extended, and the hock is rotated outward (upward) until the head of the femur slips back into the joint. If the joint is damaged, the hip will usually reluxate as soon as the traction is released.

Cranioventral luxations, luxations with trochanteric damage, or chronic luxations require arthrotomy and are very challenging to fix.

Tendon luxations

The most common tendon luxation in horses is luxation of the superficial digital flexor tendon. This occurs with damage to the retinaculum that holds the tendon to the calcaneus. As horses move, the SDF will visibly move as it runs over the hock. The luxation is usually on the lateral aspect and is associated with marked swelling over the point of the hock. The luxation may not be apparent in the standing animal. Horses are acutely and severely lame and may be very anxious when moving.

Treatment includes sedation and pain relief. If the tendon stays luxated, prolonged stall rest (4-6 months) is recommended. Limb movement may be minimized via a heavily padded bandage. A residual mechanical lameness (jerky motion) may remain after lameness improves. Horses may not be able to jump or race. Persistent medial luxations have a poorer prognosis for return to function.

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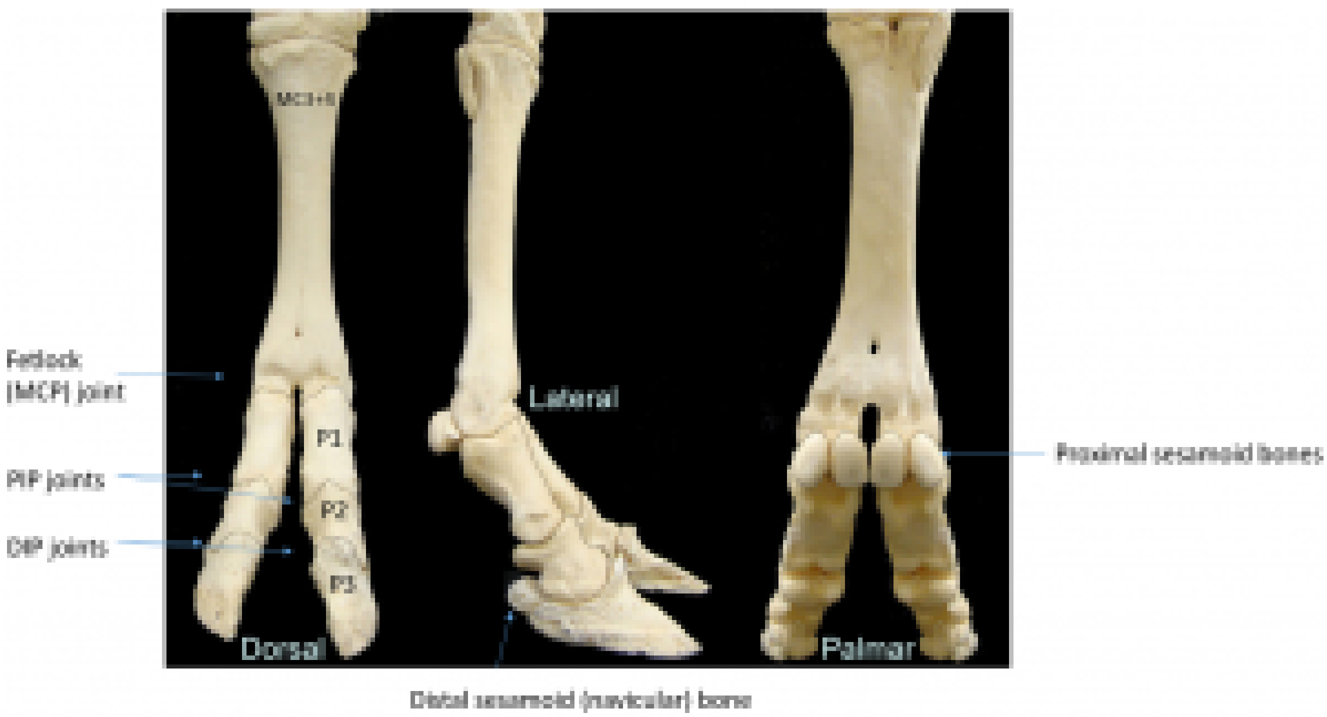
Bovine Lameness and Podiatry

Its the foot.

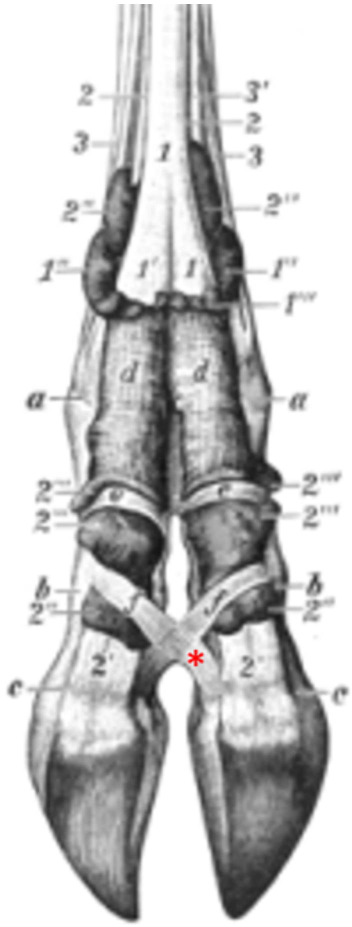
Bones and joints

While the cannon bone of a horse is MCIII or MTIII, in a cow it is a fused MCIII+IV or MTIII+IV. The fusion is present at the fetlock joint and above. Cattle do have the same bones and joints as horses below the fetlock but in duplicate form. There are four proximal sesamoid bones and two distal sesamoid bones on each limb. The fetlock joint is fused; the pastern and coffin joints are bilateral on each limb and separate.



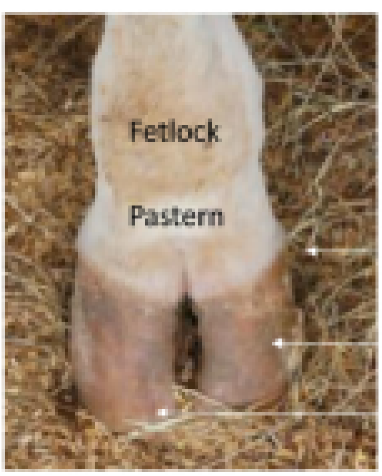
http://vanat.cvm.umn.edu/ungDissect/Lab03/Img3-7.html

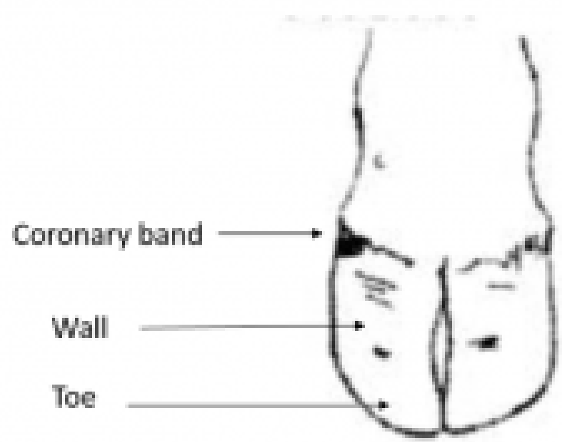
Interdigital ligaments keep the digits from splaying apart.

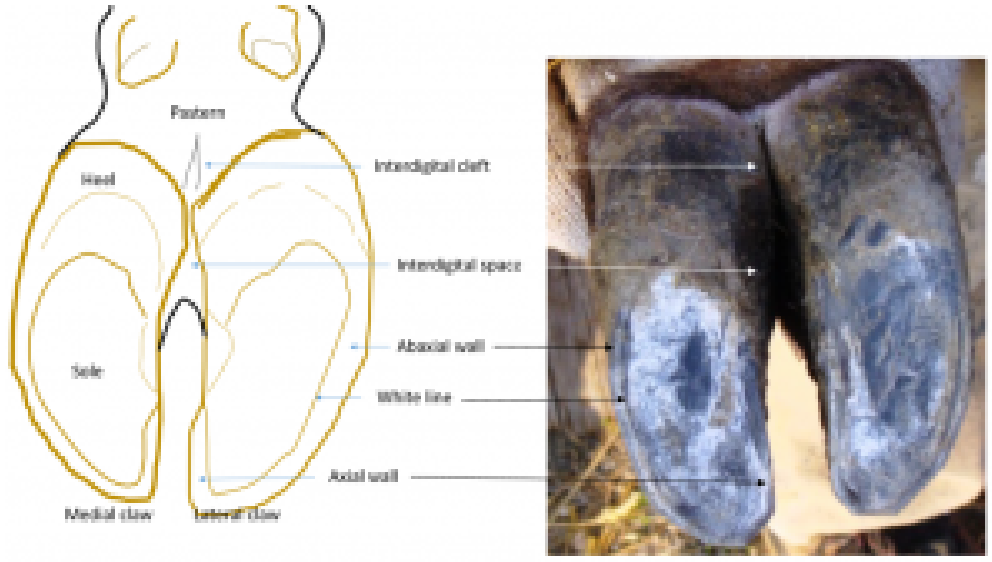


** denotes distal cruciate ligament*

Foot structure







Flexor tuberosity

The deep flexor tendon attaches on the bottom of P3 at the flexor tuberosity. The pressure of this tuberosity creates sole ulcers.

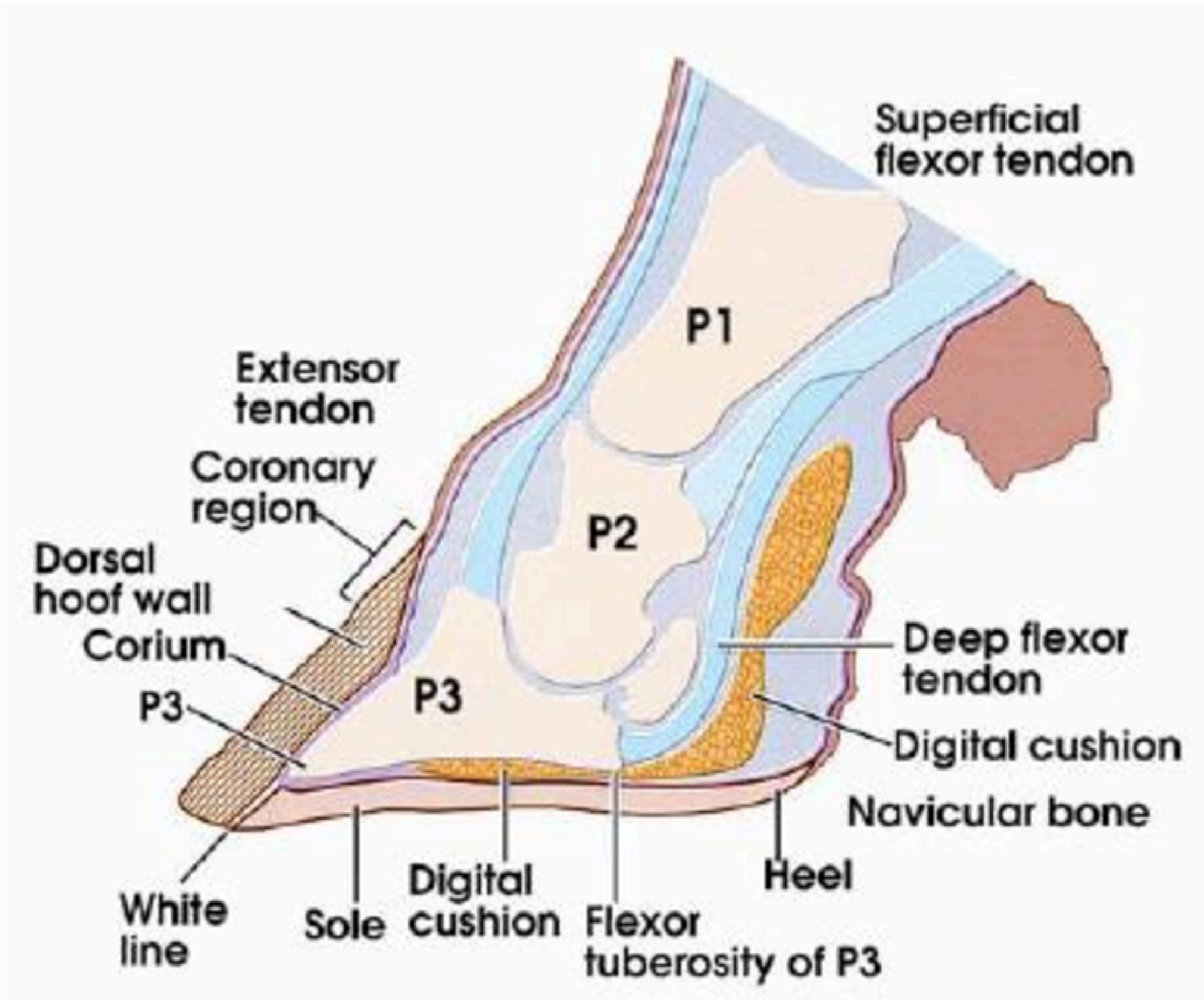


Figure 2: Anatomy of a cow claw (Gooch 2003)

The digital cushion is designed to dissipate the cows weight (and keep the flexor tuberosity padded). However, the digital cushion gets thinner as the cow goes through each lactation. A low BCS (body condition score) has also been associated with a thinner digital cushion.

Per Cramer, the bovine foot is suspended by ligaments, rather than by laminae. So cows do not get laminitis but stretching of ligaments. Otherwise it sounds very similar! Most texts will refer to "laminitis".

Deep digital flexor tendon and tendon sheath

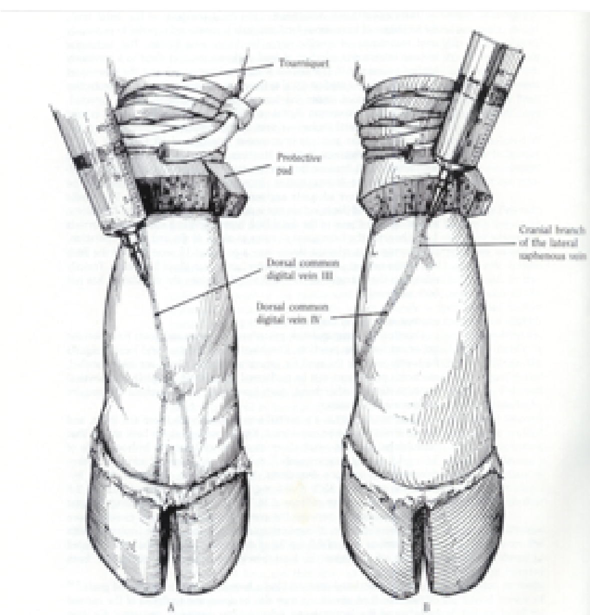
As in the horse, the deep digital flexor tendon is surrounded by a tendon sheath as it passes caudal to the fetlock joint and inserts on the third phalanx. A navicular bursa helps it glide over the navicular bone.

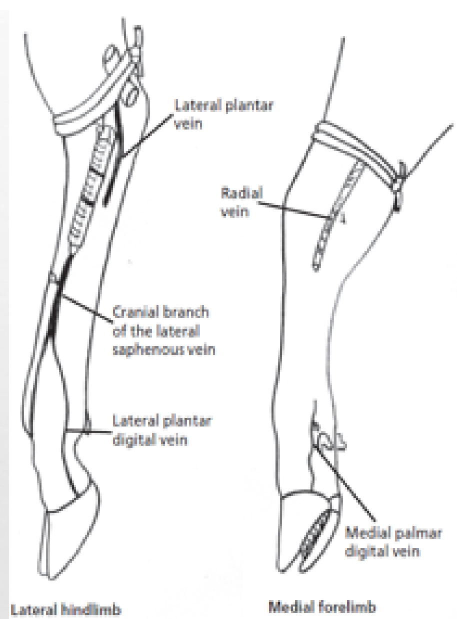
This close proximity to the foot predisposes the tendon and tendon sheath to ascending infections. The coffin joint is similarly predisposed. Infections in the interdigital space (foot rot) and in the digit (abscesses) will often migrate upwards.

Vessels

To numb the foot for diagnostics or treatment, we often perform IV regional anesthesia

It is important to know the location of the veins so you can perform regional anesthesia (these are really hard to see on a live animal with a swollen limb). The best ones are dorsal and just in front of the dewclaws.





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The vessel can also be stabbed by injecting perpendicular to the limb (parallel to the ground):

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=1869#oembed-2

Review of digital anatomy, infectious causes of lameness and regional intravenous perfusion in cattle. KM Simpson et al. AABP 2020

Bovine Lameness

Lameness is a significant cause of economic loss in cattle and is often a herd problem. Bovine lameness is heavily underdiagnosed. In the Midwest, the level of lameness in cattle is 13-16%. Herdsmen recognize less than 1/2 of the cases.

Indications of lameness

Indicators of lameness in cattle are similar to those in horses but are evaluated at a walk. One of the most common findings is an arched back. Head weaving, head nods, changes in length of stride, limb deviation (abduction, adduction), limb asymmetries, pressure sores and weight shifts can also be identified. Cattle should be watched from a distance and when rising from a recumbent position.

- Cattle normally rise to a standing position by getting to their knees, then lifting their hindquarters and finally rising on the forelimbs. Changes from this pattern typically indicate pain in the phase that is out of turn (eg trying to rise from knees to directly standing up on the forelimbs would indicate back or hindlimb issues).
- Head weaving (head moving side to side) is seen with milder lameness cases and is another way to shift weight
- Pressure sores are usually identified on the good side as the animal has a difficult time rising when the bad limb is uppermost.
- Hygromas are nonpainful swellings (false bursas) that arise to protect the underlying tissues that are being repeatedly traumatized. Hygromas are not a cause of lameness but can indicate chronic changes in weight bearing or environmental problems as they arise
- If the limb is being more weight, the fetlock will sink more. This is the good limb.
- The medial digit bears the majority of weight in the forelimb while the lateral digit bears the majority of weight in the hindlimb. Cattle will stand base wide or with crossed forelimbs to adjust weight away from an injured digit.
- Most lameness issues are in the hindlimb lateral claw; this is likely related to the limited ability to shift weight off that limb (hip joint structure)

Locomotion scoring of dairy cattle

Environmental Evaluation

It can be useful to think of lameness as a herd outbreak and evaluate the environment and other predisposing factors. Treating the individual animal is often still necessary but is generally the tip of the iceberg.

The major factors involved with lameness in cattle are flooring surfaces, management protocols and diet.

Regular hoof trimming programs help prevent hoof overgrowth and associated foot lesions. Regular trims also promote healthier hoof growth.

Low BCS (<2.5) is associated with more foot issues (sole ulcers, white line disease), more issues due to recumbency and likely less success in competing for food. If cattle are less able to get to the trough, this could create a vicious cycle in maintaining a low BCS.

Larger herds tend to be better managed but individual members less observed. While the overall health of the herd may be better, it can be easier for individual cow issues to be missed.

Wet environments, abrasive surfaces and skin irritation from chemicals or manure can predispose animals to opportunistic infections, particularly digital dermatitis and foot rot. Interdigital skin trauma from rocks, cables or sharp objects increases the likelihood of foot rot.

Cows with inadequate lying down time can overstress their feet, leading to sole ulcers. Cows need to have access to their bedding/pen area at least every 3-4 hours. Cooling mechanisms need to be implemented to ensure heat stress doesn't impact lying down time.

Slipping and sliding (from walking too fast) creates torque that can lead to white line damage. Cows should not have excessive walking time on concrete (particularly slippery concrete) and should not be rushed when walking.

Population demographics

Identifying the group(s) affected can also help direct management plans.

Cows in the first four months of lactation are at higher risk of lameness issues, likely related to the large swings in husbandry, nutrition and environment that occur with calving. Cows producing large quantities of milk also tend to lose body condition.

Higher parity (more pregnancies) cows tend to have more foot issues, likely due to the cumulative trauma of the artificial surfaces and metabolic swings over time. The foot is also affected by ligament laxity – the pedal bone is primarily supported by ligaments in cattle vs the laminae.

In feedlots, heifers and animals affected with bovine respiratory disease were more likely to have joint infections, while steers were more likely to be lame but without an identified cause.

Key Takeaways

An arched back is often seen with lameness in cattle.

Treat bovine lameness as a herd outbreak and look for management and environmental issues.

Minimize risks by keeping the environment clean and dry, removing sources of trauma and ensure cattle can move without being rushed or sliding around. Footbaths are useful to minimize bacterial infections (footrot, digital dermatitis).

Watch cattle BCS scores and lying down time. Identify groups with the most issues to best target management support.

Keep cows on a regular foot trimming schedule!

Resources

J Davis-Unger et al. Prevalence and lameness-associated risk factors in Alberta feedlot cattle. Transl. Anim. Sci. 2019.3:595–606

AW Oehm et al. A systematic review and meta-analyses of risk factors associated with lameness in dairy cows. BMC Veterinary Research (2019) 15:346

The Impact of Lameness on Welfare of the Dairy Cow, VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 153-164

MB Sadik et al. Prevalence of lameness, claw lesions, and associated risk factors in dairy farms in Selangor, Malaysia. Tropical animal health and production, 2017-12, Vol.49 (8), p.1741-1748

Cattle Lameness, 2019

Approach to the lame cow

The vast majority (85%) of bovine lameness originates in the foot. The lateral hind digit is the most common site.

There are typically three main options for a lame bovine:

- cull
    - used if the lameness is severe, the animal has other issues (poor body condition etc), the disorder has a poor prognosis or will be difficult to treat (eg joint infections)
- refer or treat with surgery
    - referral is rare as it is costly in both time and money and opens the herd to biosecurity issues
    - surgery options will depend on the comfort of the practitioner and the farm environment (management, housing etc)
- treat on farm
    - trimming
    - analgesics
    - supportive care
    - +/- antibiotics

This means the first step is to determine if treatment on the farm is a viable alternative. Many foot lesions can be managed on the farm; most conditions above the foot are more difficult to manage.

Foot issues that can require more intensive management or surgery include those with damage to the coffin bone and/or deep seated infections. Digit amputation, arthrotomies and/or arthrodesis can be successful in managing these but do take repeated intensive treatment.

Above the foot, arthritis can be treated with analgesics and supportive care. However, arthritis is rarely an identified concern except in breeding bulls. Most other conditions above the foot are difficult to manage, particularly in adult animals. These include damage to joints, infection in synovial structures, tendon/ligament injuries, nerve injuries and fractures.

Non-weight bearing lameness

Cattle are not built to maintain weight on three limbs; non-weight bearing lameness needs to be evaluated and treated aggressively or animals culled.

Differentials include

- White line infection
- Fracture
- Joint luxation
- Injury of a weight-bearing ligament or tendon (eg, gastrocnemius muscle)
- Nerve injury affecting weight-bearing (eg, radial nerve, femoral nerve, sciatic nerve)
- Septic arthritis or tenosynovitis

Of these, white line infections have the most favorable prognosis. The remaining conditions are challenging to treat and have a guarded prognosis. While very valuable animals (any condition) and neonates with certain fractures are treated, most cattle with bone/joint/nerve/tendon injuries are culled.

Determine if the pain is in the foot or above the foot.

Lameness localization

A physical examination is key to most lameness localization in cattle. The foot needs to be assessed closely for injury and lesions. Hoof testers can be applied. Changes in stance can give clues about what structures are painful (eg standing on toes if heels hurt). The front limbs may be crossed if the cow is attempting to avoid weight bearing on the medial digits. If the foot is normal, the remainder of the limb is assessed for swelling and/or pain.

Nerve blocks are not routinely performed. Intra-articular blocks can help with evaluating lameness above the foot. If needed, the foot can be numbed with a "ring block" (local anesthetic injected circumferentially around the limb). The ring block is typically performed midcannon bone as this is narrowest part of the limb. It is also possible to numb the lower limb with an IV regional anesthetic block (IVRA). A tourniquet is placed around the cannon bone and local anesthetic (usually lidocaine) is placed into a vein below the tourniquet. The lidocaine diffuses into the tissues and blocks sensation. The effect wears off as soon as the tourniquet is removed. Unfortunately, the tourniquet itself can cause pain so the interpretation can be tricky. IVRA is used primarily for treatments rather than diagnostics.

Radiographs and/or ultrasound are useful to further explore injuries and swellings.

Key Takeaways

85% of the time, the lameness is in the hoof. Over 70% of those are in the lateral digit of the hindlimb.

A midcannon ring block is typically used to numb the foot if no lesions are identified on gross examination.

If the lesion is above the foot, the prognosis is generally guarded.

Foot lesions can be challenging to treat but many respond to trimming and management changes.

Resources

The Impact of Lameness on Welfare of the Dairy Cow, VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 153-164

An Update on the Assessment and Management of Pain Associated with Lameness in Cattle VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 389-411

The Dairyland Initiative Lifestep Lameness Module

Bovine Living Quarters

Foot health is impacted by where the cows live (rest, eat, play, have babies, get milked) and how they move between these areas. This is particularly true for dairy cattle.

All animals need a comfortable space to rest. Between milkings, most dairy cattle should be found in the "resting area". They eat a bit, drink and then go lie down – lying down about 12 hours per day. The resting area is usually comprised of a canvas "mattress" stuffed with shredded tires. This gets covered with sawdust or similar material. This area gets cleaned during milking. Other cows may be bedded on sand (eg during the dry off period) or on dried manure packs.

Bedding comparisons

The goal for the resting area is comfort and cleanliness. Comfort means not only soft under the cow (remember dairy cows have minimal extra padding on bony protuberances) but also room to lie down and stand up without bumping into firm objects. Cleanliness is related to how long the resting area is as well as how often it is cleaned. Ideally, the resting area is long enough for the cow to have lunging space forward (needed to stand up) but is just the right length so the manure falls off the edge of the space and into the gutter. If a cow is short relative to the space, she poops in the bedding versus into the gutter. It is also important to have enough resting space for all the cows.

Freestall design

Resources

Small Scale Dairy Calf and Cattle Housing, UMass

The Relationship of Cow Comfort and Flooring to Lameness Disorders in Dairy Cattle; VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 227-233

An Update on the Assessment and Management of Pain Associated with Lameness in Cattle VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 389-411

Digital Dermatitis

G Cramer

What is it

An infectious and contagious bacterial infection of the skin, commonly seen in the interdigital cleft of the foot.

How to recognize it

Digital dermatitis presents in a variety of stages ranging from painful, bright red and ulcerated, or a less painful, grey/black, circular, granulomatous skin lesion. Edges can have a white margin and/or "hairs" protruding from them.

Lesions are clearly demarcated and are typically located in the interdigital cleft, but can occur on other locations such as the interdigital space or at the front of the foot.

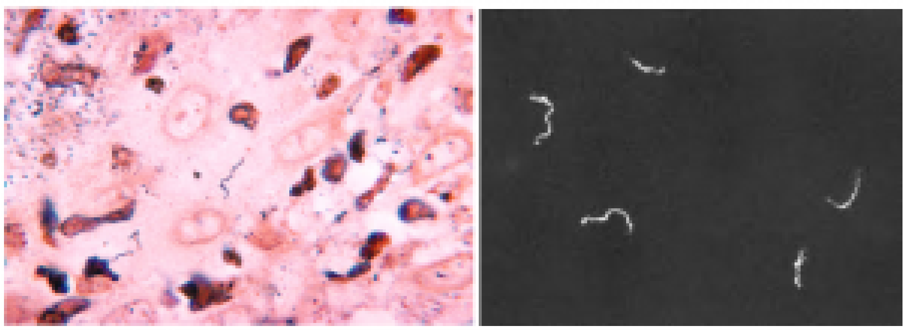
Severe lesions can become proliferative with filamentous projections or hyperkeratotic.

It is useful to classify lesions into “active” (painful and ulcerative lesions > 2 cm) and “chronic” (grey/black hyperkeratotic lesions without painful ulcerative lesions >2 cm)

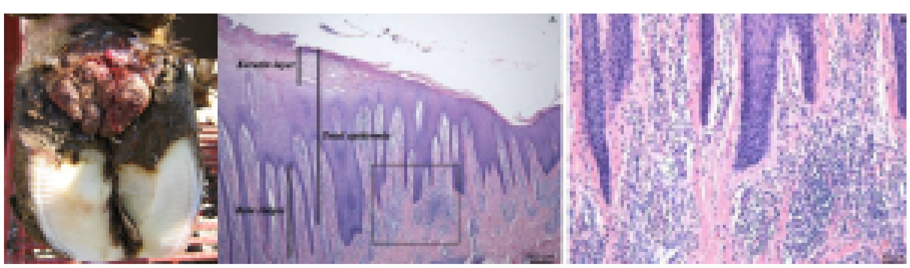
Pathogenesis

Mechanical irritation of the skin and maceration by water and chemicals from manure weakens the skin barrier.

A synergistic group of bacteria including Treponema spp then invade and infect the weakened skin barrier, leading to acute inflammation of the dermis and epidermis.



These bacteria are common in the environment and normally live in the rumen. There do appear to be some more virulent strains on some farms (or more susceptible cattle) as not all farms are infected with DD. Treponema species are gram negative spirochetes that are microaerophilic and can encyst for environmental survival. As the bacteria invade the epidermis and damage the different layers, the body responds with a local inflammatory process that can result in the hyperkeratosis and proliferative lesions.



How to prevent it

The main focus of prevention is hygiene. Providing a clean environment without wet or abrasive walking surfaces decreases the chances of bacteria invading a weakened skin barrier.

Footbaths are a preventative measure that should be used at whatever frequency is necessary to minimize the occurrence of active painful lesions. Footbaths need to be at least 10 feet (3m long) and are typically filled with disinfection solutions such as copper sulfate or formalin.

Other preventative measures include preventing infected animals from entering the herd and ensuring replacement animals are managed to prevent new infections.

How to treat it

Currently, no licensed products exist to treat DD. Treatment typically consists of applying topical tetracycline based antibiotics to active lesions using a wrap or a paste. Wraps are not necessary but if they are used they should be removed within 24 hours.

tetracycline applied, foot bandaged and then part of bandage cut away

Non-antibiotic compounds typically containing heavy metals such as copper are also often used in the field. The role of topical treatment is to treat active lesions and hasten its transition to a chronic lesion. Once the lesion is chronic, footbaths are used to prevent recurrence.

Systemic antibiotics do not penetrate into the lesion. Topical antibiotics seem to work quickly and effectively.

Key Takeaways

Digital dermatitis is due to Treponema infection of wet, traumatized feet. It leads to lameness and foot erosions or growths. Topical tetracycline is used to treat it.

Footbaths are useful to prevent bacterial infections – foot rot and digital dermatitis.

Resources

Clinical Perspectives of Digital Dermatitis in Dairy and Beef Cattle, VCNA 2017; Volume 33, Issue 2, July 2017, Pages 329-350

An Update on the Assessment and Management of Pain Associated with Lameness in Cattle VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 389-411

The Dairyland Initiative -good pics!

Foot Rot

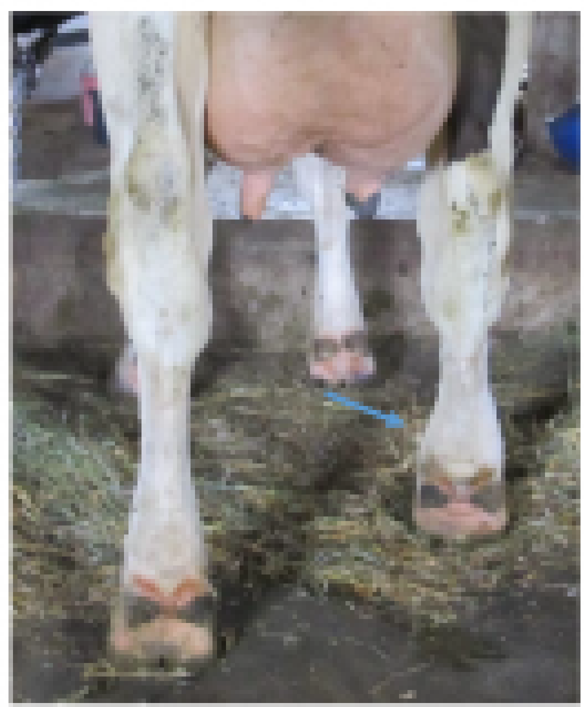
G Cramer

What is it

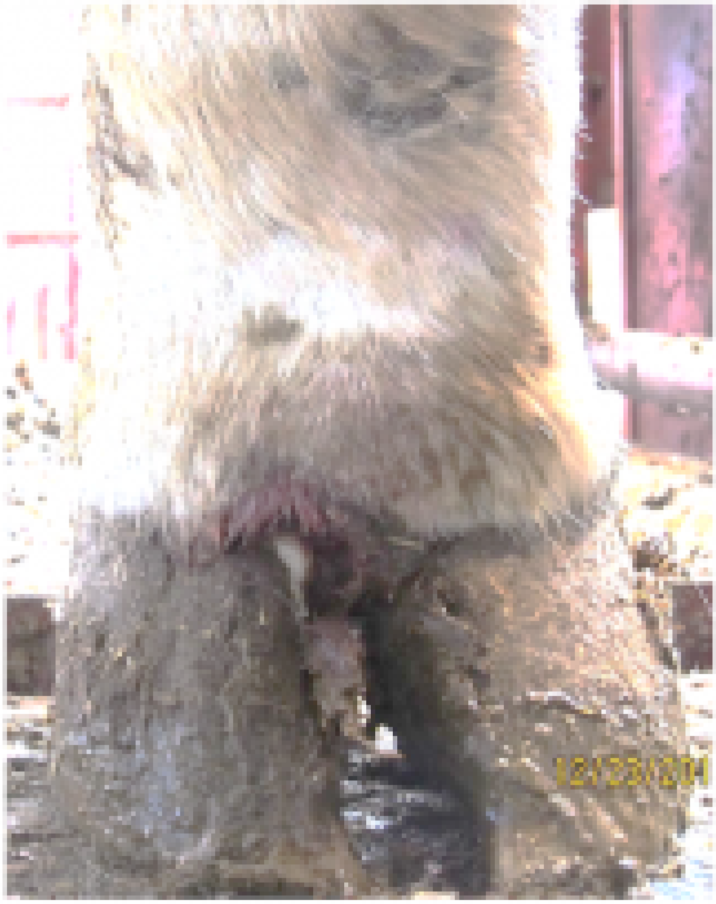
Foot rot is usually a sporadic infection of the soft tissues of the foot in dairy and beef cattle. Foot rot lameness can range from mild to severe and usually has a sudden onset.

How to recognize it

Foot rot is recognized by the sudden onset of lameness accompanied by the symmetrical swelling of the lower leg above the digit. Swelling above the coronary band that affects both digits and includes the interdigital space is almost pathognomonic for foot rot. [Hoof horn issues will typically only affect one digit and the swelling will be asymmetrical.]

Depending on the stage of the disease the interdigital skin splits open and putrid, foul-smelling discharge is noticeable.



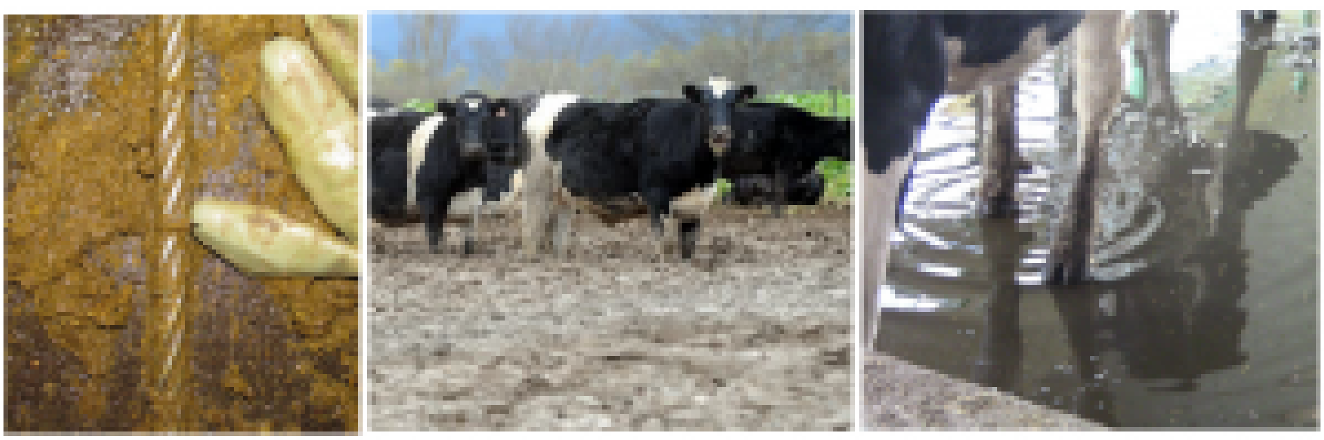
In more severe cases, loose pieces of necrotic tissue can be easily removed from the interdigital space.

Pathogenesis

The most common bacteria associated with foot rot are *Fusobacterium necrophorum* subspecies necrophorum, *Dichelobacter nodosus*, *Trueperella pyogenes*, *Porphyromonas levii* and *Prevotella intermedia*. The bacteria are all gram negative anaerobes that are present in the GI system of cattle and thus their environment. A defect in the interdigital skin to allow opportunistic invasion by these bacteria. The bacteria then work in synergistically to cause inflammation and necrosis of the soft tissues in the lower leg. In severe cases the infection can spread to tendons/flexor tendon sheath and/or the distal joints resulting in a very severe lameness.

How to prevent it

The key focus for preventing foot rot is on preventing skin damage. Skin damage typically occurs due to things such as rocks, sharp edges, and cables in the in animals environment. Skin damage can also occur due chronic wetting of the foot in muddy or wet and dirty environments.



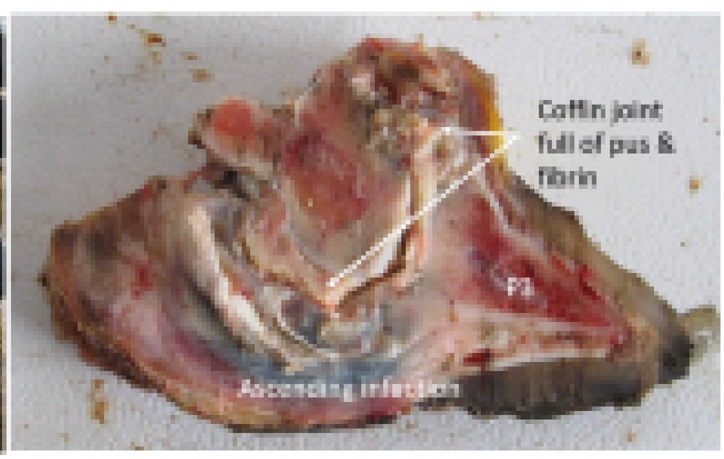
On dairy farms, footbaths with a range of disinfectants are used to clean and disinfect the interdigital skin.

Currently, there are no pharmaceutical products labelled with a claim to prevent foot rot.

How to treat it

Foot rot should be treated with systemic antibiotics according to label directions. This is the only foot condition that is typically treated with systemic antibiotics! There are several drugs specifically labeled for foot rot. These include LA 200®(oxytetracycline), Naxcel® (ceftiofur), Excenel®RTU (ceftiofur), and Draxxin® (tulathromycin).

There is typically no need to remove necrotic tissue or apply bandages. Treated animals should visually improve with 2-3 days. If animals do not respond the diagnosis should be re-evaluated. Animals with ascending infection will not respond well to standard antibiotic therapy and will require drainage of infected joints or tendon sheaths (or should be culled).



Key Takeaways

If the swelling above the foot is symmetrical, think foot rot! If it just above one digit, think hoof horn issues.

Foot rot causes lower limb swelling, smelly feet and lameness. It occurs due to opportunistic infection of wet traumatized feet by gram negative anaerobes. Systemic antibiotics are used for treatment. Ascending infection can develop and lead to coffin joint or flexor tendon sheath infections.

Footbaths are useful to prevent bacterial infections – foot rot and digital dermatitis.

Foot rot is treated with systemic antibiotics.

Resources

Footbath design

Pathogenesis and Treatment of Bovine Foot Rot VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 183-194

A Review of the Design and Management of Footbaths for Dairy Cattle; VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 195-225

An Update on the Assessment and Management of Pain Associated with Lameness in Cattle VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 389-411

Foot rot slide share – great hints on detecting swelling

Sole ulcers

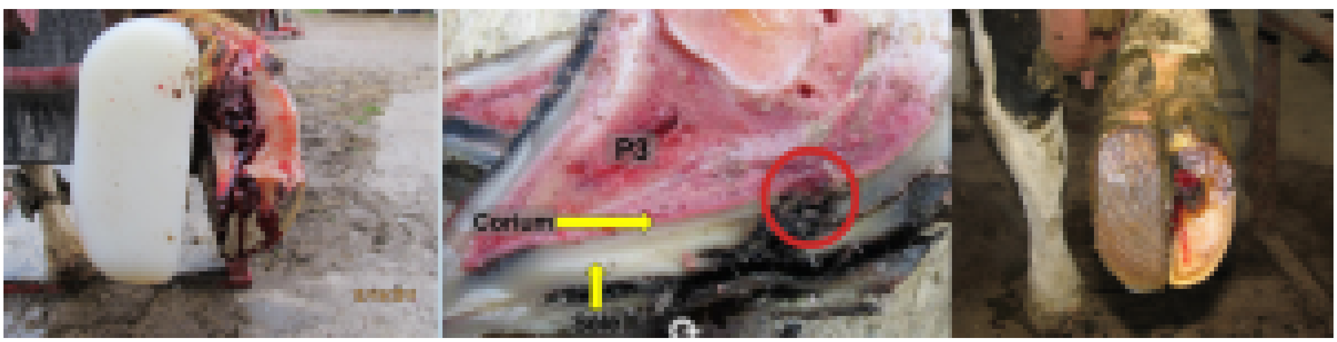
G Cramer

What is it?

Sole ulceration is one of the 3 most common causes of lameness affecting beef and dairy cattle. Sole ulcers occur beneath the flexor tuberosity of P3 (third phalanx). These occur most commonly in the outside digit in rear legs and are associated with varying degrees of changes in weight bearing.

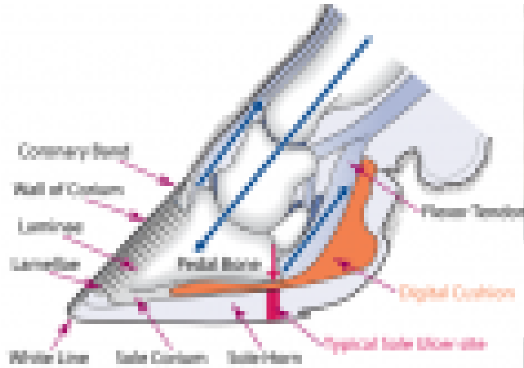
How to recognize it?

Sole ulcers are recognized by the presence of severe hemorrhage or protrusion of the corium at the typical sole ulcer site. Hemorrhage or bruising may be evident. Hoof tester pressure in the area will result in a withdrawal response due to pain.



Pathogenesis

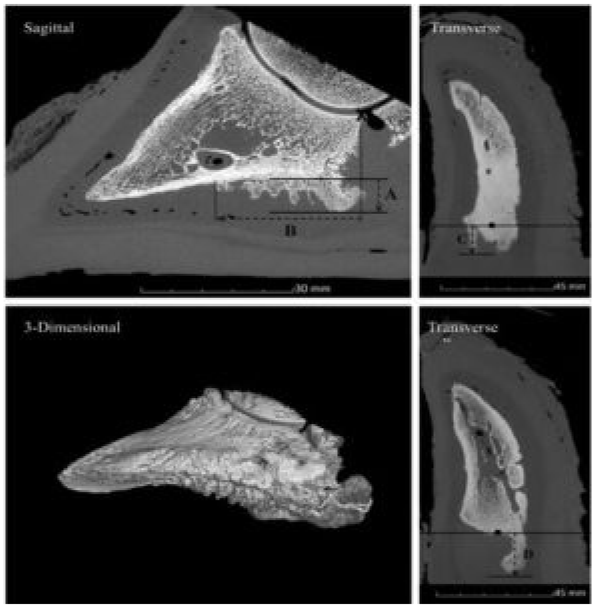
Sole ulcers are due to continuous pressure by the flexor tuberosity of P3 on the corium. This pressure is caused by mechanical or metabolic alterations in the supporting structures of the hoof (P3 is allowed to drop).



This pressure initially leads to the corium leaking blood into keratinocytes at the dermal-epidermal interface. Over time this pressure from P3 leads to the destruction of keratinocytes and the interruption of horn growth resulting in the corium protruding through the horn defect.

Corium separated from hoof wall

The resultant inflammation also results in long term structural changes to P3 and the corium.



How do you prevent a sole ulcer?

The prevention of sole ulcers consists of ensuring adequate lying time, minimizing negative energy balance (making sure they have adequate body condition) and following an appropriate hoof trimming schedule.

To ensure a lying time of 12-14 hours, cows should not be away from their pen for more than 3-4 hours. In addition, forced lying time should be kept to a minimum and effective cooling strategies to reduce the impact of heat stress on standing time should be implemented.

Finally the strategic use of an appropriately timed and correctly performed hoof trimming should be a key component of a prevention program.

How do you treat a sole ulcer?

Sole ulceration results in chronic changes and is a painful condition. Appropriate early treatment is critical to successful resolution of symptoms and to minimize the impact of long term changes. NSAIDs or other analgesics are indicated.

The treatment of sole ulcers involves the removal of all loose horn around the corium. This removal should occur delicately with great care taken to minimize further damage to the corium.

Once loose horn has been removed around the lesion pressure on the lesion should be reduced to maximize the speed of horn growth. The reduction of pressure on the lesion is is achieved by the removal of horn around the periphery of the lesion and by application of a properly sized hoof block to transfer weight to the sound digit.

Cows with sole ulcers should be rechecked in 3-6 weeks to assess healing, and to either remove or reposition the block if necessary.

Key Takeaways

Sole ulcers develop as the flexor tuberosity of P3 pushes on the sole from inside the foot. This occurs due to loss the supporting structures in the foot. Treatment includes removing loose horn and placing a block on the opposite digit.

Prevention is key. Cows should have comfortable areas in which to lie down, be on a regular trimming schedule, and be on a good nutritional plane.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=5041#oembed-1

Resources

Pathogenesis and Treatment of Sole Ulcers and White Line Disease; VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 283-300

Traumatic Lesions of the Sole; VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 271-281

An Update on the Assessment and Management of Pain Associated with Lameness in Cattle VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 389-411

The DairyLand Initiative -good pictures

White line disease

G Cramer

What is it?

White Line disease encompasses a range of lesions that typically occur in the abaxial white line region towards the heel or outside digit of the rear foot. On most dairy farms it is one of the three most common causes of lesions and lameness.

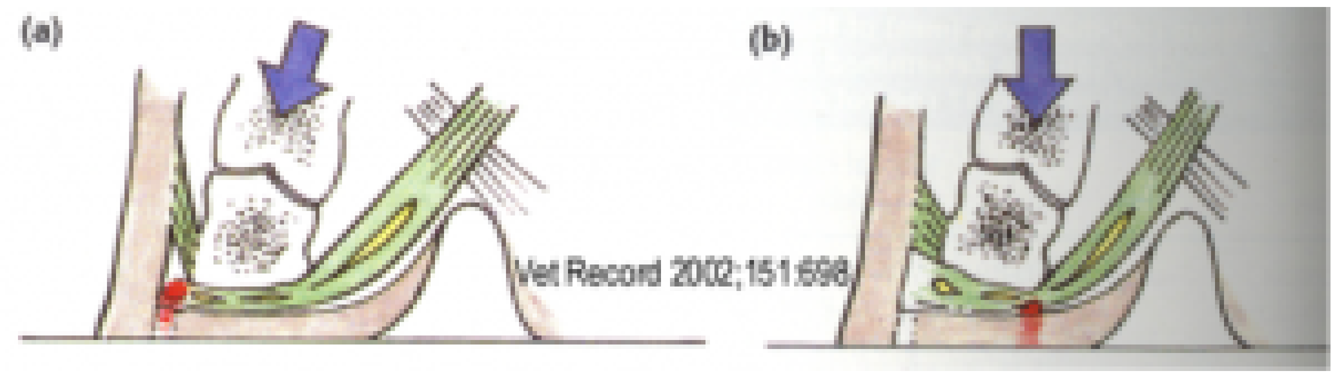
How to recognize it?

White line lesions range from hemorrhages to separations and abscesses. Lame cows typically present with areas of white line separation that are painful when tested with hoof testers or areas of more extensive hoof wall separation that can extend up to the coronary band.

Pathogenesis

The exact nature of the cause of white line lesions is unclear. What is known is that the white line is a made up 3 different types of horn and white line horn is weaker than the wall or sole horn.

The current theory is that white line disease occurs in a similar fashion to sole ulcers: P3's suspensory mechanism is compromised and this results in damage to the keratinocytes that grow white line horn. The presence of both shearing forces and weaker horn at the white line allows the formation of fissures.



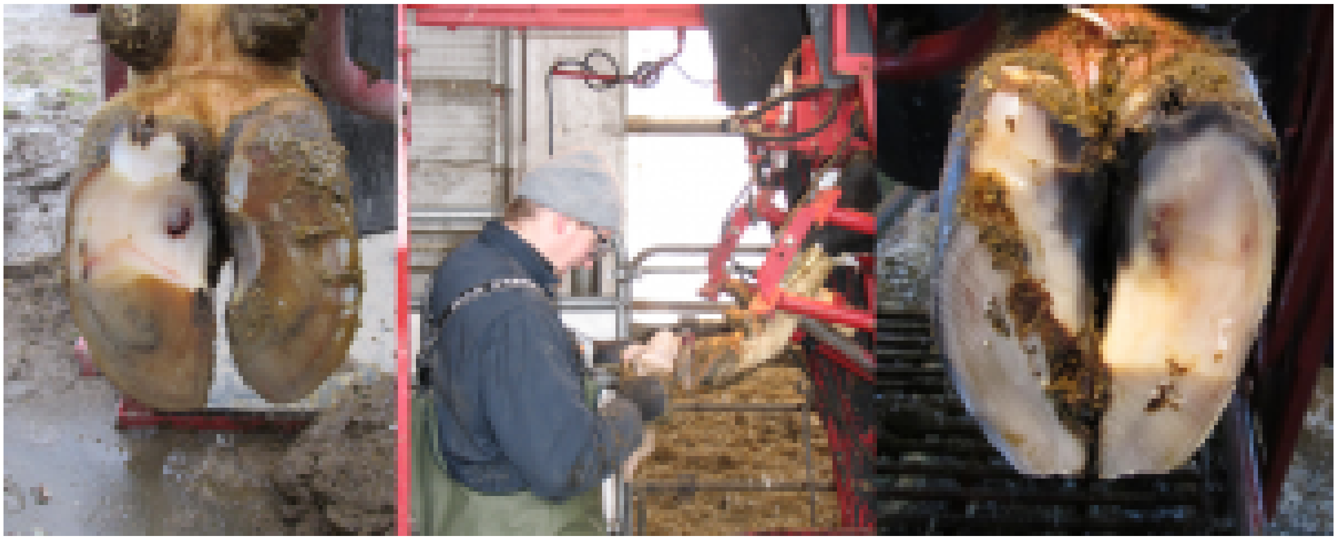
These fissures can allow the entry of bacteria and foreign bodies resulting in damage to the corium and inflammatory changes to P3.

How do you prevent white line disease?

Prevention of white line lesions starts with avoiding excessive trauma to the white line region by ensuring both cow walking surfaces and cattle handling allows the cow to walk at their own pace and not slip.

Supplemental minerals (Cu/Zn) and biotin can be added to the diet to increase horn strength.

Finally the strategic use of an appropriately timed and correctly performed hoof trimming is a key component of any prevention program.



How do you treat a white line lesion?

White line disease can appear as an acute and painful condition. However, there are gradients of white line lesions and appropriate early treatment is critical to successful resolution. Due to the pain, NSAIDs or other analgesics are indicated.

The treatment of painful white line lesions involves the removal of all loose horn around the lesion including the wall. This removal should occur delicately, with great care taken to minimize further damage to the corium.

Once loose horn has been removed around the lesion, pressure on the lesion should be reduced to maximize the speed of horn growth. The reduction of pressure on the lesion is achieved by the removal of horn around the lesion and by application of a properly sized hoof block to transfer weight to the sound digit.

Cows with white line disease should be rechecked in 3-6 weeks to assess healing, and to either remove or reposition the block if necessary.

Further damage should be prevented by minimizing the risk of moving too fast or slipping while walking (torque is bad). Minimizing walking minimizes risks.

Key Takeaways

White line disease is compromise of the laminar junction. Bacteria and debris can enter the space, causing further damage. White line disease is associated with cattle moving too fast or slipping while walking. Treatment involves opening up the infected area and removing loose horn. A block is placed on the opposite digit to permit the area to heal.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=5030#oembed-1

Resources

Pathogenesis and Treatment of Sole Ulcers and White Line Disease; VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 283-300

An Update on the Assessment and Management of Pain Associated with Lameness in Cattle VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 389-411

Interdigital fibromas

What is it?

Interdigital fibromas (corns) are growths (proliferative skin) in the interdigital space. The growths may be associated with foot rot.

How to recognize it?

Hairless mass between the digits, located at the dorsal aspect of the interdigital space and extending from the coronary band. It may become ulcerated and foul smelling. Debris can be trapped between the mass and the digits. Cattle may be lame.

Pathogenesis

The growths develop due to overspreading of the digits, likely due to undeveloped ligamentous support. Herefords and Friesians are predisposed and bulls more commonly affected than cows. Hindlimbs are affected most often.

Spirochetes have been found in the proliferative tissue.

How do you treat an interdigital fibroma?

The mass is removed. Cautery, cryosurgery and en bloc resection are all options. IVRA or perilesional anesthesia is performed. With en bloc, resection, hyperplastic tissues and the interdigital fat are removed using a wedge shaped incision. The foot is bandaged and the toes wired together. Antibiotics are given if infection is present.

Recurrence is possible.

Key Takeaways

Interdigital fibromas are hairless masses between the digits. These are most commonly found in the hindlimbs of bulls and develop due to excess spread of the digits. Treatment involves removal of the mass but the predisposing factors make recurrence possible.

Hoof cracks

What is it?

Vertical or horizontal defects in the hoof wall that destabilize the hoof.

How to recognize it?

Cattle may be lame, particularly with vertical cracks. Horizontal cracks do not cause lameness until a portion of the crack reaches the ground surface. Weight bearing causes it to chip off or peel away. This causes soreness when weight is put on the foot, levering the cracked wall into the sensitive laminae.

https://hereford.org/static/files/0815_HoofHealth.pdf

Pathogenesis

Vertical cracks may develop due to drying of the hoof wall, probably combined with more pounds/square inch (heavier cattle). Both genetic and environmental factors are likely involved.

Horizontal cracks develop due to disturbances in hoof wall growth (metabolic issues, fever).

How do you treat a hoof crack?

Many can be ignored if not causing issues.

Vertical cracks are debrided with a hoof knife or motorized burr. The hoof wall is stabilized with wire, umbilical tape or polymethylmethacrylate, depending upon the level of infection. A hoof block may be applied to the good hoof to permit healing

Horizontal cracks are treated by removing the cracked wall once it is causing lameness and is mostly grown out.

Corkscrew claws

What is it?

Corkscrew (screw toe, screw claw, curly toe) claw is a conformational abnormality that leads to weight being born on the side of the wall versus the sole, causing lameness.

https://nwdistrict.ifas.ufl.edu/phag/2016/05/27/watch-for-a-lameness-issue-in-cattle-called-corkscrew-claw/

How to recognize it?

Corkscrew claw is primarily seen in the hindfeet of cattle 3.5 years of age or older. In younger animals, look for toes pointing inwards instead of forwards.

Pathogenesis

It is regarded as a heritable trait in beef animals. Affected animals should not be used for breeding but since it may not show up in younger animals, it may be missed initially.

Treatment

Animals should be culled.

Resources

Diagnosis, treating hoof cracks in cattle, BEEF

Risk (Predisposing) Factors for Non-Infectious Claw Disorders in Dairy Cows Under Varying Zero-Grazing Systems, In Tech – Great pictures of hoof disorders, 2012

Brahman structure and lameness, ABBA, 2011

Corkscrew Claw, VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 351-364

What is it?

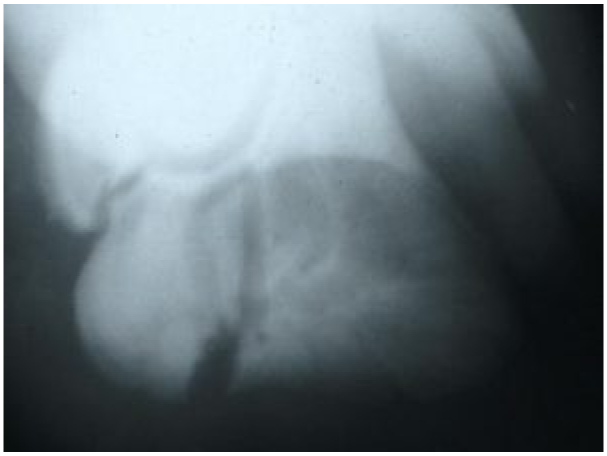
Pedal bone fractures occur due to trauma and can be associated with breaks in the hoof capsule.

How to recognize it?

Most hoof cracks are not painful. Evaluate the digit for pedal bone fracture if the animal has severe foot pain but no evidence of white line disease, foot abscess or other significant lesion.

Crossed forelimbs due to bilateral P3 fractures

Radiographs are required for definitive diagnosis.



Pathogenesis

Fracture may occur due to trauma from the foot being trapped in slatted flooring, side rails or boards. Alternatively, P3 may be damaged due to infection and fractures may be pathological.

Treatment

The hoof wall will stabilize the fracture if motion is prevented. Elevate the injured digit by placing a block on the opposite digit. The digits can be wired together to minimize motion. If infection is present, debridement and drainage is necessary.

Healing will typically be by fibrous union.

Resources

An Update on the Assessment and Management of Pain Associated with Lameness in Cattle VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 389-411

Pathogenesis and Treatment of Toe Lesions in Cattle Including "Nonhealing" Toe Lesions VCNA FA 2017 Volume 33, Issue 2, July 2017, Pages 301-328

What is it?

Several structures in the digit can become infected, typically due to ascending infections from foot rot or foot abscesses that develop from sole ulcers or white line disease. Interdigital trauma can also be a source of infection. The pedal bone (P3), the navicular bone, the coffin joint and the flexor tendon can be impacted, often in various combinations.

How to recognize it?

Affected cattle are usually non-weight bearing lame and the lower limb and coronary band are often swollen.

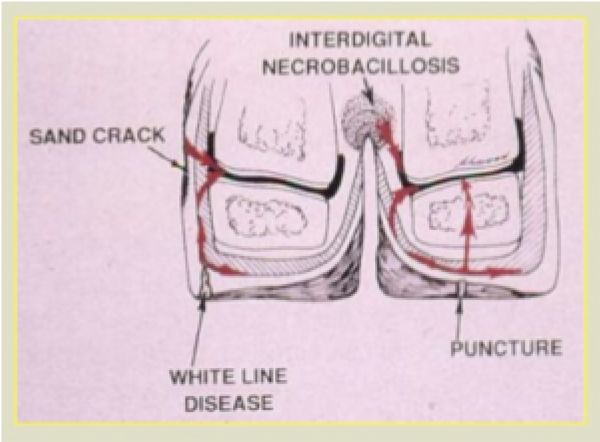
Fistulous draining tracts may be evident above the digit.

The foot is often sensitive on hoof tester examination and other pathology typically visible on foot examination. The lameness improves with IVRA (regional anesthesia).

Pathogenesis

Bacteria involved are typically those in the environment and related to fecal and skin flora. Mixed populations are common and include E coli, Actinomyces pyogenes, Staphylococcus and Fusobacterium. Infection ascends due to the hard sole and limited drainage.

Bacterial infections elsewhere in the foot lead to infection of deeper structures



From Van Metre, Foot Rot and Digital Dermatitis https://www.slideshare.net/DAIReXNET/foot-rot-and-digital-dermatitis

Diagnostics

Confirmation of joint sepsis is obtained by passing a probe into the joint through a fistulous tract or through sampling of joint fluid (infected if >40K cells/ul). Cow pus is thick; a 14ga needle may be necessary to obtain a sample. Radiographs are useful to identify bony changes. Bone lysis can be seen with bone infection and periosteal reaction with infection near the surface. Changes develop faster in cattle than in horses but still take 4-14 days to be visible radiographically.

Periosteal reaction due to local infection

Cow pus is also so thick that it will physically push the bones apart, widening the joint space. Gas may also be present radiographically

Pedal osteitis is infection of P3 and develops due to similar ascending infection. The local inflammation lead to significant lysis of P3.

The navicular bone can be similarly affected.

Treatment

Joint lavage via needles or arthrotomy (preferred) is used for acute cases of synovial infection. Cattle rapidly develop fibrin within the joint, making needle lavage of limited use. Systemic antibiotics are indicated.

With chronic infection in the distal limb (pastern or coffin joint), lavage and antibiotics are minimally effective. Treatment options are amputation of the digit or arthrodesing the joint (facilitated ankylosis). Amputation works best in unilateral lesions in smaller stature animals that are not housed on slatted floors. Amputation is the fastest means of removing pain and infection. Survival is limited. On average, the animal will last ~ 18 months in the herd before they are culled for related issues. Arthrodesis is generally needed for bulls, heavy animals, uneven flooring, and valuable animals. Referral or consultation is recommended if arthrodesis is desired.

Bone infections are treated by debridement and/or digit amputation.

Key Takeaways

A nonweightbearing bovine may have deep digital infection – in the joint, bone or tendon sheath.

- Antibiotics and/or joint lavage are rarely successful in treating these conditions
- Digit amputation is a means of rapid removal of the problem but does limit lifespan of the animal due to breakdown of the opposite digit
- Ankylosis involves debridement and fusion of the infected joint and can lead to a full lifespan in larger or valuable animals; it does take more time to resolve the pain.

Resources

Surgical Procedures of the Distal Limb for Treatment of Sepsis in Cattle; VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 329-350

An Update on the Assessment and Management of Pain Associated with Lameness in Cattle VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 389-411

Functional hoof trimming

G Cramer

A functional hoof trim is used to prevent and treat lameness in cattle.

Dairy cattle feet should typically be trimmed twice yearly. [See more](#)

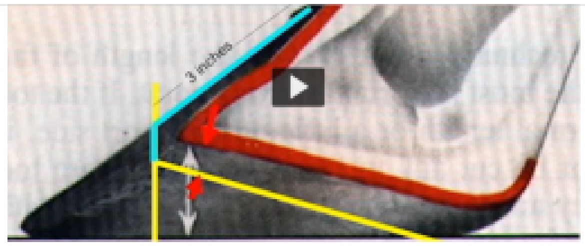
Steps of a functional hoof trim

1. Trim the medial hoof
2. Trim the lateral hoof
    - balance heels
3. Modeling
4. Treat lesions
5. Remove loose horn

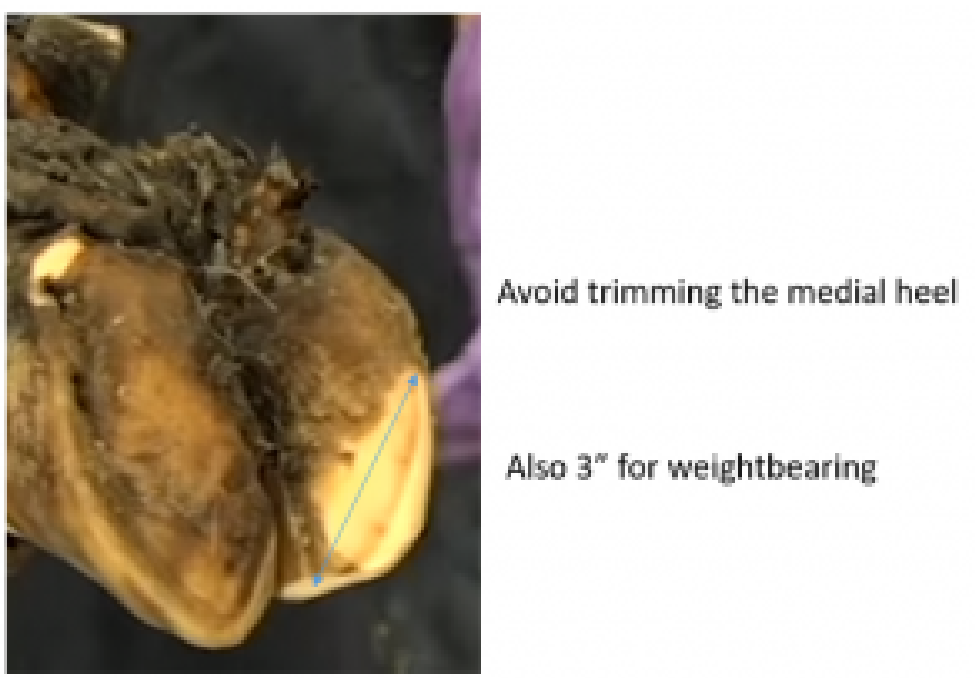
One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=5004#oembed-1

Key points

The hoof should be 3″ long in most cattle. Measure from the coronary band and trim off the excess using nippers or other tools to create a cut perpendicular to the weight bearing surface. Trim bottom of foot to 1/4″ thickness, focusing on trimming the wall in the toe region.



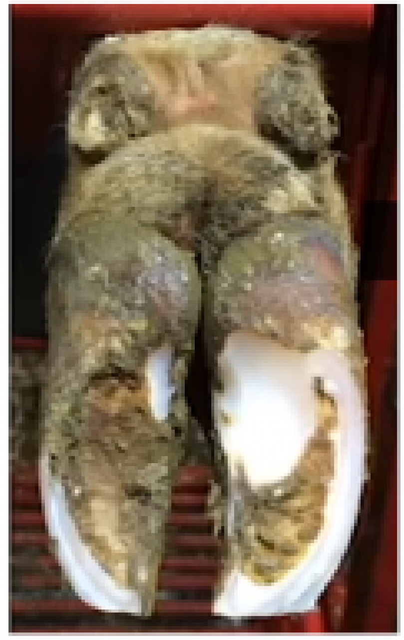
Ensure 3″ of weight bearing surface. Avoid trimming the medial heel and keep the bottom of the foot flat.



Repeat on the other side. Also trim the heel to ensure the heels are evenly weight bearing or the medial claw is slightly longer and actually bears more weight.

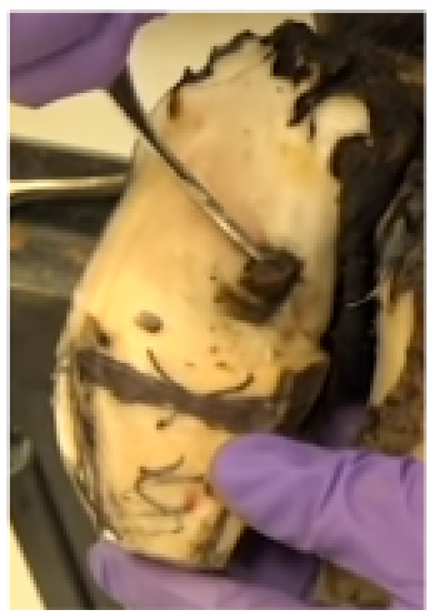
Model the toe to remove weight from under the flexor tuberosity in order to prevent sole ulcers.

Remove horn over the flexor tuberosity aggressively from the lateral claw and slightly from the medial claw to create a space between them. Avoid the toe triangles



Stop here in a healthy foot.

To treat this sole ulcer, the foot is trimmed so the area around the sole ulcer isn't weight bearing. The horn can be removed in the heel region until the area is indentable with finger pressure. Then the loose horn around the ulcer is carefully removed so it doesn't trap manure or bacteria.



Remove the loose heel horn to minimize the crevices and the anaerobic environment that would make it a good environment for digital dermatitis. Keep the medial heel as long as possible if you are trying to protect the lateral claw. Keep it weight bearing.

For damaged feet

- remove loose and undermined hoof horn
    - pare away to create smooth surfaces that won't trap debris
    - remove all unhealthy horn but stop if you get bleeding
- adjust weight bearing on damaged digits
    - pare the damaged digit lower to minimize weight bearing on it

Key Takeaways

A functional hoof trim is designed to create a better walking surface by encouraging weight bearing on the toe and wall region, balancing the heels, and protecting the flexor tuberosity area.

Overall goals for treatment:

- Remove loose and undermined claw horn
- Adjust weight bearing on damaged claws

Functional hoof trims help prevent sole ulcers and white line disease.

Most dairy cattle should be trimmed twice yearly or prior to drying off and if signs of lameness

Resources

A Review of the Relationship Between Hoof Trimming and Dairy Cattle Welfare, VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 365-375

How to - Apply hoof block

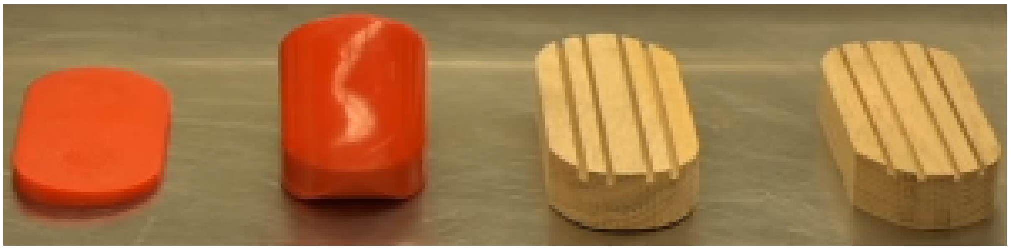
Goal- Use the block to lift the affected foot off the ground so that the lame digit is not weight bearing and can heal. [This is not necessary if the sore digit can be kept off the ground with trimming.]

Step 1. Properly trim the healthy hoof

- The block should be perpendicular to the long axis of the leg; this means the heels have to be balanced.

Step 2. Pick the right sized block

- Plastic blocks are useful in high wear environments (eg sand). Generally thicker blocks are used.



Step 3. Roughen the foot

- Use a grinder to lightly remove the horn and debris.

Step 4. Dry hoof and block

- The foot needs to be clean and dry. Dry the hoof and block with a heat gun.

Step 5. Apply glue to block

- Two part component clue
- Apply 1/8″ glue to weight bearing areas: to the toe triangle and along the wall; avoid the flexor tuberosity area

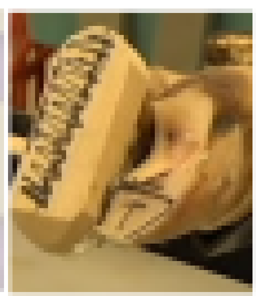
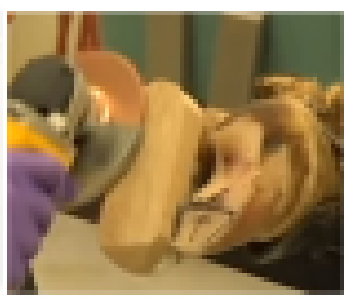
Step 6. Lightly press block on hoof

- Too much pressure will squeeze the glue out.
- Smooth the glue around the edges with a tongue depressor
- Ensure the block extends over the heel area; if excessive it can be trimmed back

Step 7. Check positioning and fix if needed

- Walking can be improved by using a grinder to create an angle to the block (roll over)

- Ensure the other digit is protected from weight bearing and that the entire block will be weight bearing. Adjust if needed.


Step 8. Reassess in 4 -6 weeks

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How to - Digit amputation

Indications

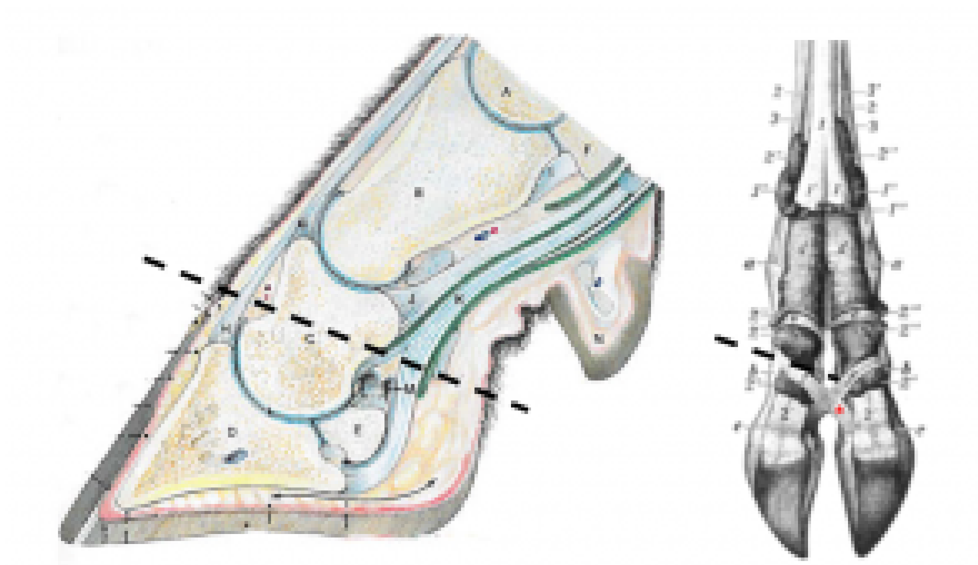
Bovine digit amputation is recommended when the digit is painful and unlikely to improve, deep digital structures are infected, or when drainage is needed for the flexor tendon sheath.

The lateral digit on the hindlimb and the medial digit on the forelimb are the main weight bearing structures. Removal of either will significantly impact the lifespan of the animal in the herd. Breeding bulls also need full function of all hind digits. Arthrodesis should be considered instead of amputation in these instances.

There are two basic types of digit amputation. This is one version and enables rapid coverage of the exposed surfaces with granulation tissue.

Relevant anatomy

The amputation should be performed as distally as possible to main the supporting structures of the limb. Whenever possible, the amputation is performed through P2 or the limb disarticulated through the pastern joint.



This level of amputation removes any infection in the coffin joint and navicular bursa. It also opens the flexor tendon sheath for drainage

Preoperative management

Food restrictions:

The procedure is usually short enough that food restriction is not required. If more surgery time is anticipated, food should be withheld for 48 hours whenever possible.

NSAIDs/analgesics: Preoperative and postoperative analgesics are recommended.

Antibiotics: Not usually required.

Local blocks: IVRA (iv regional anesthesia) or ring block

Position/preparation: The cow is **cast** into lateral recumbency (with the affected digit accessible) using sedation and casting ropes.

Surgery Supplies:

- Gigli wire and handles
- Wire cutters
- Scalpel blade (no handle)
- Mosquito hemostats
- Bandage material

Surgical procedure

- Using the scalpel blade, make a sharp incision to the bone on the axial aspect of the digit. The incision is made above the coronary band. Keep the incision as distal as possible while still ensuring the infected or traumatized tissues will be removed
- Seat the gigli wire in the incision and use the handles to saw through the bone
    - Saw at an angle so the surface of the bone is angled with the higher side more abaxial. This will minimize the risk of the cow getting her digit stuck someplace
    - The scalpel may be needed to finish cutting though the skin on the abaxial aspect.

- If cartilage is exposed, it should be debrided to permit granulation tissue coverage.
- Remove any small fragments of bone.
- Use the mosquito hemostats to clamp, twist and pull (Cornell cautery) any bleeders.
- Bandage the foot, being careful to not add so much bandage that the cow is walking on the bandage.

Postoperative care

- The bandage is typically left in place for 5 days (until granulation tissue can cover the exposed bone).
- Change the bandage if it becomes soaked through with blood or if it becomes wet or soiled.
- Remove the bandage if still in place 10 days postoperatively.

Complications

- Exposed cartilage may prolong healing time (but it is a cow, so not by much)
- Cattle may have difficulty on slatted floors or with prolonged standing.
- Breakdown of the opposite digit is expected. Cow life expectancy in the herd is <18 months.

Videos

FB video

Resources

An Update on the Assessment and Management of Pain Associated with Lameness in Cattle VCNA FA 2017; Volume 33, Issue 2, July 2017, Pages 389-411

Practice

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https://open.lib.umn.edu/largeanimalsurgery/?p=5065#h5p-115

Bovine musculoskeletal disorders

Everything above the foot.

This table helps localize lesions

Table 1
Most common conditions with their location

	Sepsis	Osteochondrosis	Degenerative Joint Disease	Ligament Rupture	Luxation	Fracture	Sequestrum
Thoracic limb							
Shoulder	X	X	—	—	X	X	—
Humerus	—	—	—	—	—	X	—
Elbow	X	X	—	—	—	X	—
Radius ulna	—	X (distal physis)	—	—	—	X	X
Carpus	X	—	X	—	—	X	—
Pelvic limb							
Hip	X	—	—	X	X	X	—
Femur	—	—	—	—	—	X	—
Stifle	X	X	X	X	—	X	—
Tibia	—	X (distal physis)	—	—	—	X	X
Tarsus	X	X	X	X	X	X	—

From Desrochers A. Diagnosis and Prognosis of Common Disorders Involving the Proximal Limb. Vet Clin Food Anim 33 (2017) 251–270.

Septic synovitis (joints, tendon sheaths and bursas)

Joint infections are a common cause of lameness in neonates and young feedlot animals.

Infections can enter via direct inoculation (wound or injection), local extension of infection (eg via hoof ulcer or foot rot) or via the blood supply (infection elsewhere). Hematogenous is most common in neonates, especially for the larger joints, but can be seen in all ages and can affect multiple joints. Adults can get hematogenous spread, especially to sites of injury even if there is no wound.

Animals are typically non-weight bearing and the area is often swollen and painful.

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Cytology can be useful but cows produce lots of neutrophils. Consider a synovial structure infected if >40K cells/ul. Colostral antibodies should be evaluated in neonates.

Bony changes develop fast in cattle but still take 4-5 days to appear on radiographs. If there is infection near bone, it will develop extensive periosteal reaction. This can be a useful clue.

Bones will also lyse when infected. Cow pus is also so thick that it will physically push the bones apart, widening the joint space.

Proximal sesamoid bones pushed away by fetlock joint infection

Treatment is high volume lavage (generally need arthrotomy per Malone*; don't do that per Trent), NSAIDs and four weeks of systemic antibiotics. Animals will generally need restricted exercise for pain control. Physical therapy may be required to minimize limb contracture, especially in young animals.

> *In cattle, you just end up flushing the tract with needle lavage. The fibrin is so thick that you can't flush it out through a needle. Arthrotomies are often necessary to actually flush the junk out – at least in my hands. EDM.

With chronic infection in the distal limb (pastern or coffin joint), you can amputate the distal limb or arthrodese the joint. Amputation works best in unilateral lesions in smaller stature animals that are not housed on slatted floors. Survival is limited. On average, the animal will last ~ 18 months in the herd before they are culled for related issues. Arthrodesis is generally needed for bulls, heavy animals, uneven flooring, and valuable animals. Referral is recommended if arthrodesis is desired.

Prognosis depends on rapidity and effectiveness of early treatment.

Osteochondrosis

Osteochondrosis is much less common in cattle. It is seen in bulls and fattening steers. Generally it is not treated.

It is very common in swine and is not treated.

Hygromas

Hygromas are extra-articular swellings that occur on the lateral aspects of the hocks or the dorsum of the carpus. These may reflect poor bedding or housing and occur due to repeated trauma. They are not an issue unless they become infected. Removal is difficult. Drain abscesses.

Cruciate injury

See ligament chapter

Flexor tendon lacerations

Unfortunately flexor tendon lacerations are common and are generally caused by interactions with farm machinery. If the fetlock is dropped, the superficial digital flexor tendon is damaged. If the toe is tipped up, it is a deep digital flexor laceration.

Damage to both superficial and deep flexor tendons

Treatment

Debride and cast or debride and splint. Half limb casts are adequate for lacerations below the hock. Suturing the tendon doesn't really help healing. The outcome can be good but healing takes 10-12 weeks for stable fibrous union.

If it is just the tendon to one digit, placing a block on other digit may be sufficient.

If it is the gastrocnemius tendon, suture repair and full limb cast is required. See below.

Prognosis

Fair. Better if the tendon sheath is not involved. Healing within the tendon sheath is less effective.

Gastrocnemius tendon lacerations

Gastrocnemius tendon lacerations or ruptures are are bad. The hock will dropped when animals attempt to bear weight on the limb. Treatment is placement of a Schroeder-Thomas splint but it is often unsuccessful.

Dr. Trent with goat with dropped hock due to gastrocnemius rupture

Extensor tendon lacerations

These have a good prognosis. Initially the animal cannot advance the leg well but this resolves rapidly.

Cruciate injuries

Cruciate injuries are bad. These are most commonly seen in heavy postparturient cattle with milk fever. Due to muscle weakness, they have difficulty standing and fall. Mild to moderate lameness with joint effusion is noted. Cattle will have a positive drawer sign but these are tricky to do and you can only try once (before they try to injure you back). The cow has to be weight-bearing to perform the test. Stand behind her, place your shoulder into her stifle and pull. Surgery is required for repair; this is a referral procedure.

Flexural contractures

Treatment of flexural contracture involves physical therapy, pain relief, and progressive splinting. Oxytetracycline can be useful in neonates as it temporarily relaxes the muscle-tendon unit. Surgery may be needed to transect tight tendons. In ruminants, the contracture often involves the joint capsule, rather than just the tendons. Due to the joint capsule involvement, treatment is not as effective in ruminants as in horses. If the joint capsule is contracted, that means there is no muscle to respond to tetracycline and nothing to cut at surgery.

Angular limb deformities

Camelids have mild carpus valgus normally. More severe angulation can be seen. However, the growth plates are slower to close than in horses. Mother nature and restricted diets can take care of the problem. Fast growing crias may need to be weaned early as the dam’s milk may be too rich.

Spastic paresis (Elso Heel)

This is a genetic, multifactorial condition seen primarily in Angus and Holsteins. It is primarily contraction of the gastrocnemius muscle. The gait change starts with very straight leg, then the animal can't bring leg forward, and, finally, the leg is held behind. It is accompanied by a raised tail head (looks like tetanus and shivers).

Goal of therapy (tenectomy and/or neurectomy) is to get to slaughter rather than to maintain in herd.

Spastic syndrome (Stable Cramps)

Muscle contractions or spasms of the hindlimbs. This can progress to hindlimb paresis or paralysis. Considered a genetic disease.

Femoral/obturator paresis

This is often related to parturition or falling with legs back . Treat with floating in water (float tank), NSAIDs, lifting with hip lifters or a sling.

Cattle can get this with hip lock dystocias.

Radial/brachial plexus

Damage to the nerve occurs with humeral fractures, rapid abduction (fall on ice), or being recumbent without padding. Treat with supportive care, splinting, NSAIDs, padding and floating. Splint down the back of the limb to help fix the triceps.

Neonatal musculoskeletal injuries

These injuries are associated with the birth process, often with dystocias

Cannon bone fractures

These are the most common injury associated with dystocias and human interference.

The fracture tends to involve the distal physis of cannon bone. These are usually closed, simple and relatively stable if alignment can be achieved (the physis interlocks to hold the bones in place). The fractures are sometimes accompanied by vascular damage. Vascular damage will show up later and can delay or prevent healing. Calves may not have stood to nurse or absorbed colostrum well, so may need colostrum.

Internal fixation does not work in calves as their bone is too soft. Treat with a cast or Schroeder-Thomas splint.

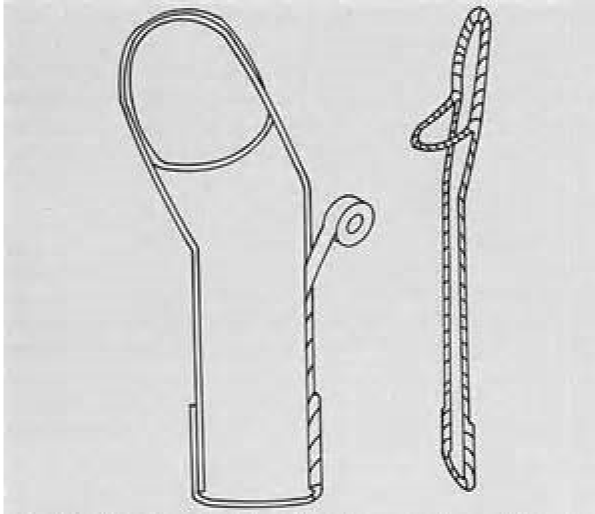


FIG. 15-9 The front-leg Schroeder–Thomas splint would assume this shape for a midhumeral fracture.

A full limb cast is ideal to stabilize joint above and below the fracture; however, with lower limb fractures, often a half limb cast is sufficient (and is much easier for the calf to manage).

Prognosis is guarded due to the potential for blood supply damage. Blood supply damage may not be evident until the cast change at 2-3 weeks. Most do fine but it is hard to know in advance.

Cast cutters can cut skin! Especially in large aimal species with minimal soft tissue coverage. If you create a wound with the cast saw, do not close it (fiberglass particles in the wound). Just clean it up.

Rib fractures

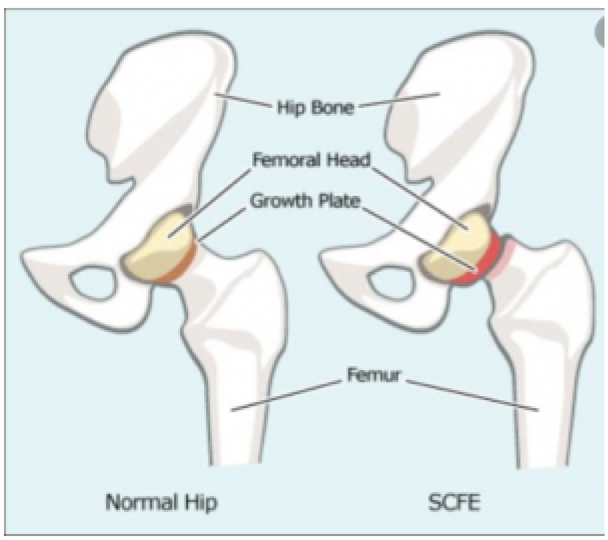
Rib fractures are related to posterior/breech presentation. Careful palpation is necessary to diagnose these. The fracture ends can rupture thoracic vessels. Treatment involves restricted exercise and/or stabilization. Flail chests require stabilization.

Jaw fractures

The jaw can be damaged by jaw pullers used for dystocia. Check for colostrum absorption (the calf may not have nursed). These have a variety of stabilization options but need something.

Slipped capital femoral epiphysis

The physis is weaker than the round ligament of the femur. Instead of hip luxation, the physis breaks. The hip stays in the socket, femur gets loose. These occur with hip lock dystocia – often in double muscled breeds. Diagnosis may be delayed. Radiographs are useful for diagnosis.



Prognosis is fair with surgery, poor otherwise. FHOs (femoral head ostectomy) are not a good option in cattle.

Femoral nerve paresis "patellar luxation"

These are not truly patellar luxation but the quadriceps is not working. These are congenital lesions and often bilateral lateral luxations. The problem is with the femoral nerve. And, as the patellar doesn't move correctly the groove doesn't form properly. Calves will have a crouched stance. Poor prognosis if no return of nerve function.

Synovial infections

Synovial infections are typically associated with umbilical infections, respiratory infections or GI infections. One or more of the large joints may be affected. Prognosis is guarded and the cause of the infection needs to be addressed (umbilical resection, etc). See joint issues chapter.

Cannon bone fractures

These are high energy fractures and are often comminuted and open. Fixation requires full limb cast or transfixation cast. Prognosis is better in cattle than in horses but poor if open and articular.

Radial and tibial fractures

Better prognosis in cattle than horses but these need transfixation cast or external fixateur apparatus. A regular cast does not usually work unless the fracture is very distal on the radius. Internal fixation is great but often too costly.

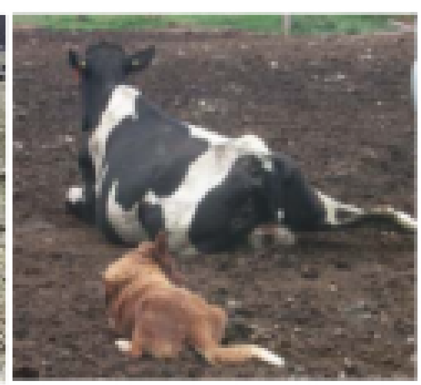
Femoral fractures

We cannot fix these but they will often heal on their own as the musculature will stabilize it. Affected animals need good bedding and nursing care. The limb may end up with abnormal conformation.

Coxofemoral luxation

Caused by sudden hyperextension. These generally have a poor prognosis; referral is needed for therapy unless very acute (then try to manipulate back into the socket).

Luxations may be caudodorsal (animals can usually stand up) or cranioventral (animals are usually down).



Patellar luxation

Can be treated with imbrication but this is challenging in larger animals.

Sequestra

Devitalized bone fragments can develop after full thickness wounds. Debridement is needed to allow healing. Suspect sequestration if draining tracts persist.

How to - Cast application

Indications

Casts are used to stabilize areas for healing. This includes wounds (horses), bones, and tendons.

Relevant anatomy

Casts should typically extend from the sole of the foot (encasing it in large animal species) and include the joint above the destabilized area (or above the wound if possible). Casts should end at the top of a bone and just below a joint. Ending in the diaphyseal region creates a fulcrum and could lead to a new fracture.

Ruminants heal well and can tolerate a cast that does not include the joint above if the injury is distal enough. E.g. a half limb cast (ending below the carpus or tarsus) is often sufficient for a distal cannon bone fracture, even though the joint above (carpus or tarsus) is not included in the cast. If needed, transfixation pins can be used to stabilize the distal limb or even the tibia, avoiding the need for joint above and below.

Preoperative management

Food restrictions: Often NA. If possible, species and age specific food withholding is recommended.

NSAIDs/analgesics: NA for the cast; recommended for fractures and acute wounds.

Antibiotics: NA for the cast; may be recommended for the primary issue.

Local blocks: NA. IVRA can lead to initial swelling. This can lead to a loose cast when the swelling resolves.

Position/preparation: Lateral. If the limb is unstable, it can be placed on the down side to minimize angulation. If the limb is very unstable, wire through the hoof can be held by an assistant to help maintain normal alignment. Radiograph equipment is useful if available.

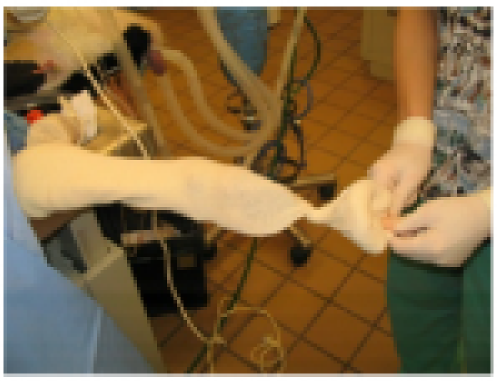
Supplies:

- Stockinette sized to be snug on the limb; 3x as long as the area to be casted
- 3M cast foam (larger animals) or thin cast padding
- Felt band for top of cast
- White tape
- Towel clamps (for felt band)
- Fiberglass cast material (3-5 rolls for a lower limb; 4-8 rolls for full limb)
- Gigli wire (>3x length of cast) x 2
- AI pipettes or tubing for gigli wire
- Wire cutters for gigli wire
- Inner tubing or technovit for the bottom of the cast
- Elasticon for top of cast
- Water
- Exam gloves
- Scalpel blade or scissors
- Heavy gauge wire for foot (optional)

Procedure

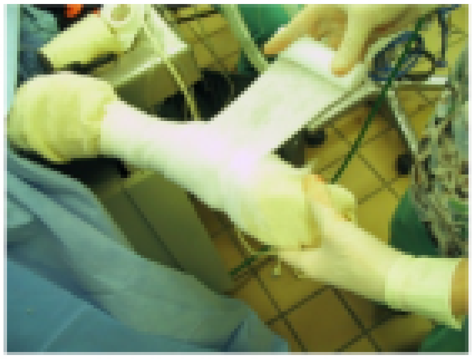
- If applicable, the fracture is reduced and the limb is positioned so that the cast will hold it in reduction or in healing position (e.g. tendon ends apposed). The foot is left in a neutral position with the toe pointing away from the spine (ballet dancer).
- One to two assistants support the limb. The limb is supported by holding the upper limb above where the cast will stop while the other holds the foot. A table leg brace can be useful, as well.


- The stockinette is placed on the limb in a double layer. One half is rolled up the limb, the foot end twisted and the second half rolled up the limb. This should result in a covered foot.




- The felt is placed at the top end of the cast. Cut the felt to fit snugly, ends just meeting. Secure with towel clamps or tape.

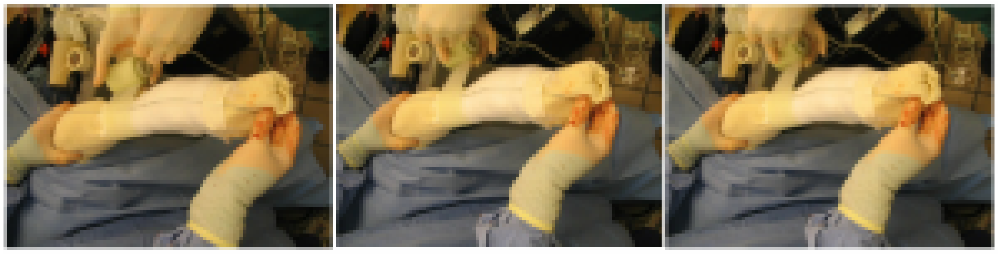

- If used, a *thin* layer of cast padding is placed on the limb from coronary band to felt.
- If used, the 3M foam is dunked in water and placed gently on the limb, overlapping only minimally. This layer should extend from the coronary band to the felt.



- Place gigli wire if being used. One strand should extend up the medial side and one up the lateral side. Enough wire should extend out both proximally and distally to make sawing possible later. To avoid the gigli wiring sticking in the cast material, it can be passed through tubing (iv tubing) or AI pipettes. The tubing and pipettes should be cut to the length of the cast. Tape in place. Just above the felt, pass the proximal end of the wires through through the stockinette so between the stockinette and skin (this will make it possible to fold down the stockinette later).

bare gigli wire (left) and gigli wire in tubing (right)

- Cast application(3 layers, distal limb +/- splint)
    - The first layer of cast material will extend from 1/2 way up the felt to the foot but not further distally. The person holding the foot should not need to let go.
    - The cast material will start to activate as soon as the package is open. Warm water sets better and faster; cool water gives you a bit more time. Dunk the cast material and hold for a few seconds. Squeezing once is okay but not necessary.
    - At the felt level, make 3 full revolutions with the casting material before moving distally. This will make a strong top. A slight amount of force can be used over the felt.



Notice how the roll is held so that the cast material comes off the spool smoothly.

- Move distally, overlapping the prior revolution by 50%. Just unroll the cast material onto the limb, do not pull it taut or use force. Keep fingers off the cast. Surface indentations are internal bumps (and cast sore creators).If there is enough casting material, move back up the limb after reaching the coronary band. Extra revolutions should be placed over joints.

Still holding the foot

Unrolling the hard way

- The second layer of cast material will cover the foot. Start at the fetlock and move down with the same 50% overlap. Cover the foot in any way possible. This will not look good or smooth. Twist the cast material as needed to change direction. *Do not cast in your gigli wires.* Once the foot is covered, move back up the limb, providing extra support over joints. Alternatively, create heel support.

- Heel support: The animal is currently only going to be weight bearing on the toe. Use cast material, the inner plastic roll from the cast material or any other material at hand to create a larger weight bearing surface for the hoof (fill in from heel to ground). Cast this in place with additional cast material.

Creating heel support with cast roll insert (left) and packaging (right)

- Splinting: Most casts will break on the dorsal surface. The cast can be strengthened without much additional weight using a splint made from the fiberglass cast material. Unroll a length of cast material equal to the 3-x the length of the cast. Fold into thirds. Wet if not already. Apply to the front of the cast and cast in place with additional cast material.

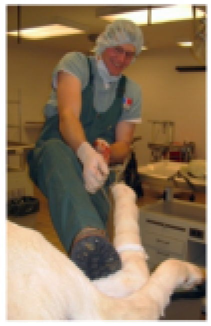
- Polishing : Trim the stockinette above the cast so 2-3″ and fold down over the cast, pulling snugly. With the remaining cast material from the last layer or with a new roll, cover this material. Include 2-3 revolutions at the top to make a solid region that won't bend.

- Apply technovit or inner tubing to the bottom of the cast to prevent it from being damaged.

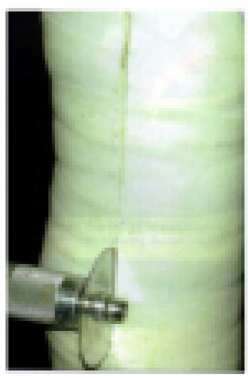
- Once the cast is dry, tape the gigli wire to the cast so it doesn't get caught and pulled. Place Elasticon over the top of the cast to keep debris out.

Postoperative care

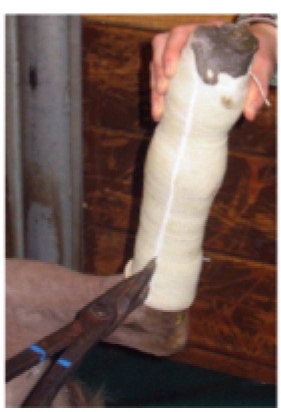
- Keep the animal stall rested without hand walking.
- Monitor the cast twice daily for the development of cast sores : warm areas, strike through, flies, swelling above the cast or decreased weight bearing.
- Monitor the cast twice daily for breakage
- Remove or change the cast in 2-3 weeks for fast growing animals, 4-6 weeks for adult horses and small ruminants; 6-8 weeks for cattle (thick skin).
- Cast removal
    - use gigli wire to saw from the inside out




- use cast cutters and splitters to cut down to the limb
    - keep the saw perpendicular to the limb, cutting medial and lateral (not over the flexor tendons)
    - keep in contact with the limb so if the limb moves, you move (see far right image below)
    - cut until you feel a give
    - slide 1/2 way down the current cut and repeat


- If the cut is deep enough, the cast will start to gap. Both sides need to be fully cut to see the separation
- Place the splitters in the gap and open to separate the sides
- The limb can be lifted out of the cast; no need to separate the foot




Complications

- Acute injuries can be associated with edema. As the edema resolves, the cast will not fit as well. Loose casts lead to cast sores.
- Cast sores are common and are hard to detect. If signs are seen, the cast should be removed ASAP.
- Osteoporosis is common in younger animals (all animals <1 year and horses <4 years casted for wounds only – no bone stimulation). Avoid immediate weight bearing when the cast is removed. Replace the cast with a bivalved cast (both halves or one half) or support shoes and gradually remove support.
- It is possible to cut skin with the cast cutters.

Videos

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Resources

Manual of Clinical Procedures in the Horse

Practice

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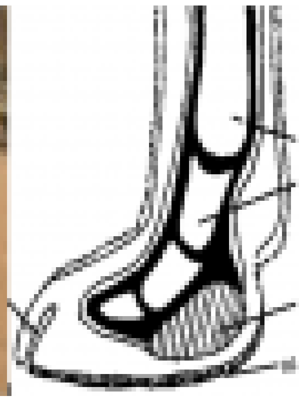
https://open.lib.umn.edu/largeanimalsurgery/?p=6659#h5p-111

Swine, SRC and poultry lameness

Currently just the basics

Anatomy

Camelids bear weight on *both* P2 and P3 rather than just on P3 as with most large animal species. There is no navicular bone. They walk on double pads with a claw in front. The claw is nonweightbearing but is important for traction and propulsion. A digital cushion supports both P2 and P3.


https://stillunfold.com/animal/camel-feet-amazing-facts

Other notable anatomical features:

- In most animals, the medial and lateral compartments of the fetlock joint are separate (unlike in cattle).
- The superficial flexor tendon has a direct fascial connection to the proximal suspensory ligament
- More in Chapter 58 – Musculoskeletal Surgery of Llama and Alpaca Care
- Camelids can manage with 3 limbs so amputation is a feasible option. Similarly, postoperative care and fracture management are eased due to the ability to use slings and various splints. The light weight body also means camelids can be treated with implants designed for dogs, horses or humans. A wider variety of options exists.

Foot issues

Camelids are not prone to foot rot but can get interdigital dermatitis if conditions are right (moisture + trauma). The same conditions and organisms can cause ulcerative pododermatitis of the foot pads. Treatment requires removal of any loose skin or pad, antiseptics and protection with a wrap or bootie. The animal should be kept in a clean, dry environment. Antibiotics may be used for deep infections.

The dorsal interdigital region and heel area are both common sites for chorioptic mange.

Limb deformities

Mild bilateral carpus valgus is prevalent in camelids. More severe deformities may be related to hypophosphatemic rickets. Crias with dark hair coats are especially prone to developing low vitamin D levels because of reduced absorption of sunlight by the skin. Crias born during the cloudy months should be supplementation with 1000 IU/kg vitamin D3 subcutaneously (SQ) every 60 days. Physitis due to rapid growth has also been identified. Once the cria was weaned, the physitis resolved and the angulation improved.

Camelids with severe angular limb deformities can be corrected with transphyseal screws or bridging as in horses. Camelid growth plates close much later than horses so more time is available for self-correction.

Flexural deformities are encountered and are treated similarly to foals. More aggressive tenotomy or desmotomy is possible due to the limited athletic need.

Suspensory degeneration /Fetlock hyperextension

Camelids can develop dropped fetlocks, similar to that seen in horses with suspensory degeneration. Unilateral cases can occur with excessive weight bearing and more likely suspensory damage. Bilateral cases have been associated with mineral deficiencies, proteoglycan levels in the suspensory and genetic predisposition. As with horses, no effective therapy exists and prognosis is poor.

Juvenile osseous sequestration

While horses and cattle develop bony sequestration after wounding, many of the **sequestra** diagnosed in camelids do not have open wounds associated. These are most common in young camelids and more closely resemble a syndrome seen in children in which bacterial emboli seed bone, leading to bone ischemia.

Long bones of the appendicular skeleton seem to be most affected. Animals present heat, pain, local swelling and lameness. Diagnosis is made radiographically.

Sequestrectomy usually results in a good prognosis as long as enough supporting bone remains to prevent fracture. Culturing the bone is recommended

Joint issues

Stifle ligamentous injuries (cruciate tears) are not common but can be found in camelids. Both intracapsular and extracapsular approaches have been successful.

Patellar ligament tears have been reported in pack-llamas and breeding male llamas. Affected camelids walk with a crouched posture (stifle stays flexed) and are unwilling to bear weight fully. Diagnosis is confirmed via surgery with variable attempts at repair being relatively successful even though repair failure rates are high (scar tissue?).

Shoulder luxation is uncommon but is seen in young males and in alpacas. Surgical repair is generally successful. Animals are kept in a Velpeau sling in the early postoperative period.

Hip luxation is treated as it would be in dogs.

General arthritic pain is treated with meloxicam and supportive care.

Patella luxation

Patellar luxation can be due to trauma or to congenital conformational abnormalities. Animals castrated early in life (<12 mo old) tend to develop straight hindlimbs and are considered more prone to luxation. Treatment involves lateral imbrication and release (surgery), possibly combined with trochleoplasty. Recurrence is common. A sling may be needed for the first two weeks postoperatively unless trochleoplasty is performed.

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Septic arthritis

Septic arthritis occurs primarily due to trauma. Hematogenous septic arthritis is less common than in cattle and horses. Diagnosis includes joint cytology and culture. Treatment is similar and focused on joint lavage and antibiotic therapy (iv antibiotics, intra-articular antibiotics, and/or iv regional perfusion of antibiotics).

Congenital lesions

Camelids have significant numbers of congenital lesions. Orthopedic lesions include wry nose, polydactyly, syndactyly, patellar luxation, flexural deformities and rotated talus bones. The rotated talus bones are associated with an abnormal gait.

normal (left) and rotated talus (right)

Key Takeaways

Camelids do not get too many lameness issues.

Be aware of

- suspensory degeneration leading to fetlock hyperextension
- juvenile osseous sequestration unrelated to open wounds

Camelids can be treated much more like dogs in terms of joint luxations, etc. Light bodies and able to ambulate on three limbs.

Resources

Pain management in small ruminants and camelids: Analgesic agents. Vet Clin North Am Food Anim Pract . 2021 Mar;37(1):1-16.

Llama and Alpaca Care. Medicine, Surgery, Reproduction, Nutrition, and Herd Health. Elsevier, 2014.

Small ruminant orthopedics

As with cattle, lameness in small ruminants is a major cause of economic loss due to impacts on fertility, milk and fiber production, animal growth and animal well-being.

Common causes of lameness in small ruminants include contagious foot rot, horn disorders, poor foot conformation, retrovirus-associated arthritis/synovitis (CAE and OPP viruses), bacterial polyarthritis caused by *Mycoplasma* and *Chlamydia* spp., and white muscle disease.

Goats tend to lift or minimize weight bearing on an affected limb. Bilateral issues will lead both sheep and goats to adopt different postures for eating and walking (eg eating on their knees). More subtle lameness is detected by head nods and changes in stride length.

Foot disorders

As with many LA species, most lameness issues are due to foot conditions.

The main foot issues are foot rot (biggest concern), contagious ovine digital dermatitis (growing concern), ovine interdigital dermatitis (foot scald), white line disease (shelly hoof), sole ulcers (called laminitis) and pedal joint infection. *Dichelobacter nodosus*, *Fusobacterium necrophorum*, *Treponema* spp., and *Actinomyces pyogenes* are the most significant foot pathogens.

As mentioned below, some sheep are resistant to contagious foot rot. Genetic susceptibility or resistance to white line disease has also been reported. Otherwise the risk factors are very similar to those reported in cattle. Overgrown, cracked or damaged hooves are more prone to secondary issues. Sheep with lower BCS and at higher production have more issues. Environmental and management conditions impact disease risk.

Foot disorders can be minimized through keeping animals in a dry environment and on a good nutritional plane. Good foot trimming is essential and proper foot baths or antiseptic sprays can help, particularly when animals are housed on soft footing.

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Contagious digital dermatitis

Treponema (spirochete) infections cause digital dermatitis in both sheep (contagious ovine digital dermatitis; CODD) and goats (caprine digital dermatitis; CDD). While the infection starts at the coronary band level with either proliferative or ulcerative lesions, the infection can will undermine the hoof wall and eventually lead to avulsion of the hoof capsule. [This is in contrast to bovine digital dermatitis which stays above the coronary band and is not associated with hoof wall issues.] Due to damage to the coronary band, hoof regrowth is often abnormal.

https://nadis.org.uk/disease-a-z/sheep/contagious-ovine-digital-dermatitis-codd/

Topical tetracycline is recommended for CODD, as it is for bovine digital dermatitis. Severe infections may require digit amputation. Control is via maintaining closed herds, foot baths, disinfection of trimming equipment and potentially vaccination. It may be prudent to avoid co-grazing sheep with cattle that have digital dermatitis. Digital dermatitis seems to be a worsening problem in sheep. In 2017, over 50% of UK flocks were affected. Caprine digital dermatitis is a similar problem and can also be difficult to treat.

Foot scald and foot rot

Foot scald and foot rot typically arise due to interdigital trauma and/or macerated skin from wet conditions. When just the interdigital space is affected, this is often referred to as “foot scald” [more akin to bovine foot rot]. The interdigital space will be red with slimy exudate and a foul odor due to Fusobacterium infection. The skin may become ulcerated and necrotic. Affected animals may be seen grazing on their knees.

In small ruminants, foot rot is a higher level of severity compared to foot scald. Foot rot is when the interdigital dermatitis has been exacerbated by Dichelobacter nodosus infection. Dichelobacter produces an enzyme that can dissolve hoof horn. Dichelobacter enzymes can undermine the sole and/or loosen the hoof wall. This can cause hoof wall detachment and/or subsequent abnormal hoof growth. The level of enzyme activity varies by strain of Dichelobacter.

An example of a hoof with scald. Notice in this recently trimmed hoof that the scald is confined to the interdigital space, and has not underrun the hoof tissue.

An example of a fairly severe case of footrot. Notice the decayed tissue at the heel and separation of the hoof wall.

https://www.extension.purdue.edu/extmedia/As/As-596-footrot.pdf

Treatment includes topical and/or systemic antibiotics for affected animals, ensuring a clean and dry environment, weekly foot baths or sprays and appropriate foot trimming regimens. Biotin supplementation may help speed recovery. During recovery, it is important to ensure animals are able to reach food and water; very lame animals will not be willing to move with the flock. Many will need NSAIDs. Animals that do not respond should be culled.

Prevention is key. Precursors to the disease include overgrown, cracked or damaged hooves; regular trimming is recommended. It is important to keep Dichelobacter out of the sheep/goat herds. Dichelobacter does not persist very long in the environment – it only lasts a month or two. The main source of infection is feet of infected animals, where it can persist for years. Lame animals should not be brought into the flock. Any new or returning animals should have feet inspected and be quarantined for 30 days. Foot trimming equipment should be cleaned properly.

Some sheep are genetically resistant to foot rot. Merino sheep are known to be *prone* to foot rot. Vaccines for Dichelobacter exist but have relatively short duration of action (<6 mo) and are not totally effective. Injection site reactions are high. Multivalent vaccines are not recommended.

• BOX 11-1

Foot Rot Prevention Program[a]

- Separate infected animals, and when trimming feet, disinfect trimming equipment between animals.
- Move all animals through a 15% zinc sulfate foot bath. Where possible, have them stand in the foot bath for 30 minutes. Foot baths should be repeated two to four times at weekly intervals.
- Put both affected and nonaffected sheep in a previously unused (clean) pasture or paddock.
- Cull all severely affected animals and those not responding to treatment.
- Vaccinate with specific serogroup (monovalent or bivalent) vaccines based on farm isolates 8 to 12 weeks before the season when large numbers of foot rot cases are anticipated (disease tends to occur at the same time each year).
- Selectively breed for animals that appear less susceptible.

Sheep, Goat, and Cervid Medicine (THIRD EDITION) 2021, Pages 251-280

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Other foot lesions

Interdigital fibromas do occur but are uncommon. Surgical removal is usually curative.

Toe **granulomas** typically occur due to over-trimming (toe region). These can be hard to treat. The granuloma can be shrinked with a mixture of sugar+iodine. Undermined horn needs to be removed. Prevention is by maintaining a good digital cushion and avoiding aggressive or unnecessary trimming.

Milking goats may develop metabolic issues that lead to laminar inflammation. Or not. We used to consider this a problem in cattle but now we think this is more flexor cortex issues due to changes in the digital cushion.

Goats with foot pain due to metabolic issues may be found walking on their knees. Hoof growth may also be abnormal. Goats can also be affected by interdigital dermatitis, foot cracks and heel bulb erosions.

Foot and mouth disease will cause lameness due to lesions at the coronary band and in the interdigital tissues. Remember that ulcerative lesions require reporting to the Department of Health in the US.

Joint disorders

Septic arthritis is typically due to hematogenous spread in neonates (16% had an umbilical infection) and due to trauma in adults. Infections due to trauma are treated like they are in other species – joint lavage and antibiotics.

Chlamydial polyarthritis is a common contagious disease of feedlot lambs and likely occurs in goats, as well. Disease occurs in 1- to 8-month-old lambs, with 3- to 5-month-old lambs most commonly affected. In feedlots, outbreaks often occur a few weeks after lambs are introduced. Animals are febrile and reluctant to move. Multiple joints may be swollen. Chlamydial conjunctivitis can be seen simultaneously. Joint cytology may show elementary inclusion bodies. ELISA and PCR testing is confirmatory. Morbidity can be as high as 80% but mortality is very low; *most cases resolve without treatment in 10-14 days*. Antibiotic therapy (erythromycin, tylosin, tetracycline) will speed recovery.

Mycoplasmal arthritis is a highly fatal disease of goats. Affected animals show signs of polyarthritis, septicemia, and mastitis. In the United States, most outbreaks are in large goat dairies. Morbidity and mortality rates as high as 90% have been reported in kids. The organism is usually introduced to the farm by an asymptomatic shedder. Antibiotic treatment does not usually resolve the infection. Prevent the disorder by feeding only pasteurized milk to goat kids.

Erysipelothrix polyarthritis is typically seen in 2- to 6-month-old lambs but it can also cause neonatal joint infections. Outbreaks may affect as many as 40% of the lambs in a flock. Animals present with fever and lameness but minimal joint swelling. Erysipelothrix polyarthritis will progress to chronic arthritis if not treated appropriately.

Infection with caprine arthritis – encephalitis virus (CAEV)is widespread and chronic polyarthritis is the most common finding. Most infection is transmitted from doe to kid through the milk. Venereal disease and horizontal transmission are possible. Four clinical syndromes have been described for CAEV-infected goats: arthritis, leukoencephalomyelitis, interstitial pneumonia, and mastitis; hoowever, most animals are asymptomatic. Chronic progressive arthritis is seen in goats older than 6 months and is usually characterized by swelling of one or both carpal joints. Arthritis may affect other joints but it usually not detected. Signs may wax and wane initially. Some animals deteriorate over a few years while others remain stable for much longer. Combining ELISA and PCR with repeated testing is the best way to detect positive animals. No treatment is available. Ovine progressive pneumonia is a similar disease in sheep that only occasionally affects joints.

Lyme disease (Borrellia burgdorferi) does affect deer, sheep and occasionally goats. Testing is challenging. Sheep seem to be able to avoid systemic infection but can enable tick to tick transmission. A typical treatment regimen is a 2- to 4-week course of oxytetracycline, ceftiofur, or penicillin. Prevention of the disease currently relies on tick elimination.

Degenerative osteoarthritis is relatively common in older animals and can be exacerbated by CAEV. Elbow OA seems to be particularly prevalent. Elbow joints will not have much effusion will have decreased range of motion. Animals may have a stiff gait and many have overgrown feet. Disease is usually advanced by the time of diagnosis. Treatment is focused on NSAIDs but can include joint protectants and surgical arthrodesis.

Physitis and osteochondrosis are found in rapidly growing animals.

Bone disorders

Osteomyelitis can occur due to trauma or hematogenous spread. Signs include lameness, pain on palpation, and focal swelling. Animals may be recumbent. Radiographic changes may not be visible for up to two weeks. Prognosis is guarded.

Rickets and osteomalacia can occur in young animals to due deficiencies in Vitamin D, phosphorus and/or calcium. Corriedale sheep can develop inherited rickets. Signs may include stiff gait, shifting legs, lameness, and recumbency due to bone fragility and pathological trauma. Joints and bones of the distal aspects of the limbs may be enlarged along with enlargements of the ribs at the costochondral junctions (rachitic rosary). Limbs may be bowed (angular limb deformities). Teeth may be mottled and their eruption delayed. Treatment is based on Vitamin D3 injections.

Fibrous osteodystrophy (nutritional hyperparathyroidism) may be seen in animals on a high phosphorus diet. Animals have a big head/rubbery jaw due to replacement of bone by fibrous tissue.

Fractures and other injuries can be treated fairly effectively due to the ruminant healing potential and small size. Amputations are a possible option, as are limb slings. Schroeder-Thomas splints can be effective at fracture stabilization when a cast is not appropriate.

Muscle disorders

- Blackleg
- Sarcocystis
- Nutritional muscular dystrophy

Congenital disorders

- Spider lamb syndrome/ Hereditary chondrodysplasia
    - Suffolk and Hampshire breeds are at greatest risk for this inherited condition
    - Chondrodysplasia may be seen at birth or develop within the first 6 weeks of life
    - Caused by a mutation in the fibroblast growth factor receptor 3; testing is now available
    - UC Davis spider lamb information and testing
- Arthrogryposis
    - congenital fixation (contracture) of multiple joints associated with a variety of teratogens
    - inherited arthrogryposis has been reported in Suffolk and Corriedale sheep. Autosomal recessive mutation.
    - also caused by Schmallenberg virus
- Polydactyly
    - likely inherited
- Patellar luxation
    - Affected animals will crouch due to inability to straighten the hindlimbs
    - differential – femoral nerve injury due to dystocia (rare in small ruminants)
    - genetic predisposition?
    - may not ingest colostrum due to inability to stand and nurse
    - surgical imbrication +/- trochleoplasty
- Myotonia congenita / Fainting goats
    - tetanic contraction when startled
    - autosomal dominant trait

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- Spastic paresis
    - constant contraction of gastrocnemius muscle -> leg extended behind and back arched

  - considered inherited

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- Flexural deformities
  - treat as for foals with oxytetracycline and bandaging
  - if surgery is needed, just cut the flexor tendons vs the check ligaments
  - most are congenital

Key Takeaways

Foot issues are still predominant. Sheep get an infectious form of foot rot that can be devastating to flocks. Infectious digital dermatitis can lead to hoof avulsion and is spreading through flocks. The same prevention and maintenance as for cattle helps minimize issues.

Some breeds have a genetic resistance to hoof disorders.

Goats also get several infectious forms of arthritis.

It is difficult to find good numbers for treatment response rates.

Fracture healing and repair is typically good. Limb and digit amputations are options.

Resources

Pain management in small ruminants and camelids: Analgesic agents. Vet Clin North Am Food Anim Pract . 2021 Mar;37(1):1-16

Aetiology, Risk Factors, Diagnosis and Control of Foot-Related Lameness in Dairy Sheep. Animals (Basel). 2019 Aug; 9(8): 509.

Sheep, goat and cervid medicine. 3rd ed. Elsevier, 2021, Ch 11. Diseases of the musculoskeletal system.

Musculoskeletal Disease including Foot Disorders. In Goat Medicine and Surgery. 1st ed. 2017

Understanding contagious digital dermatitis. In Practice, 2018-03, Vol.40 (2), p.60-65

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=5160#oembed-5

https://youtu.be/mgpSB4HNMX4 -includes several videos with good pictures

Swine orthopedics

Regular foot trimming is necessary. 25% of visits for one hospital were due to lameness related to overgrown digits.

Pot bellied pigs like to jump off things. They tend to fracture the distal aspect of the humerus. This is weird as the humerus does not typically fracture unless high energy forces are applied. This predisposition has been proposed to be due to incomplete ossification of the humeral condyle, similar to a condition in Cocker, Springer and Brittany Spaniels. The condition may be inherited. The current recommendation is to radiograph the area in any pig with forelimb lameness, even if mild. The fractures may occur early on in life, with the lameness related to the development of arthritis or may occur due to weakness in the abnormal bone.

Fast growing swine are prone to osteochondrosis. As with other species, males predominant. The most common findings are subchondral cysts in the medial femoral condyle and in the trochlea of the humerus. Osteochondrosis is typically not treated in market swine. Pet pig owners or rescue-type groups may present their animals for treatment that might not otherwise be performed.

INCOMPLETE OSSIFICATION OF THE HUMERAL CONDYLE IN VIETNAMESE POT-BELLIED PIGS. Veterinary radiology & ultrasound, 2000-03, Vol.41 (2), p.147-153

Incomplete ossification of the canine humeral condyle, Vet Practice 2009

Osteochondrosis in swine, Dr. Zhitnitskiy

Sheep, goats, camelids and pot bellied pigs with orthopedic injuries can typically be managed as dogs. Sheep, goats and alpacas can manage on three limbs indefinitely and most can manage on three limbs during the recovery period (eg with a limb in Velpeau or Ehmer sling).

Ruminants tend to heal well and can heal even in situations that would be challenging for other species. Pigs can be crated and carried by their owners.

Stabilization

Since surgical repair has a good prognosis, the most crucial step is managing an injury so that it doesn't worsen in the preoperative period. Fracture ends need to kept from rubbing on each other (eburnating), puncturing skin, or damaging vessels or nerves. Tendon lacerations need to be kept from worsening. Animals may need fluid therapy for shock or limb stabilization to prevent anxiety.

Many times, the stabilization method will serve as the repair method.

Repair options

Casts

Many tendon lacerations and lower limb fractures can be managed by cast application. Casts incorporate the foot and extend past the joint above whenever possible. Very distal cannon bone fractures and flexor tendon lacerations often respond well to half limb casts even though these casts don't extend proximally as far as recommended. See chapter on cast application

Casts are generally restricted to fractures below the tibia or radius due to difficulty casting the elbow or stifle joint. Occasionally a cast can be placed high enough in an alpaca to stabilize a radial fracture. Most of these are managed with a Schroeder-Thomas splint or with transfixation pin casts. Both of these options allow stabilization of tibial and radial fractures.

A transfixation cast uses pins placed across the bone and then incorporated in the cast to mimic an external fixateur.

Schroeder-Thomas /Thomas Schroeder splint

This splint places the limb in traction. The splint can be used when casting is not an option. It was designed for tibial fractures but can be modified for radial fractures. It tends to distract (worsen) humeral or femur fractures due to the location of the ring.

See manufacture and placement of this splint on a calf at Forest Hill Farm. The red stick represents the fractured limb. The splint is usually made out of aluminum tubing and secured with tape or casting material.

Other options

Humeral or femur fractures are typically stabilized by the upper limb musculature. These are managed by stall rest and supportive care (help the animal stand). In some cases, IM stack pinning may be used but the prognosis tends to be equivalent to supportive care. In a valuable animal intramedullary nails may be the treatment of choice.

Splints incorporated into bandages or heavy bandages are typically NOT sufficient support for initial healing. After the fracture callus has started to develop, a bivalved cast (splint) may be sufficient. Earlier than that, the bandage changes required will usually result in motion at the fracture line and poor healing.

Complications

Bones will not heal if insufficient blood supply, excessive motion or overwhelming infection.

Healing will be delayed or prevented if excessive motion exists. Internal fixation provides the most stability; splints the least. Bone ends also need to override at least slightly. Too much distraction (separation) of the fracture ends will prevent appropriate callus formation.

Amputation is an option for most small ruminants if the fracture is unlikely to heal or isn't healing.

Casts can also create cast sores. Prolonged casting will lead to severe osteoporosis in young animals. This weakened bone may fracture when the cast is removed.

Cast care and monitoring

Casts can create significant issues if not molded and cared for properly. Rub sores are created when casts are too loose and when the limb changes under the cast. Fit is best when cast padding is minimal. Cast padding rapidly compresses, leading to a loose cast. If the limb is very swollen when the cast is applied, a new cast will likely be needed in a few days (when the swelling decreases).

Rub sores are also created when the cast has ridges (eg where your fingers push inward) and when the cast cracks. Animals should be stall rested. Movement is discouraged as movement can lead to cast breakage. Cement (technovite) or inner tubing is placed on the bottom of the cast to prevent wearing through from friction from the stall flooring.

Over time, the cast will no longer fit properly due to limb (young animals), claw or hoof growth. As this happens, the cast is pushed upward, creating additional rub sores.

Rub sores can erode into tendons and joints if the cast is not removed and/or changed.

Casts should be checked twice daily. Rub sores will create heat in the cast. Exudate may attract flies to the cast. Inflammation will create swelling that localizes above the cast. The pain and the swelling will lead to lameness. If the cast is worn, broken, has exudate or flies, it should be removed as soon as possible. The same is true if swelling is developing above the cast or if the animal stops using the cast as well as it has been. Remember that your ability to detect changes under a cast is delayed so consider these emergencies.

Most casts placed on adults will last 4-6 weeks so only one cast is typically necessary. In some cases, another cast may be placed if needed for continued fracture healing. In babies, the cast may need to be changed due to limb growth; on the other hand, these animals heal quickly.

The limb should be supported after the cast is removed to allow the limb structures to adjust to the modified weight bearing. Bones tend to become osteoporotic and ligaments lax. This will make animals prone to pathological fractures and joint issues (luxation, ligament tears). If the cast is split longitudinally (medially and laterally), one or both halves can be used as a splint. Splinting and support is gradually decreased over the next two weeks to allow bones, tendons and ligaments to adjust.

Key Takeaways

Blood flow is essential for fracture healing. If you don't have blood flow, it won't heal. Stability is next. The more stable the fracture ends, the better the healing.

- Internal fixation > Casts> Schroeder Thomas splint > other splints

Casts in hooved species should incorporate the foot and extend past the joint above the fracture to the proximal end of that bone.

- stopping the cast just above the joint or in the middle of the bone creates a fulcrum and may lead to another fracture

Monitor casts for heat, pain, swelling above the cast, cracks and change in use. If noted, remove and/or change the cast ASAP.

Resources

Surgical Management of Fractures and Tendons. VCNA FA Practice VOLUME 32, ISSUE 3, P797-811, NOVEMBER 01, 2016

Sheep, goat and cervid medicine. 3rd ed. Elsevier, 2021, Ch 11. Diseases of the musculoskeletal system.

Musculoskeletal Disease including Foot Disorders. In Goat Medicine and Surgery. 1st ed. 2017

Llama and Alpaca Care. Medicine, Surgery, Reproduction, Nutrition, and Herd Health. Elsevier, 2014.

Limb amputations

Poultry

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An interactive H5P element has been excluded from this version of the text. You can view it online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2300#h5p-91

Practice

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https://open.lib.umn.edu/largeanimalsurgery/?p=6808#h5p-145

Equine and Camelid Castration

This section will focus on the principles of equine castration both standing and recumbent. Equine castrations can be performed standing or recumbent and are typically performed on yearlings. As yearlings are big enough to be dangerous and young enough to not be well trained, you need to plan carefully for sedation or anesthesia, the procedure and the recovery. Resources for sedative and general anesthesia protocols can be found in earlier chapters. Review this section to learn

- who, when and where to castrate
- how to castrate
- postoperative requirements
- how to minimize and manage complications

Equine Castration Overview

Overview

Most adult horses are castrated. This minimizes the dangers and decreases the number of unexpected pregnancies. Stallions can be ridden and trained but do need special housing, care, and handling. Most colts are castrated between 6 months and 2 years of age; the ideal age for castration is closer to 1-1.5 years of age.

Testosterone is responsible for the male sexual characteristics in horses, including the muscular jaw, neck and body. Testosterone also stimulates growth plate closure. Animals that are castrated earlier in life develop longer and straighter limbs and grow taller because they grow for a longer period of time. Horses castrated too early may actually develop orthopedic issues (arthritis) due to the straighter limb conformation.

Younger horses can be very challenging to castrate as it does help to have testicles big enough to stay in the scrotum. Smaller testicles can be harder to remove and are more easily confused with other structures (including the penis).

The procedure is usually done on the farm where the colt lives. Supplies are only those brought with you on your truck. Due to variability in horse responses to handing and anesthesia as well as to challenges of working outside, make sure your truck is stocked with double what you anticipate needing!

Castration steps

The following is a rough outline of the process. Please refer to the following chapters for more details.

Ensure the colt is healthy, manageable and has two testicles

Castration is an elective procedure. The horse should be vaccinated (especially for tetanus) and not show any signs of illness. The day of castration is not a time to halter break a colt if there are any alternatives. It is very nice to know how much the horse has been handled and his response to handling. Yes, he has a halter on but does he actually respond to signals?

Do a thorough examination including palpation of the testicles if possible. Be sure and listen to the heart!

Horses are rarely monorchid but can have delayed or inhibited testicular descent (cryptorchidism). It is imperative that either both or no testicles are removed. Leaving one testicle for a later procedure is considered both unethical and unwise. The horse appears to be a gelding but can act like a stallion. Records are not usually reliable enough for a surgical approach and can be separated from the horse. Do not remove a lone testicle. If you *think* you have two testicles, remove the less obvious one first. You can always stop and wake the horse up if it is not truly a testicle.

If you can avoid fly season, that is ideal.

Decide on recumbent or standing castration, location, and roles

Most surgeons have a preference for either recumbent or standing castration. Both work. Sometimes a situation or a horse's characteristics means one is a better option.

A grassy field away from cars, roads, buildings and other animals is best. Stalls are dangerous and sand gets into everything.

Your client should play a minimal role; use your technician, vet student or prevet student for any horse handling.

Administer preoperative medications

Horses should receive an NSAID preoperatively. Antibiotics do reduce the risk of postoperative complications but are not required. Tetanus vaccination should be up to date (within 6 months) or boostered. Remember, the first tetanus toxoid takes a couple of weeks to provide a full response. Tetanus antitoxin can be used to provide an earlier immune response but antitoxin has been associated with serum hepatitis and equine parvovirus infection. If the horse is unvaccinated, it is better to vaccinate with tetanus toxoid and wait, if possible.

Place an iv catheter if desired (a good idea unless you have a donkey or a miniature stallion – sometimes those aren't worth the effort).

Sedate or anesthetize the horse

This includes placing a local block in the testicle or spermatic cord.

Castrate the horse

Castration may be performed via an open or closed method, depending on whether the vaginal tunic is cut to expose the testicle (open) or removed with the testicle (closed). In most cases, an incision is made over each testicle. Testicles are removed after each artery is ligated, crushed and/or twisted to create hemostasis. The incisions are left open for drainage. Before the horse wakes up, other procedures may be performed such as hoof trimming or wolf tooth extraction.

Recover the horse

The horse is allowed to stand on its own time (if recumbent) and allowed to return to its stall once able to walk safely.

Educate the client on postoperative care

Most horses are stall rested for the remainder of the day. The colt can be fed once he is fully awake. After the first day, the colt should be exercised to keep the surgical site open and draining. Too much swelling will cause the incision to seal together and prevent that drainage. If not draining, the area can readily become swollen and/or infected. NSAIDs help decrease swelling and encourage exercise. A horse turned out on its own and in pain is unlikely to exercise.

Horses may retain stallion like behavior even after the testicles are removed; however, most lose the behavior after a few days or weeks. New geldings can remain fertile for several weeks (it depends on if they have viable sperm in the epididymis at castration and if they ejaculate or not). New geldings should be separated from mares for at least two days; many recommend two months to be totally safe.

Resources

This video gives a general overview of the process (4 min)

Castration in the horse, The Horse, 2001 – nice overview written for clients

Castration complications: A review of castration techniques and how to manage complications. VCNA (2021): 37:259-273

- Note- Please continue NSAIDs for 3 days postoperatively and most horses that develop infections due to premature scrotal closure do not need antibiotics, just drainage.

Castration Planning

As with any surgery, preplanning is crucial.

Work through this narrated powerpoint (3.25 minutes):

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After viewing the introduction above, watch the video below (through 1:30 at least) to get an overall picture of recumbent equine castration. As you watch, think about:

- how old (big) is the colt?
    - (I like the boys to be older/bigger vs younger/smaller. The young ones have teeny floating testicles that are hard to hold still for removal. Some people worry about castrating adult stallions. I think old stallions are easier.)
    - Some colts are so obnoxious (stud like, aggressive and/or attempting to breed Momma) that we have to castrate them at an earlier age
- what season is it?
- where are they performing the castration?
- how does the colt become recumbent and stand up again (how much help does he need)?
- how do they keep the hindlimb out of the way?
- where does the surgeon stand to perform the castration?
- what level of sterility is being used? caps/gowns/masks and gloves (good idea) or something else?This gives a nice big picture overview of the process:

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=269#oembed-2

How does the video compare with what was suggested in the powerpoint above?

Exercises

Level A. Now work through this quiz to review a few more factors:

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https://open.lib.umn.edu/largeanimalsurgery/?p=269#h5p-25

Plan for complications

It is also good to plan for complications and be prepared. The most common complication is postoperative swelling. Other complications include

- facial nerve paralysis
- radial nerve paralysis
- hemorrhage
- evisceration/eventeration
- infection
- tetanus

To prevent facial nerve paralysis, it is important to remove the halter to for recumbent anesthesia. This avoids pressure on the nerve. To prevent radial nerve paralysis associated with recumbent anesthesia, the down forelimb should be drawn forward so that it is in front of the body. This decreases the direct pressure on the nerve. Assign someone with the roles of making sure these things happen. [If they do happen, time and steroids can help. Facial nerve paralysis has minimal complications. Radial nerve paralysis freaks out the horse and the limb needs to be splinted so they can use it properly. Freaked out horses have less brain function than normal.]

Hemorrhage is minimized by using the appropriate means of hemostasis for the animal. For younger colts, about any technique will work as long as it performed appropriately. For larger stallions, an emasculator may not provide sufficient clotting if it is also trying to crush the other structures in the spermatic cord. These do better if the tunic is opened so the artery can be crushed separately and/or ligated. Ligation can be combined with emasculation for additional security. Add ligatures and different size emasculators to your truck.

Evisceration is difficult to prevent but those animals at risk should be identified. In particular, animals with inguinal hernias as foals or requiring cryptorchid surgery are at greater risk due to the larger size of the inguinal ring. Surgery at an equine hospital may be indicated. If not, bring supplies to manage escaping guts (sterile towels, vetwrap, suture and an assistant)

Infection is managed through preoperative antibiotics and good drainage. Large incisions and postoperative exercise will minimize the risk. Warn your owner in advance. This is not a good time to put the colt in a stall for a week.

As horses are very sensitive to tetanus, all surgery patients should be well vaccinated prior to surgery.

Key Takeaways

Why – Stallions can be dangerous and are difficult to house safely with other horses.

Who –Healthy, vaccinated, trained colts that are at least 6 months old and have two testicles . Castration is an elective procedure.

When- Spring is ideal since fewer bugs, but it depends on where you are practicing.

Where – An open grassy field is the best. Avoid stalls, wooded areas and slopes.

How – I prefer recumbent open castration. Castration can also be performed standing.

What else – Preoperative and postoperative analgesics and tetanus are necessary. Preoperative antibiotics recommended. Owners need to be prepared for the aftercare.

Resources

Two Regimes of Perioperative Antimicrobial Prophylaxis for Equine Castration. Journal of Equine Veterinary Science 57 (2017) 86–94

BEVA primary care clinical guidelines: Analgesia; Equine Veterinary Journal, January 2020, Vol.52(1), pp.13-27

Key guidelines produced by the panel included recommendations that horses undergoing routine castration should receive intratesticular local anaesthesia irrespective of methods adopted and that horses should receive NSAIDs prior to surgery (overall certainty levels high). Butorphanol and buprenorphine should not be considered appropriate as sole analgesic for such procedures
(high certainty). The panel recommend the continuation of analgesia for 3 days following castration (moderate certainty) and conclude that phenylbutazone provided superior analgesia to meloxicam and firocoxib for hoof pain/laminitis (moderate certainty), but that enhanced efficacy has not been demonstrated for joint pain. In horses with colic, flunixin and firocoxib are considered to provide more effective analgesia than meloxicam or phenylbutazone (moderate certainty)

Field anesthesia for equine castration

Review the earlier chapter on equine general anesthesia!

Routine recumbent castration (7.14 min)

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Field recovery (3 min)

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After reviewing the introductory powerpoints above, watch this videos, focusing on the anesthesia and perioperative steps (3 min)

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=253#oembed-3

Exercises

Now work through these quizzes to review some additional points:

Level A

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An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=253#h5p-27

Key Takeaways

Why – I like injectable anesthesia because the recoveries are smooth. I prefer recumbent castration as I have more control over the situation.

Who – You need an assistant to help with anesthesia, recumbency and helping with any needed supplies during the procedure. The owner is not ideal.

What – Bring drugs, supplies for scrubbing and restraint and a surgery pack (emasculator, scalpel, hemostats, carmalts) and extras. Bring suture material even if you don't plan to use it. Drugs should include anesthesia, lidocaine, an NSAID, an antibiotic and tetanus toxoid.

When – Anytime typically works as long as everyone is healthy. We don't routinely hold horses off feed for castration.

Where – Grassy fields are great for anesthesia and recovery. Please stand on the back side of the horse to avoid being injured

How– Drop the horse using a sedative and induction agent(s). Typically we use xylazine followed by midazolam+ketamine. Catheters and triple drip make life easier. Lidocaine block also prolong your anesthesia time and make the testicle easier to remove since no pain retraction. Protect the facial and radial nerves! Control the head to control the horse. For field recovery, just stay out of the way and make sure your last drug was a sedative, not ketamine.

RESOURCES

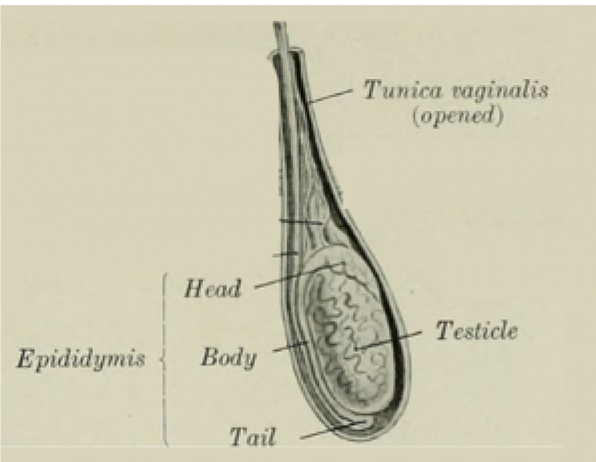
Equine Drugs Chapter

How to - Equine Castration, Recumbent

Indications

Equine castration is performed to remove the aggression and attention deficits associated with stallions.

Relevant anatomy



Preoperative management

Food restrictions:

Ideally, food should be withheld for 6 hours. This is rarely performed but a heavy meal should be avoided.

NSAIDs/analgesics:

Preoperative NSAID administration is indicated to minimize pain and inflammation. Postoperative NSAID administration is strongly recommended for 3 days, longer if complications. Common choices are flunixin meglumine or phenylbutazone.

Antibiotics:

Preoperative antibiotics decrease complication rates. Procaine penicillin G or Excede are commonly used and are similarly effective.

Tetanus prophylaxis is required.

Local blocks:

Cord blocks are more challenging but more effective; lidocaine can also be injected directly into the testicle. Intra-testicular mepivacaine is likely to be more effective at relaxing the cremaster muscle.

Position/preparation:

Lateral or dorsal recumbency under general anesthesia (xylazine/ketamine/midazolam/GG or similar combination). Lateral recumbency is better for lung ventilation and can be done with fewer people. The upper hindlimb should be pulled forward to expose the testicles.

Dorsal can make it easier to identify and remove small testicles. Assistance is required for dorsal recumbency.

The scrotum is scrubbed and rinsed with alcohol before and after the local block is performed.
The surgeon cleans hands, applies an alcohol based sanitizer and gloves.

Surgery Supplies:

- Emasculator
- Scalpel blade
- Suture (0 absorbable, avoid chromic gut)
- Sterile gauze
- Scissors
- Forceps – carmalts and kellys

Surgical procedure –

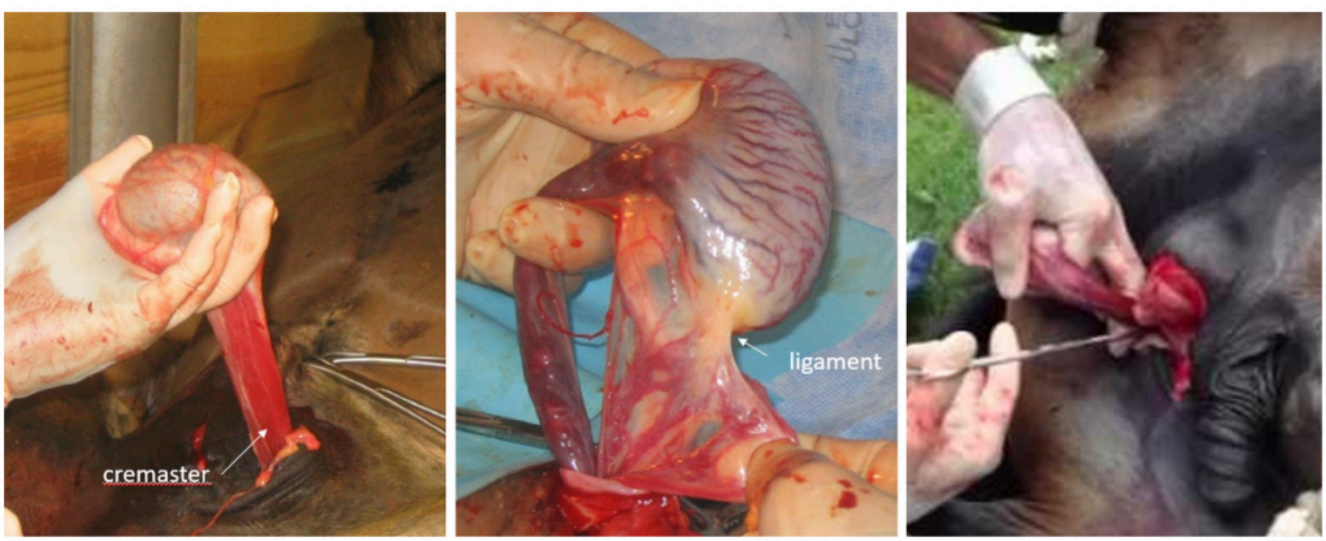
narrated version (9:45 min) – video on youtube

Surgical procedure- written version

After both testicles are identified, the smaller or ventral testicle is removed first to ensure it is a testicle and to make it easier to remove to the second testicle. The testicle is stabilized and an incision made the full length of the testicle along its vertical axis down to the testicle. For an open castration, the tunic is opened and the testicle should pop out. For a closed castration, the tunic is not opened. Dry gauze is used to strip the fascia from the testicle.

Incision made over testicle; tunic opened and stripping fasica in a closed castration

With open castrations, the cremaster muscle can be cut or emasculated (emasculation is quick, easy and minimizes bleeding). Additionally, the ligament to the tail of the epididymis is torn or cut with scissors. The cord is tagged (grasped at the edge) with a hemostat to enable it to be recovered if bleeding is noticed. Avoid crushing vessels with the hemostat; that confuses the issue later when you want to make sure you have a good crush or ligature.



Open castrations showing the cremaster muscle and the ligament to the tail of the epiddiymis. Hemostats used to tag the cord so it can be found later.

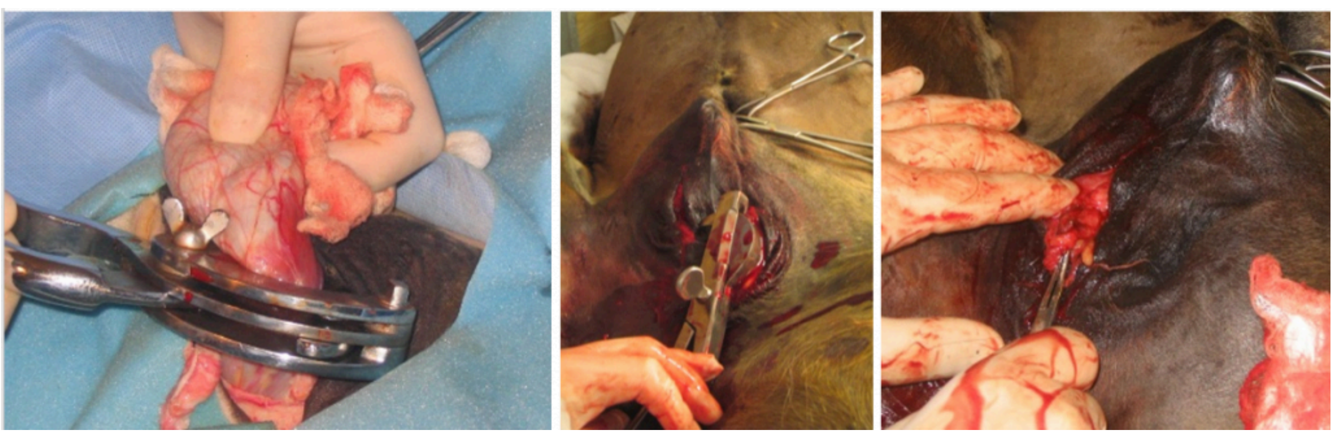
Optional : place a ligature (strangle knot, Millers, transfixation ligature) as far proximally as possible on the cord.

This is much more difficult with closed castrations – note below how far the testicle can be exteriorized from the body in an open versus closed castration.

Closed castration

Open castration

Place the emasculators on the cord, making sure to be at least a few centimeters distal to ligature. Verify no skin is caught in the emasculators. Relax the testicle so there is no stretch on the vessels that would impair hemostasis Crush firmly and completely. Leave the emasculators in place while you remove the second testicle or for at least 1 minute for yearlings, 2 minutes for older horses. The testicle can be transected distal to the emasculators if it is still connected.



Emasculator in place (note nut to nut), testicle removed but emasculator kept in place, hemostats used to hold cord while checking for bleeding

Repeat for the second testicle.

As the emasculators are removed, check for bleeding. Ligate or recrush if needed. Remove the hemostats and check again for bleeding.

Stretch the incisions to ensure good drainage. Optional : cut the median raphe so that if one incision closes, drainage is still possible. Note: this usually wakes the horse up.

Clean up the patient, replace the halter and recover.

Postoperative care

- No food until awake, then feed a normal ration
- Stall rest until the following day. Then pasture turnout with forced exercise for 20 minutes per day or more.
- Continue NSAIDs for 3 days.
- Monitor for swelling, arterial bleeding, eventration or off feed (fever). The wound should drip constantly for at least several days.

Complications

- swelling
- facial or radial nerve paralysis
- infection
- eventration/evisceration
- hemorrhage
- hematoma if scrotum closed
- penile trauma if mistaken for a testicle

Videos

Video on youtube. Note his "modified closed" technique is really an open castration and a better option vs modified closed (7:50 min)

Video on youtube. Student castration lab (1:47 min)

Resources

You will find many contradictions and old wives tales in the literature, in practice and in the videos. These two articles "win" as far as being the most sound and evidence based. Start here for most efficient use of your time:

- New: Castration complications: A review of castration techniques and how to manage complications. VCNA (2021): 37:259-273
    - Note- Please continue NSAIDs for 3 days postoperatively and most horses that develop infections due to premature scrotal closure do not need antibiotics, just drainage.
- Option: Equine castration : A review of techniques, complications and their management. Equine Vet Educ (2013): 25(9): 476-482

Intratesticular mepivacaine versus lidocaine in anaesthetised horses undergoing Henderson castration, Equine Vet J 2020;52:805–810

Castration complications

R-Vets wild horse castration website

Equitwister, 2015 AAEP

Equitwister use :

https://youtu.be/Z5nHQZjzzSY

Video compilation : good, bad and ugly

Practice: Equine Castration

Key Takeaways

- Open castration is better for larger, older stallions since you can see the artery and crush it individually.
- Closed castration minimizes opening the peritoneal cavity but makes the procedure harder; restricted to younger patients
- Avoid modified open/ modified closed techniques.
- Large incisions are needed for drainage
- Hemostasis is by tissue trauma – crush with emasculators (nut to nut) or twist with the Henderson. Ligatures are optional but handy.
- Always tag the proximal part of the cord before you emasculate because it will be easier to check for bleeding.
- Do not close the scrotum.
- **The epididymis does NOT produce testosterone and will NOT make a horse act like a stud.**

Exercises

Now try your hand at these questions. If you are stuck, try the "i" or "link" buttons for more information

Level A

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Level B

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https://open.lib.umn.edu/largeanimalsurgery/?p=280#h5p-28

Postoperative care for equine castration

Thinking about the processes needed for normal healing and to prevent the common complications, what postoperative care recommendations would you give to your clients?

- Medications:
- Exercise:
- Nutrition:
- Other therapies:
- Monitoring:
- Call if:

Common questions

How long should a horse be stall rested after castration?

> *We typically put them in a stall for 12-24 hours. This has no real scientific background but is most likely related to avoiding eventration and letting any bleeding subside. It would also minimize heat stress and undue activity due to pasture mates. It also allows them to be observed more closely for any potential complications from the procedure or anesthesia.*

How long are pain medications indicated? Antibiotics?

> *Inflammation usually lasts at least 3 days after minor surgery. It is good animal care to provide freedom from pain. Older practitioners will report that we don't want horses to "overdo" it so they avoid NSAIDs. On the other hand, people used to "break" horses right after castration as they were more amenable (ie in pain and sedated). Neither version seems reasonable these days but old habits die hard.*

> *The ideal for antibiotic coverage is to have high levels at the time of surgery in case things go wrong. If all goes well, continued antibiotics are typically not needed for castrations. Drainage is better than antibiotics at resolving any infection. Antibiotics are considered when the animal shows systemic signs (eg fever) despite adequate drainage.*

When after castration does the stallion-like behavior goes away? Fertility?

> *Residual testosterone effects can last 6 weeks. Fertility should diminish sooner. Some stallions retain stallion-like behavior despite gelding-like testosterone levels. Another old wives tale is that these stallions are "proud-cut" and the "squealer" was left behind. In other words, the epididymis was left behind. The testicle is what makes testosterone and "squealing" in intact stallions, not the epididymis. And it is actually*

hard to leave the epididymis behind unless the horse is a cryptorchid. In those horses, the epididymis is often loosely attached to the testicle and may be the thing removed. Leaving the testicle behind will definitely encourage them to retain stallion like behavior.

When should they call you about swelling, hemorrhage, things coming out?

This is a great time to come up with your favorite food or sports ball references. "Orange" sized swelling is generally okay. Bigger often indicates that the incisions have sealed shut (via fibrin tags) and will need to be reopened by a veterinarian. Hemorrhage that is a drip is ok, not a spurt or a stream. Things coming out may be fat (okay), tunic (okay), omentum that is attached to intestines or intestines (really bad). Images may or may not help with "things coming out" and an emergency visit is advised.

How is swelling managed?

Exercise is key to minimize swelling. Even after the horse is turned out, it is important to give them at least 20 minutes of forced exercise (hand walking) per day, following surgery. Swelling is common as the area has been traumatized and is ventral. With exercise, lymphatic flow is improved and the edema removed. NSAIDs and cold water hosing can also help. If the swelling is significant, the edges of the incision tend to seal back together, trapping in bacteria. To reopen the incision, just pull the fibrin seal apart with digital manipulation. Do NOT take a scalpel blade back in there. It isn't needed.

Exercises

Try the quiz to see how much you have learned

Level A

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=302#h5p-38

Key Takeaways

Drainage is key for postoperative management of the surgery site. To have adequate drainage, you need large holes and minimal swelling. To get minimal swelling horses need to exercise. Horses without pain relief will not exercise well. NSAIDs help them exercise and help with swelling. Horses should get about 3 days of NSAIDs postoperatively. One day of stall rest if often recommended but isn't required.

If the drainage stops too soon, an infection is likely to develop. Drainage needs to happen. Generally recreating drainage just means using a gloved finger (with the horse sedated and twitched) to open the fibrin seal. Antibiotics are used only if the horse still has a fever after drainage.

Arterial bleeding, large swelling and things hanging out need veterinary attention. Large swelling is important, the others can be life threatening and need immediate attention.

It takes awhile for the horse to become infertile and to lose the mounting behavior of stallions. Keep him away from mares for about 6 weeks. Proud cut is not a thing.

RESOURCES

Equine Castration Complications Reviewed, The Horse 2013

Castration in the Horse, The Horse 2001 (but still really good)

Standing equine castration

Watch this explanation of standing castration (9:53 min) – see on youtube

Did you identify the error in her explanation? Hint: It was the part about the function of the epididymis. What part of the gonad actually produces testosterone? And she gave her drugs after the fact; they are much more effective preop.

Exercises

Now work through this exercise for more on standing castrations:

Level B

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=305#h5p-32

Key Takeaways

Evaluate your patient. Will he be safe if he feels pain or something funny? If he isn't safe without pain, abort the plan and offer a recumbent castration.

Stay close to the horse and with your handler on the same side

Give your preop medications (NSAID +/- antibiotic) PREOP.

Do not use xylazine alone as your sedation. Xylazine+butorphanol or detomidine +butorphanol would be much safer.

Block the spermatic cords and the skin with lidocaine.

If complications (hemorrhage, evisceration), you will want to lie him down. Be prepared for that possibility.

RESOURCES

Equine Standing Sedation

Video compilation– no video is perfect!

Camelid Castration

Overview

Llamas are castrated after they are at least 18 months of age unless behavioral issues develop earlier. Llamas are slower to mature than manny other species and need more time to develop. If castrated too early, they develop very straight hindlimbs and this can lead to stifle issues. Alpacas can be castrated at a slightly younger age as they seem to have fewer issues with early castration.

Preoperative medications

Camelids should be vaccinated for tetanus toxoid and receive preoperative NSAIDs, typically flunixin meglumine. Oral meloxicam can be used but needs to be given a few hours in advance to be present at sufficient blood levels. Due to their small testicles, recovery is straightforward and the infection risk is low.

Anesthesia

Llama lullaby is the standard anesthetic protocol, with alpacas being less sensitive and needing more drug per kg bodyweight.   Due to the risk of regurgitation and aspiration, animals should be fasted for at least 12 hours. Similarly, the head should be positioned to ensure any saliva or regurgitant drains out of the mouth vs down into the lungs. Atropine is avoided as it thickens salivary secretions.

Local anesthesia minimizes the need for other drugs and lowers the pain levels postoperatively. Cord blocks or testicular blocks should be performed.

Surgery

Camelids can be castrated like big dogs or like small horses. Either a prescrotal or scrotal incision can be used. The testicular artery can be emasculated or ligated. The incisions can be closed or left open.

Recovery

Once the procedure is completed, the animal should be propped into sternal with the head supported until the animal can support it himself.

Postoperative care

The animal should be monitored for appetite and attitude as well for any bleeding or eventration but complications are very rare.

Male like behavior usually lessens within 24 hours but, at least in other species, males may be fertile for at least 6 weeks. (Little information is available for camelids). Occasionally male behavior is learned and does not fade with castration.

Special conditions

Cryptorchidism is rare but missing testicles can be hard to find.

Inguinal herniation is very rare.

Practice

Level A Exercises

Review your anesthesia info:

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=282#h5p-49

Earlier today you castrated a 2 yo alpaca. Flies were bad so that affected your choice of procedures. It had been 6 months since he had his spring shots but he was otherwise healthy and there were no complications. Please fill out the following surgery report.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=282#h5p-50

Resources

Camelid sedation and anesthesia

Routine Camelid Procedures – Part 1: Castration of Alpacas and Llamas, 2019 VetFolio

Ch 62 Reproductive surgery in Llama and Alpaca Care

Ch 64 Castration in Veterinary techniques for llamas and alpacas

Donkey castration

Donkeys are not just small horses! They tend to be more resistant to handling, anesthesia drugs and hemostasis. Plan on needing more patience, more drugs and suture. This vet talks through two castrations in different situations and different attitude donkeys.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=477#h5p-77

Watch on youtube

She does a great step by step for everything from calculating doses to how to find the jugular vein. You can also admire her calm control of the situation regardless of what happens.

Key components

8:44 – Drugs

20:42 and 24:09- Rope placement and induction, how to do rope restraint of back leg

25:53 – local blocks

27:00- Surgery – open castration with ligature-

Skip to:

43:21 -outside with a nervous jack

45:19- how to make a squeeze chute with two panels and a post

51:30 -recovery of nervous jack- could just let him get up on his own but notice she mostly just tries to hold him still so he doesn't stumble

Feel free to watch the entire thing (or thru the first end of castration at about 36 min). She covers instruments, why to castrate, preop exams and more.

Exercise 1

Thoughts on the video:

1. How did her doses (1.1 mg/kg xylazine and 2.2 mg/kg ketamine) compare to a horse of the same size?
2. What does the epididymis really do? What would happen if you leave it behind?

3. Why would standing castrations be more risky in donkeys (for the donkey)?
4. How does her recommendation for restriction from jennets (3 days to be infertile, 6 weeks to be less stud-like) compare to the restrictions from mares?
5. What tips and tricks did you take away that would apply to any equid? Standard donkey weight of 550# was one I liked.

Exercise 2

Time to try finding some answers. Use whatever you can find to explore more about jack castrations:

1. She didn't give NSAIDs. Those are really useful. When should they be given?
2. Donkeys metabolize drugs differently. Do you need a different dose or frequency of NSAID administration for donkeys?
3. Donkeys have a tendency to bleed more. Why is that? Do most people ligate as she did?
4. Donkeys may not want to exercise properly. What do people recommend to minimize swelling in donkeys?
5. Donkeys can be extremely overweight. How will this affect drug dosing and recovery from anesthesia?
6. Some people feel older donkeys are unsafe to castrate? Why is this and is it true?

Exercise 3

Test yourself.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=477#h5p-44

Resources

Validation of a donkey pain scale. Front. Vet. Sci., 11 June 2021

Emergency Management for Donkeys and Mules, 2021 VCNA Vol 37 pp 495-513

Clinical approach to castration in the donkey, In Practice 2007;29:526-531.

Anesthesia and analgesia of the donkey and mule, Equine veterinary education. , Vol.25(1), p.47-51

Cryptorchidism

Use the resources below to find the answers to these questions. Then try to quiz to verify your answers.

Study Questions

Cryptorchids come in 3 flavors – high flankers, abdominal cryptorchids and monorchids. Monorchids are very rare.What is the difference between the other two?

Could either high flankers or abdominal crypts be reasonably castrated in the field?

What is the descent path of the testicle (so where might a cryptorchid testicle be found)?

Which testicle descends last (and might be more likely to be abdominal)?

If you are attempting to find the missing testicle on a cryptorchid animal, should you remove the descended one first?

What are the possible consequences of leaving a testicle in the abdomen, particularly if you remove the other?

Exercises

Now try your hand at these questions.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=445#h5p-37

RESOURCES

Testicular descent animation

Cryptorchidism, McCue CSU- short and sweet overview

Cryptorchidism, ACVS- client focused but has some good details included

The Ambulatory Practitioner and the Referral Center, Volume 28, Issue 1, April 2012, Pages 69-81- discusses pros/cons of referral cryptorchid surgery

Inguinal percutaneous ultrasound of cryptorchids, Equine veterinary education. , Vol.28(3), p.150-154 – cool stuff

The Cryptorchid, R-Vets- Note: just because you CAN do a cryptorchid surgery in the field, doesn't mean you

SHOULD in most cases. Your ethical obligation is to provide the best care possible. If referral is possible, that is generally the best care.

Inguinal hernias

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=447#oembed-1

In horses, inguinal hernias are seen in babies (not usually an emergency) and in breeding stallions (an emergency). In both, the hernia is related to a vertical inguinal canal. The inguinal canal is comprised of an internal inguinal ring, an external inguinal ring and the space between them. In most adult animals, the canal is slanted, making it more difficult for things to just drop through. In geldings and mares, the rings are also very constricted. When stallions are in a breeding position, the rings are more directly lined up and intestines can slide through the canal and into the scrotum. When the horse returns to a regular standing position, the intestines and their blood supply are squeezed and will soon become strangulated. Emergency referral to a surgical facility is essential.

In babies, the inguinal canal is also vertical but the intestines do not get stuck and can be shoved back into the abdominal cavity, even though they quickly slide right back into the inguinal canal. Over time, the rings adjust position and the hernia typically resolves. Mother nature usually takes care of this without intervention. Hernia wraps (diapers) and surgery are not usually needed. However, babies should be checked on a daily basis to make sure the hernia is reducible and the intestines are not trapped. If the baby should become colicky or the intestines seem to be stuck, emergency referral is indicated.

Certain breeds are predisposed. Saddlebreds, Standardbreds, Tennessee walking horses, draft breeds and Andalusians are at higher risk.

These foals may be at increased risk of evisceration at castration so extra precautions should be considered. Closed castration, restricted exercise and having the procedure performed at an equine hospital may mitigate the risk. If you open the tunic and can slide a finger up it, the ring is bigger than usual! You can palpate the inguinal ring via rectal palpation and check it for intestines. You can also ultrasound the area if concerned.

Closure of the internal inguinal ring is challenging and not readily performed in the field.

Note: In rare cases, the intestines herniate due to trauma to the body wall. Intestines are subcutaneous vs in the inguinal ring and scrotum. This condition does require emergency surgery.

Study Questions

Inguinal hernias in adult stallions are concerned emergencies and often require surgery to remove entrap intestines. What about in foals? Are these emergencies? Do they need surgery?

How do you diagnose them? How are they managed? Are there breed predilections?

How would you adjust your castration plan if you knew the horse had a history of inguinal hernia? Diagnostics? Surgical approach? Postop care?

Are they considered an inherited trait?

Exercises

Try these after you do your research:

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://open.lib.umn.edu/largeanimalsurgery/?p=447#h5p-43

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://open.lib.umn.edu/largeanimalsurgery/?p=447#h5p-85

RESOURCES

Management of inguinal hernias in foals, VetFolio, 2019

Hernias explained, The Horse, 2008

Selected pathological conditions in horses, AAEP 2015 page 272 (will link to the entire proceedings)

JUST FOR FUN

Guts being pulled out of inguinal hernia laparoscopically – not usually required but note how healthy they look

Castration complications

With any surgery, there are standard complications:

Infection

Equine castrations are generally performed in a non-sterile environment with incisions left open; contamination is ensured. As long as the incisions stay open for drainage, infection doesn't typically cause any problems. Issues with infection develop when drainage is impaired (as when the incisions close up too soon) or when chromic gut is used to ligate the vessels (since it is highly irritating). Gut is rarely used for castration now and other suture types seem much safer.

Infection at the castration site can potentially extend into the abdomen, causing peritonitis. Subclinical peritonitis definitely occurs after castration but rarely causes issues. Open castrations are potentially riskier in that they open the peritoneal cavity but closed castrations carry other risks.

Hemorrhage

The testicular arteries can bleed well. Generally hemorrhage is controlled by innate clotting mechanisms, ligation or by pressure.

It is close to impossible to apply effective pressure to the testicular arteries due to their location.

Many castrations are performed without ligation, using only crushing to stimulate natural clotting. If the crush is not effective, hemorrhage can be significant and potentially fatal. To ensure a good crush, the emasculators need to be assembled and used correctly so that the crush is proximal on the cord and the cut is distal. New emasculators can accidentally cut with the crushing part of the instrument. Many practitioners use the emasculators on rope a few times to dull the new metal in the crush section.

Ligatures can be used to control hemorrhage. Modified Miller's knots are more effective than typical surgeon's knots but both can be used successfully. Use material that will not cause long lasting irritation (eg not chromic gut).

Swelling

Swelling is always an issue with surgery and is always exacerbated in ventral locations such as the scrotal area. Swelling will occur with your surgery and is typically the most severe at 2-3 days postoperatively. After that time it should decrease gradually; continued swelling can indicate infection.

Swelling can be decreased by pressure, cold hosing, NSAIDs and exercise. As applying pressure in the area is tricky, that is typically not used.

Cold hosing can be used if tolerated by the horse. The hose should not be directed up into the incisions since that would be aiming directly into the abdomen. Some horses will not tolerate cold hosing and it is not worth the risk to the owner or to the horse.

NSAIDs should be part of your protocol both for analgesia and control of swelling.

Exercise will help to minimize and reduce swelling by encouraging blood flow and lymphatic drainage.

Hydrocoele is another complication that can lead to swelling. The tunic closes and peritoneal fluid fills the tunic giving the appearance that the horse has regrown his testicles.

Poor healing

Poor healing is generally related to the factors listed above or to foreign material in the wound. If the incision continues to drain and does not close, it is likely that there is or was a foreign body in the wound. General anesthesia and wound exploration is indicated. Persistent infection can lead to spermatic cord infection. Spermatic cord infection can extend into the abdomen and require abdominal surgery to remove the infected cord.

Tetanus

Tetanus is uncommon but is life-threatening and horses are very sensitive to the bacterium. The vaccine works well and is highly protective. A booster is required for full protection. Since castration is an elective procedure, horses should receive their initial tetanus toxoid at least two weeks prior to castration and can receive their booster shot at the time of castration. If a horse must be castrated in a shorter time frame, tetanus anti-toxin is recommended to provide immediate protection. Serum hepatitis is a risk with tetanus antitoxin.

Tetanus vaccines are widely available; however, cold storage is necessary to maintain efficacy. Clients may not be aware of the careful handling and storage needed.

Evisceration

Evisceration is a risk for any abdominal incisions or wounds. Intestines are slippery and can fit through small holes, particularly when the holes are ventral. Gravity works in most parts of the world and once the intestines start to slide out, the weight of the exposed intestines means more is likely to follow.

Challenges

Use your search powers (see the resource page), your new knowledge base and the resources below to try and find answers to the questions below.

- When is postoperative hemorrhage considered significant? What would the owner notice?
- Why is it important to not have the cord stretched out when applying the emasculators?
- What would you ligate a cord with? Hint: Gut is bad.
- If hemorrhage is significant, would you manage the colt standing or recumbent? What do you do? What if

you can't do that?

- What extra supplies should you bring with you for castrations, just in case of hemorrhage?
- **
- When is postoperative swelling excessive? What size fruit?
- What is the association between postoperative swelling and drainage?
- When and how do you open up the swelling to allow it to drain?
- Should the horse be on antibiotics? How do you know?
- How do you prevent issues with postoperative swelling?
- What is the time frame for swelling after surgery?
- ***
- What structures could come out the scrotal incisions besides intestines? What would an owner be able to identify to tell you about?
- Are certain breeds, ages or conditions more prone to evisceration (eventeration)? What would you do to prevent issues?
- What is the time frame for risk of evisceration after castration?
- The animal stands up and is eviscerating. Do you manage him standing or recumbent? What do you do? What if you can't do that?
- What extra supplies should you bring with you for castrations, just in case of evisceration?
- ***
- What is schirrous cord/ Why does it develop?
- Are certain breeds, ages or conditions more prone to schirrous cord? What would you do to prevent it?
- What is the time frame for when schirrous cord is likely to happen after castration?
- How do you diagnose schirrous cord?
- How do you treat schirrous cord? What if you can't do that?
- What extra supplies should you bring with you for castrations, just in case?
- **
- When does penile trauma happen and what is needed for treatment?
- When does hydrocoele happen and what is needed for treatment?
- What does peritonitis look like and what is the treatment?

Exercises

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=286#h5p-174

Try these cases to see if you agree with my recommendations:

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=286#h5p-42

RESOURCES

A prospective multicentre survey of complications associated with equine castration to facilitate clinical audit. EVJ 2019- spoiler alert – they didn't find many complications. And the Brits are way ahead of us with proper analgesia.

How I manage castration complications in the field, AAEP 2015 p 224.

Incidence, management and outcome castration complications, JAVMA 2013

Review of castration complications: Strategies for treatment in the field, AAEP 2009

Open standing castration in Hong Kong: prevalence and severity of complications, EVJ 2018

Surgical management of postcastration spermatic cord infection in horses, Vet Surgery, 2018

Castration Summary Points

Key Takeaways

- Castration is an elective procedure. Make sure your patient is healthy, able to be handled and has 2 testicles
  - Early castration leads to delayed growth plate closure and taller, finer boned and straighter-limbed animals
  - Early castration may result in narrowed urethras
- Give analgesics preoperatively to prevent windup phenomenon. Local blocks help.
  - continue analgesics postoperatively
- Most recumbent anesthesia procedures use xylazine/detomidine/romifidine combined with ketamine. Adding butorphanol, diazepam or midazolam, or guafenesin can increase the effective duration and smooth recovery
  - Detomidine gel is absorbed through mucous membranes and can provide some sedation (takes about 30 min to work)
  - Diazepam doesn't play well with others; can be mixed with ketamine but not xylazine
- Tetanus toxoid is required. If the horse has been vaccinated within the past 6 months, that is usually considered adequate.
  - Tetanus antitoxin has side effects.
- Preop penicillin (or ceftiofur) may decrease complication rates. Giving after the procedure is not as effective.
- Surgery and recovery is best done in an open grassy field.
  - Field recoveries are generally low risk even with wild things but finishing with xylazine or romifidine (1/4 dose) can help smooth things
  - You can keep a horse down by controlling the head and neck (sit on the neck, hold the nose up)
  - Remove the halter to avoid pressure on the facial nerve
- Closed castration is preferred in young animals; open castration in horses with large arteries
  - The more I do, the less I like closed castrations
- Don't remove any testicles unless you are sure you can see both
- Plan for complications and ensure you have needed supplies
  - Especially suture and more drugs
- If hemorrhage or evisceration develop, re-anesthetize the horse.
- Most common complication is postoperative swelling due to early closure of the wound
  - Exercise is important for minimizing swelling postop

  - Make big holes and stretch the skin to make the incision as big as possible
  - Leave holes open!
  - If the incisions close, they can be reopened using your fingers. Twitch the horse first!
- Inguinal hernias in foals usually resolve on their own. Surgery or medical care is not needed.
- Cryptorchid stallions are not ideal breeding candidates.
- Proud cut doesn't exist despite continued beliefs from horse owners and horse vets
  - So just remove the epididymis and don't blame it
- You have less control over standing castrations

Practice: Equine and camelid castration

Level A Exercises

Take the castration review quiz as often as you like. Different questions will come up each time.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=516#h5p-40

Camelid review:

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=516#h5p-51

Level B Exercises

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=516#h5p-169

How does what you have learned compare to this castration:

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=516#h5p-52

For Future Reference I Castration planning

Optional. Complete the study guide to review the steps BEFORE you get ready to castrate a colt.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=259#h5p-23

For Future Reference | Field Anesthesia

Optional. Complete the study guide to review the steps BEFORE you get ready to anesthetize a colt for castration or similar short procedure.

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://open.lib.umn.edu/largeanimalsurgery/?p=330#h5p-29

For Future Reference I Postcastration Instructions

Optional

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=533#h5p-41

FA youngstock processing

This section discusses the surgical components involved with youngstock processing in food animal species.

Bovine castration

Overview

Calves can be castrated at any age but are typically castrated within the first week to first few months of life. Newborn calves are easier to restrain and handle and experience less bleeding and infection. Production parameters (weight gain) are also minimally affected in the younger calves.

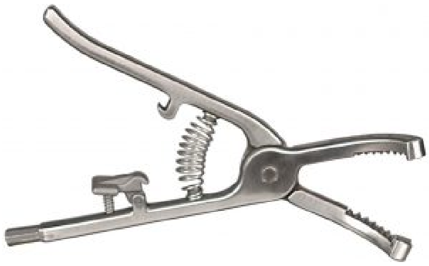
Generally producers and owners castrate their calves. Rarely would a vet be called to perform routine castration but vets may be asked to train new owners or to work with rescue groups. General types of castrations and tools are bloodless (burdizzos, banding) or open (blades).

Newbury knife

Open castration is more common in northern climates and in colder weather. Fly control is necessary. A scalpel blade may be used to remove the bottom third of the scrotum (after pushing the testicles up) or a special knife (Newbury knife; left) can be used to open the scrotum down both sides using a guarded blade for extra safety.

Once the testicles are exposed, they may be removed by pulling the cord apart (hold the proximal end well) or by using tools. With the pull method, the trauma causes vascular spasm and vessel clotting. This works best in young animals (<3 mo old) with smaller cords (and arteries). Twisting or tearing of vessels stimulates the clotting cascade; cutting doesn't.

The Henderson tool was developed in cattle and twists the cord to create trauma (releases clotting factors) and hemostasis.



Henderson tool

Emasculators or ligatures can also be used in large animals.

[Video on youtube]

[Castration with Henderson tool]

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=1160#oembed-1

Bloodless castration is created by crushing the cord vessels, leading to ischemic necrosis of the testicle and skin.

Banding. An elastrator tool is used to stretch the rubber rings so they can be passed over the scrotum and released on the cord. The scrotum and testicles fall off in 30-40 days. Elastrator bands can lead to tetanus and seem to have the most significant effects on the calves (pain or discomfort). They should not be used on older calves as the crush may not be sufficient. It is also easy to miss a testicle that slides up and out of the way, leading to incomplete castration. The Callicrate bander operates on similar principles to the elastrator tool but can be used on adult bulls.

Jeffers Band Castration Tool

One or more interactive elements has been excluded from this version of the text. You can view them online here:

Callicrate bander kit

https://open.lib.umn.edu/largeanimalsurgery/?p=1160#oembed-2

Burdizzo. The Burdizzo emasculatome also crushes the cord without cutting the skin. With this technique, the testicles atrophy but the scrotum does not slough. The clamp is placed on each cord individually and at different levels. The crush should be held for ~10 seconds. The staggered crush saves blood supply to the skin while still damaging the cord to each testicle. The Burdizzo is used on calves with slightly larger cords that can be readily palpated.

Burdizzo

Cowsmopolitan ad

Analgesia and anesthesia

Local anesthesia using lidocaine (testicular, cord blocks or epidurals) mitigates the distress of the procedure but does not prevent the cortisol response or postoperative behavior changes. Preoperative NSAIDs improve the cortisol response but are not sufficient pain control for the procedure. The combination is ideal. Meloxicam added to the milk ration at least 3 hours prior to castration makes a noticeable difference. If the procedures are to be done early in the morning, the drug can be given the night before. Cattle are not super sensitive to lidocaine (high dose 8 mg/kg) but younger animals are less able to metabolize it so some caution with larger volumes is warranted.

Key Takeaways

Bovine castration is best done in young animals with preoperative analgesia (NSAID) and local blocks

Open (surgical) or closed (crushing) methods may be used, with the recommended techniques varying by age.

Resources

Miesner and Anderson. Surgical Management of Common Disorders of Feedlot Calves. Vet Clin Food Anim 31 (2015) 407–424

JF Coetzee. Assessment and Management of Pain Associated with Castration in Cattle. Vet Clin Food Anim 29 (2013) 75–101

JM Ewoldt. Surgery of the scrotum, Vet Clin Food Anim 24 (2008):253–266

Castration of calves fact sheet, Ontario 2007 and Castrating beef calves, UTEnn – useful for age ranges and complications

Does UK licensed NSAID administration reduce signs of postoperative pain in calves castrated without local anaesthesia? Veterinary Evidence, July 2021

- good review of other studies

Barrell/Knauer Yak intratesticular block

Small ruminant castration

For castration, small ruminants are essentially small calves. The same techniques apply

- surgical
    - blade to open the scrotum with testicle removal by traction, emasculator, or ligature
- bloodless
    - Bander/rubber bands – considered the most painful and may be inhumane in older goat kids
    - Burdizzos- stagger crushes to avoid the same issues seen with banders
    - Callicrate bander – for older goats
    - Short scrotum method – the scrotum is banded, leaving the testicles in place but pushed close to the body

Goats are very sensitive to pain so it is essential to provide sedation and analgesia. Goats are also very sensitive to lidocaine. A maximum dose of 4 mg/kg is recommended. The lidocaine can be diluted to make the small volume go further; this does result in a shorter duration of action. Hint : Lidocaine is 2% or 20 mg/ml. Preoperative NSAID options include flunixin meglumine iv or meloxicam orally. Sedative options include xylazine or detomidine (careful with xylazine dosing and avoid these drugs in sheep) or diazepam/ketamine.

Goats are also prone to tetanus so should receive tetanus vaccination.

Many goats are disbudded and castrated in the first week of life. Pet goats might benefit from more growth prior to castration, particularly in case it helps urethral diameter.

How to castrate a goat

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2147#oembed-1

Key Takeaways

Small ruminants may be castrated by surgical or crushing techniques; banding is not ideal and is being gradually replaced by the short scrotum method in other countries.

Goats need preop analgesia and local blocks; sedatives can be helpful. Be careful with xylazine in sheep.

Small ruminants are sensitive to lidocaine; careful dosing is essential.

All small ruminants need tetanus vaccination.

Small Ruminant Castration Guide – includes other resources

The short scrotum method of castration in lambs

Caudal paramedian approach to cryptorchidectomy in 29 small ruminants (2011-2019). Veterinary Surgery. 2021;50:170–176.

Piglet castration

In the USA, pigs are castrated at a young age to avoid boar taint, a slight odor/taste to meat. In Europe, many food buyers will not buy castrated pigs but they sell pigs at a younger age/lighter weight and are more used to the flavor difference.

Piglets are almost always castrated using an open technique and using traction to remove the testicle.

The same reasons for early castration of calves also apply to pigs: castrate young animals for easier restraint and handling, fewer complications and minimal impact on pig weight gain, etc. Piglets are generally castrated 4-14 days of age. This avoids the first few days when they are absorbing colostrum, makes it easier to identify inguinal hernias, and is still well before weaning. Piglets should be castrated at least 5 days prior to weaning to minimize the risk of combined stressors.

The industry standard is changing to encourage local anesthesia as part of pig castration. Lidocaine can be administered intra-testicularly. Adult pigs are NOT very sensitive to lidocaine with a high dose of 8 mg/kg but neonates will be more sensitive. Meloxicam is secreted through the sows milk so feeding meloxicam to the sow at least 3 hours prior to castration would add analgesia and prevent windup.

Piglet castration steps. VA Cooperative Extension:

Castration Method for One Person Using a Surgical Knife (adapted from PIH 01-01-07)

1.	Hold the piglet by both hind legs with its head down.
2.	Using the thumb, push up on both testicles.
3.	Make an incision through the skin of the scrotum over each testicle in the direction of the tail.
4.	Be sure the incisions are made low on the scrotal sac to allow for fluid drainage.
5.	It does not matter if you cut through the white membrane of each testicle or not.
6.	Pop the testicles through each incision and pull on them slightly.
7.	Pull each testicle out while pressing your thumb against the piglet's pelvis.
8.	Thumb pressure on the pelvis is important to ensure that the testicular cords break off at the point of your thumb rather than deep inside the body, which may promote development of a hernia.
9.	If necessary the testicle may be cut free of the cord using a scraping motion.
10.	Cut away any cord or connective tissue protruding from the incision and spray the wound with antiseptic.

Youtube video

Key Takeaways

Piglets should be castrated at a young age, using analgesics and local anesthesia

Pigs are prone to inguinal hernias; waiting until at least 4 days of age enhances identification of problem pigs.

Resources

Bates et al. Impact of Transmammary-Delivered Meloxicam on Biomarkers of Pain and Distress in Piglets after Castration and Tail Docking-2014, PLoS One

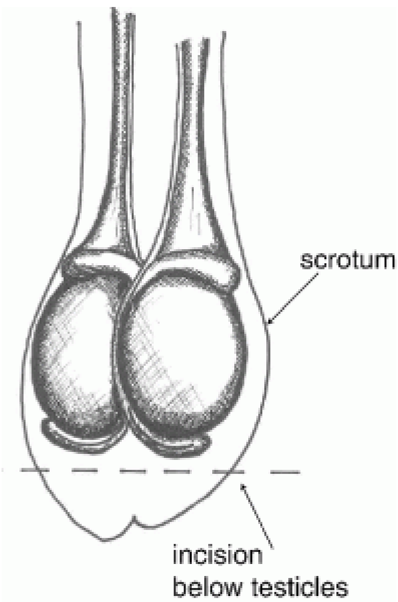
JF Coetzee et al. Transmammary delivery of firocoxib to piglets reduces stress and improves average daily gain after castration, tail docking, and teeth clipping. *Journal of Animal Science*, Volume 97, Issue 7, July 2019, Pages 2750–2768, Skelton JA et al. Cryptorchidectomy with a paramedian or inguinal approach in domestic pigs: 47 cases (2000–2018). J Am Vet Med Assoc 2021;258:1130–1134

How to - Open castration

Indications

Calf, lamb and piglet castration is typically performed on farm by the producer or an employee. However, many goat owners would prefer a veterinarian castrate their pets and more farm animal rescues are in need of assistance.

Relevant anatomy



Preoperative management

Food restrictions: NA

NSAIDs/analgesics: NSAIDs should be given preoperatively. For young calves, meloxicam added to the milk ration 3 hours prior to the procedure provides analgesia.

Antibiotics: NA

Tetanus prophylaxis is recommended.

Local blocks: Cord block, testicular block or epidural.

Position/preparation: Standing or recumbent. Goats should be sedated for the procedure.

Surgery Supplies:

- Scalpel blade or Newbury knife
- Emasculators (depending on age)
- Suture 0 absorbable (depending on age)

Surgical procedure

The testicles are pushed toward the body and the distal third of the scrotum removed with a sharp incision. The testicles should drop out of the scrotum. Depending on the age of the animal, the cords can be pulled (creating hemostasis by traumatizing the vessel), emasculated or ligated and transected

Postoperative care

- NSAIDs should be continued for 1-3 days to optimize recovery
- Monitor for incisional issues (infection, evisceration) and animals going off feed

Complications

Evisceration (rare)

Infection (rare)

Videos

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=3125#oembed-1

Youtube video

Adult goat castration youtube video

Resources

[Castration of calves]

FA Inguinal Hernias

Unlike in adult stallions, inguinal hernias tend to be an incidental finding in ruminants and swine (including pot bellied pigs) of all ages. Most cases do not cause strangulation of the intestines and are not emergencies. If you see an enlarged scrotal neck, you should immediately put inguinal hernia at the top of the differential list. Other findings would include a soft, reducible, non painful swelling and intestines entering the inguinal ring on rectal examination. Ultrasound can be used to confirm if needed.



Inguinal hernias in youngstock are considered heritable in most species. Herefords and pigs are particularly prone. Animals should be castrated or not used for breeding. Inguinal hernias in bulls and rams are potentially acquired. While some consider these hernias a delayed manifestation of an inherited issue, others claim the inguinal ring is "stretched" by right lateral recumbency and the growth of a fat pad in the region. Inguinal hernias can be found in females and castrated males but uncommonly.

The biggest concern is for evisceration at the time of castration.

Castration and hernia repair

In young animals, castration is performed with the animal in dorsal recumbency and the intestines returned to the peritoneal cavity by twisting. The tunic is ligated and/or the external inguinal ring closed to minimize the risk of evisceration:

Youtube video

Inguinal hernia repair in adult animals is best done under heavy sedation and/or general anesthesia in a hospital setting. Hemicastration should be performed to enable tight closure of the inguinal ring. Leaving room for the testicular artery to pass through the ring also means leaving room for re-herniation.

Level B:

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https://open.lib.umn.edu/largeanimalsurgery/?p=1162#h5p-78

Key Takeaways

Inguinal hernias are considered heritable in most groups.

FA inguinal hernias are rarely emergencies.

Castration of affected animals should be performed carefully to minimize the risk of evisceration.

Resources

Inguinal hernias in calves and bulls

J Rush et al. Theriogenology question of the month, 2017 JAVMA 250(4) – inguinal hernia in bull

Surgical treatment for different hernias in sheep and goats, JVetSci 2007

Bull examination and testing – includes a classic image

JM Ewoldt. Surgery of the scrotum, Vet Clin Food Anim 24 (2008):253–266

FA cryptorchidism

Cryptorchidism is considered an inherited tendency.

In ruminants, cryptorchidism is supposedly generally due to an ectopic testicle. See pgs 260-261 in Surgery of the Scrotum, VCNA 2008. However, more reports are finding the testicles abdominally.

Cryptorchid testicles are commonly found abdominally in swine. Pigs can also have ectopic testicular tissue. To remove the cryptorchid testicle in pigs, an incision in made in the paralumbar fossa with the pig in lateral recumbency with the affected side up. The testicle is usually large and will be on a path between the kidney and the inguinal ring (the descent path).

> ABSTRACT
> This paper describes features of a study of different aspects of cryptorchidism in sheep in different parts of England. A total of 83 crytorchid testes (57 unilateral and 13 bilateral) were recognised in 70 animals post-slaughter at three abattoirs in the south west of England between June 2000-January 2004. Abdominal cryptorchids (60) were common than inguinal (23); 69% percent of cases were unilateral. External examination for cryptorchidism was carried out on 5134 young male lambs carried out in 2001 at Foot and Mouth Disease disposal sites, and on farms, during the UK outbreak of the disease. A total of 29 cases of cryptorchism [0.56%] were detected; 86% of cases were unilateral. In both situations the right testis was more commonly affected than the left.
> *(10) (PDF) Cryptorchidism in Sheep: A Clinical and Abattoir Survey in the United Kingdom*. Available from: https://www.researchgate.net/publication/276491292_Cryptorchidism_in_Sheep_A_Clinical_and_Abattoir_Survey_in_the_United_Kingdom [accessed Jul 15 2019].e.

> Location of undescended testes differs greatly among species. For cats, dogs and horses, 50, 92 and 47-60% of retained testes were in the abdominal cavity, although 1 report for horses gave 33% abdominal (see Table 1 in Amann and Veeramachaneni, 2007). There are no reliable data for pigs, but subcutaneous locations might predominate.   From Cryptorchidism and associated problems in animals R. P. Amann and D. N. R. Veeramachaneni A, Anim Reprod 20

Resources

JM Ewoldt. Surgery of the scrotum, Vet Clin Food Anim 24 (2008):253–266

Scolo et al. Pig surgery: cryptorchidectomy using an inguinal approach. Vet Rec 2016

SS Nair. Ultrasound Diagnosis of Cryptorchidism in Sheep. Frontier J. Vet. Anim. Sci.Vol.4, No.1(Jan-June) 2015

R P Amann and D N R Veeramachaneni. Cryptorchidism in common eutherian mammals. Reproduction 133(3), 2007- very thorough coverage!

Testicular descent animation

Disbudding and dehorning

Overview

AVMA's position on analgesics during dehorning

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=734#oembed-1

Learning Objectives

Study Questions

Dehorning methods include paste, Barnes, gigli wire, and thermocautery. Are there age restrictions for any of these? If so, what is the recommended/maximum age?

How do you know if the thermocautery has damaged the tissue sufficiently?

What happens if you don't kill off all the germinal tissue when disbudding?

Why do we want to dehorn/disbud calves at a young age?

What nerves do you need to block?

You should be able to find the related local block how tos (reference for future).

What sedation could you use if needed?

Primary sources – use Ctrl F in a document below to find the answers you still need for the study guide

Calf dehorning, Ontario

Technique comparison page, MSU page 6

See images for dehorning vs disbudding, ABBA

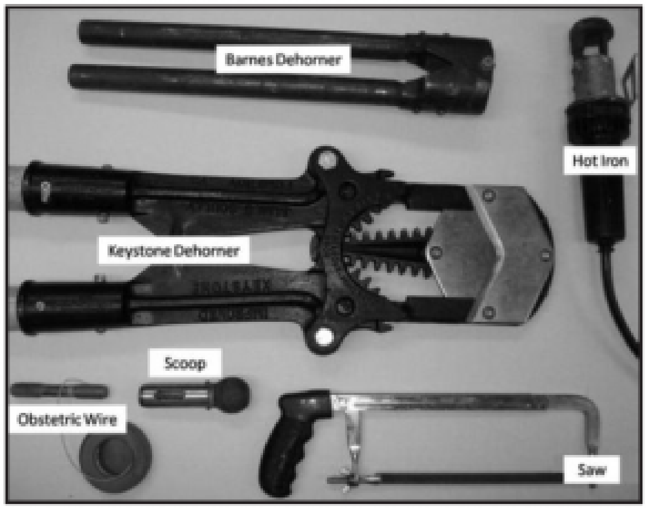


Figure 2. Dehorning Tools

Other notes

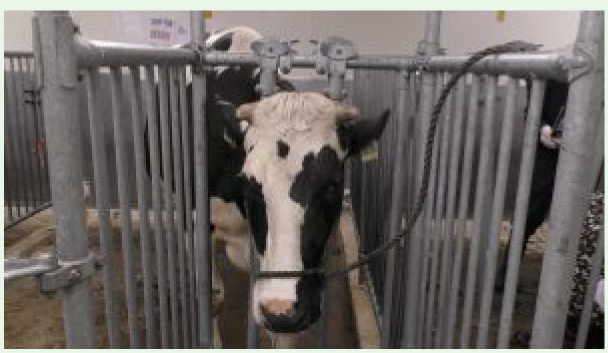
Sandra Baxendell (6/30/19) – uses "Buccalgesic" – a form of meloxicam designed to absorbed through the oral mucous membranes. Lets it work for 5 min (while clipping and weighing). Then she gives 4.5 mg/kg alphaxalone slowly iv (usually 2-3 mls). That gives just enough time to disbud if the iron is already hot.

The cornual block is described under the dehorning chapter; local anesthesia is recommended for all dehorning procedures.

OVC has developed an easier method of local anesthesia – they inject lidocaine subcutaneously under the horn bud vs trying to find the nerves. The same effect could be obtained with a ring block around the horn.

Key Takeaways

- Disbudding should be done at a young age, using perioperative meloxicam, local blocks and/or sedation.
- Hot iron disbudding is most popular. Burn until a copper ring is achieved. Burn again if necessary. Don't burn through the skull (brain is underneath)
- Scurs form if the bud is incompletely cauterized.
- Dehorning opens up the sinus and can lead to serious infections.
- Horn tipping is an option in adult cattle that are dangerous due to their horns.



Additional resources-

Miesner and Anderson. Surgical Management of Common Disorders of Feedlot Calves. Vet Clin Food Anim 31 (2015) 407–424

P Aubry. Routine Surgical Procedures in Dairy Cattle Under Field Conditions: Abomasal Surgery, Dehorning, and Tail Docking. Vet Clin Food Anim 21 (2005) 55–72

MN Hempstead et al. Pain sensitivity and injury associated with three methods of disbudding goat kids: Cautery, cryosurgical and caustic paste. The Veterinary Journal 239 (2018) 42–47

CD Neely et al. Effects of three dehorning techniques on behavior and wound healing in feedlot cattle. J. Anim. Sci. 2014.92:2225–2229

Dehorning on CCHP rotation

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=734#oembed-2

Xylazine sedation

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Barrell/Knauer dehorning block and bovine sx dehorning block

Dehorning block using lidocaine + xylazine

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How to - Surgical (cosmetic) dehorning

Indications

Surgical dehorning is most commonly indicated in adult goats due to trauma (horn breakage), scurs or missed dehorning. It is referred to as “cosmetic” but may or may not be cosmetic. Adult cattle may be surgically dehorned if not dehorned at an earlier age.

Relevant anatomy

The skin around the horn is tight; this procedure will require tension relief techniques.

The horn is attached to the bone and the procedure will open the frontal sinus.

In goats, the horn scent glands should also be removed

Preoperative management

Food restrictions:

- For goats, the procedure should be performed under general anesthesia. Food should be restricted for 24 hours.
- In adult cattle, local blocks and a chute with a head restraint are typically sufficient. Sedation may be indicated, as well.

NSAIDs/analgesics: Patients should be premedicated with NSAIDs.

Antibiotics: Preoperative antibiotics are recommended as this is a contaminated procedure due to the involvement of the airway.

Tetanus prophylaxis is recommended, particularly in goats.

Local blocks:

The cornual nerve should be blocked in cattle.

- Palpate the temporal ridge.
- Inject local anesthetic below the ridge, halfway between the lateral canthus of the eye and the horn.

- Inject local anesthetic caudal and lateral to the horn bud to ensure all branches are blocked.

Both the cornual and infratrochlear nerves should be blocked in goats. A ring block around the horn can also be helpful.

ring block

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OVC has developed an easier method of local anesthesia – they inject lidocaine subcutaneously under the horn bud vs trying to find the nerves.

Position/preparation:

Cattle are maintained in a standing position. Goats can be placed in lateral or sternal recumbency. Clip and prep a large area (will be needed for closure).

Surgery Supplies:

- scalpel and blade
- gigli wire, wire cutters and handles (keep the gigli wire at least twice the length of your arm)
- hemostats
- mayo scissors
- rongeurs or Barnes dehorners
- saline or LRS lavage solution
- suture (2-0 or 0 nonabsorbable suture)
- needle holders
- bandage material

Surgical procedure

- A fusiform incision is made around the horn, following the frontal crest and as close to the horn as possible. The incision is deepened through the periosteum to bone.

- The edges of the incision are undermined using sharp dissection to allow seating of the gigli wire.
- The gigli wire is used to remove the horn, removing as much bone as possible to permit wound closure
- Bleeding is controlled by pulling any visible arteries with the hemostat
- The wound is flushed and closed

- Closure may require undermining, mesh incisions and/or tension relieving patterns. More bone may be removed using the rongeurs or Barnes (in cattle).
- If closure isn't possible, bandaging is needed to protect the sinus

Postoperative care

- Bandage changes when slipping, wet or dirty, if applicable. Bandaging should continue until a scab has formed. Feed on the ground until the sinus is covered over (prevent hay being pulled into the sinus from an overhead feeder). Fly repellant should also be used.
- Suture removal in 10-14 days
- NSAIDs can be continued for 3 days.

Complications

- Sinusitis
- Lack of closure (will close over the next 4-6 weeks)

Videos

Using a Barnes dehorning to remove the horn in an anesthetized calf. Youtube video

Barnes dehorners should be used very cautiously in the goats as it can readily remove too much skull. Youtube video

Resources

Bovine Surgery of the Skin, 2008 VCNA

Tail docks

Tail docking is routinely done in lambs (to avoid painful fly strike), piglets (to avoid tail biting by other pigs) and less commonly in cattle (for cleanliness to cow, milk and producer). Tail docking may also be performed to treat tail trauma.

Cow tail docking is usually performed by the producer using castration rings. The tail is banded 7-8 cm below the vulva in calves, usually at the time of dehorning. Elective tail docking is now illegal in many states. There is no evidence that it improves cleanliness and there are concerns about pain, altered social communication and impact on fly control. When the tail is traumatized, tail docking can be performed surgically in a similar manner to small animal tail docks.

Sheep tail docking can be performed by rubber ring banding, banding combined with crushing (emasculatome), or hot blade. Most lambs are docked between 1-3 weeks of age. Local anesthesia does help and oral meloxicam would be reasonable. The AVMA has reviewed the practice and recommends:

> *"The Farm Animal Welfare Council (FAWC) recommends that docking should be avoided whenever possible.[22] The FAWC also concluded that tail docking of lambs up to 7 days old is best done with a rubber ring; that lambs between the ages of 1 and 8 weeks old should be docked with a docking iron (hot blade) or a clamp; and that acute pain of tail docking can be alleviated using locally applied anesthetics.[18] "*
>
> *https://www.avma.org/KB/Resources/LiteratureReviews/Pages/Welfare-Implications-of-Tail-Docking-of-Lambs.aspx*

The band is well distal to the caudal aspect of the tail folds

If tails are docked too short, lambs are at increased risk of rectal prolapse. The tail should be long enough to maintain the full length of the caudal tail folds. These folds help move feces away from the perineal region. Other reasonable measures include 3 vertebrae and/or long enough to cover the vulva.

Pigs tend to bite each others tails. Once tail biting begins it continues and can even escalate. This can be minimized by shortening the tails. Tail docking is usually done by hot iron in pigs less than 7 days old. It is commonly combined with teeth clipping. The AVMA is reviewing this practice as well:

> *"Tail docking is performed to reduce tail biting and cannibalism among pigs. Tail docking should be performed early and sufficiently prior to weaning such that no open wounds remain at the time of weaning. Clean, sharp equipment must be used to minimize pain and risk of infection. "*

https://www.avma.org/KB/Policies/Pages/Tail-Docking-and-Teeth-Clipping-of-Swine.aspx

Tail docking in piglets (when performed without any analgesia) has been shown to increase piglet pain, stress and fear of humans.

Resources

C Tallet et al. Evidence of Pain, Stress, and Fear of Humans During Tail Docking and the Next Four Weeks in Piglets (Sus scrofa domesticus). Front. Vet. Sci., 11 December 2019

P Aubry. Routine Surgical Procedures in Dairy Cattle Under Field Conditions: Abomasal Surgery, Dehorning, and Tail Docking. Vet Clin Food Anim 21 (2005) 55–72

C Stull. Welfare concerns: Tail docking of sheep. UCDavis- also goes through techniques

Li and Johnston UMN Extension –Research reaffirms the need for tail docking for pigs. 2016

E Dunthorne. Tail docking and castrating lambs: does the administration of local anaesthetic or meloxicam reduce the pain response exhibited? Veterinary Evidence, July 2021- reviews the literature

How to - Tail Dock - Adult

Indications

Tail docking in adult animals should be restricted to cases of trauma or infection.

Relevant anatomy

The tail is comprised of vertebrae, vertebral spaces, coccygeal muscles and vessels on either side. Disarticulation should be between vertebrae.

Preoperative management

Food restrictions:NA

NSAIDs/analgesics: Perioperative NSAIDs are recommended

Antibiotics: NA

Tetanus prophylaxis is recommended in horses

Local blocks: Epidural or ring block

Position/preparation: The patient is kept standing. Surgeon wears gloves. The area is clipped and prepped.

Surgery Supplies:

- Scalpel and handle
- Mosquito hemostats
- Mayo scissors
- Needle holders
- Suture scissors
- 3-0 absorbable (vessels)
- 2-0 or 0 suture, cutting needle (skin)
- Tourniquet – optional

Surgical procedure

A tourniquet may be applied proximally but usually isn't necessary.

The appropriate vertebral space is identified. Semilunar skin incisions are made dorsally and ventrally with both flaps extending beyond the point of disarticulation. The dorsal flap should extend further than the ventral flap. The flaps are undermined and retracted cranially. The vessels are ligated with 3-0 suture and muscles transected. The coccygeal vertebrae are disarticulated. The dorsal flap is folded over the end and sutured to the ventral flap.

Postoperative care

- Keep area clean and dry.
- Suture removal in 10-14 days

Complications

Dehiscence and infection are possible. Second intention healing is recommended if either occur.

Videos

Resources

See Small Animal Surgery Textbook, Theresa Welch Fossum, Ch 16 Surgery of the Integument

Challenge yourself!

Level A

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Level B

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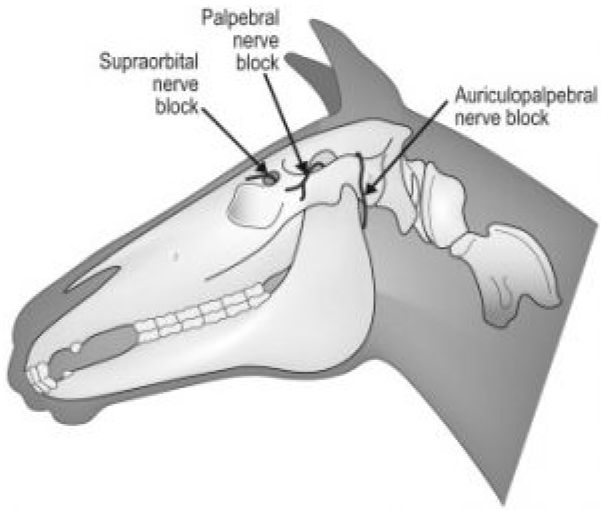
Eye surgery

This section provides resources on enucleations, eyelid lacerations and other eye issues in all LA species.

Ocular blocks

Ocular blocks are often necessary, regardless of the situation. The most commonly performed blocks are the palpebral, supraorbital, and optic nerve.



Motor nerve block; Science Direct

Horses have such strong eyelid muscles that the palpebral block is required to even examine the eye.

Palpebral block – 1 ml lidocaine, 25ga needle

> Lidocaine is injected subcutaneously at the crest of the rostral zygomatic arch or directly adjacent to the nerve as it passes over the arch if the nerve is palpable.
>
> The nerve is a branch of the facial nerve. This procedure blocks motor function – the eyelids can be manipulated. It does NOT block sensation.
>
> Note: we often call this an auriculopalpebral block. Blocking the nerve at either site seems to work.

The supraorbital nerve and/or palpebral nerves can be blocked to provide anesthesia of the surgery area during standing procedures or to minimize the need for deeper planes of anesthesia during general anesthesia.

Supraorbital nerve block – 1 ml lidocaine, 25ga needle

> The supraorbital foramen can be palpated in the supraorbital rim by placing your thumb and middle fingers on either side of the supraorbital rim. Use the right hand for the left eye and vice versa. Slide your

fingers along the rim until you reach the widest part. Drop your index finger down; the foramen is usually directly underneath your finger and is palpable as depression in the bone.

Inject lidocaine over the depression. There is no need to go into the foramen. Injecting the nerve itself is painful and not necessary.

The nerve is a branch of the trigeminal nerve. It provides analgesia to the upper lids. Lower lid anesthesia is most readily performed using a line block.

Optic nerve blocks are required, not only for standing enucleations, but for any enucleation (even those performed under general anesthesia). This is due to the oculocardiac reflex. Traction on the optic nerve can lead to cardiac asystole due to this reflex. Options include a 4 point block, a Peterson block, and several versions of retrobulbar blocks.

Curved needle retrobulbar block – epidural or spinal needle (20 or 18ga) and 10-20cc lidocaine

Wearing sterile gloves, bend the needle (stylet in place) into a C shape to match the shape of the bony orbit. Insert the needle through the skin between the globe and the bony orbit. As it is advanced, the needle follows the curve of the orbit to the back of the eye and ocular nerve. Lidocaine is injected at the back of the eye until the eye feels turgid and as the needle is withdrawn.

Using a curved spinal needle to place local anesthetic near the optic nerve.

For a 4 point block, 1″ needles are inserted between the orbit and the globe at 4 points evenly distributed around the eye. 5 cc of lidocaine is injected at each site. This block minimizes trauma but is also less effective.

For the Peterson block, a spinal needle is directed from the notch between the zygomatic arch and supraorbital bone toward the back of the eye. Direct the needle straight in until the mandibular ramus is touched, then redirect the needle toward the back of the globe. Often you can see the eye move in response.

Peterson nerve block

The retrobulbar and Peterson blocks are recommended only for eye removals as there is a risk of trauma to the optic nerve or artery.

Key Takeaways

Use local blocks for all enucleations.

- Block the optic nerve to prevent the heart from stopping when the eye is being removed
- For standing procedures, block the motor function (muscles) as well as sensation

RESOURCES

4 point block (note this would be easier if they had better syringe handling skills)

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Head blocks video: spelling issues but good content

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Ocular blocks (and more)

How to prepare for ocular surgery in the standing horse, AAEP, 2002- has pictures

Field surgery of the eye and periorbital tissues, VCNA, 2008 – good for blocks and sedation

These videos also show nerve blocks.

Entropion

Entropion is identified in some neonatal foals and often in lambs. The eyelids fold inward and the eyelashes rub on the cornea. Affected animals present with epiphora.

Most animals will outgrow the issue; treatment is just to prevent problems until the deformity resolves. Long acting penicillin may be injected subcutaneously to create swelling in the lower lid. This will roll out the eyelid and the drug will be absorbed over time. However, this isn't ideal use of antibiotics.

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In lambs, tacking sutures are often used to roll out the lower lid temporarily. Yes, this is not a lamb.

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Entropion is a common problem in adult, overweight pot bellied pigs. Many become even more aggressive because they can't see well. These animals require surgery to remove the fat pad and realign the eyelids.

RESOURCES

http://www.infovets.com/books/smrm/C/C202.htm

https://www.nadis.org.uk/disease-a-z/sheep/eye-diseases-in-sheep/

Eyelid lacerations

Eyelid lacerations require special care but not specialists. Horses like to injure their eyelids quite frequently. Horse eyelid lacerations are often referred to as "bucket handle tears" as they injure them on their water or feed buckets when they jerk their heads up too quickly.The exposed eyes of camelids make eyelid lacerations prone in those species, too.

Before repair, it is important to check the cornea for damage. Corneal ulcers can occur due to the primary trauma or due to exposure. Corneal abscesses are also possible with the initial trauma. Perform a fluorescein stain and ophthalmoscopic exam.

Eyelid lacerations may be repaired using standing sedation or under general anesthesia. Standing sedation is used when possible to avoid the risks of general anesthesia. For standing sedation, personal preference often plays a role with many options. Go light on the butorphanol as some horses will develop twitches with narcotics. These can be very annoying. Some surgeons prefer to avoid butorphanol. An iv infusion of detomidine can also maintain stable sedation.

Local blocks can help with both standing sedation or GA.

Eyelid repairs in a donkey (done standing) and in a llama (done under GA)

Key points

- Use betadine solution and saline; not scrub or alcohol. Betadine scrub, chlorhexidine and alcohol can all damage the cornea.
- Do NOT trim off flaps unless the skin is obviously dead (cold and leathery). The head has excellent blood supply and most will heal well. If the eyelid margin cannot be reconstructed, exposure keratitis is very likely due to lack of complete eyelid closure.
- Sutures rubbing on the eye can create ulcers. Keep knots away from the cornea and use very soft suture.
- When closing the skin, close the eyelid margin first to ensure optimum alignment. A figure 8 pattern minimizes the suture poking into the cornea by moving the knots back from the eyelid margin. This pattern needs to be symmetric to create a even lid margin. It may take 2-3 attempts but the time spent is worthwhile. After the margin is apposed, the remainder of the laceration can be closed with simple interrupted or cruciate sutures.

Preoperative antibiotics and NSAIDs are recommended. Postoperative antibiotics are usually not required. NSAIDs can help minimize swelling and decrease the risk of dehiscence. If animals start to rub at the eye, an eye cup or head bandage should be used to protect the wound. Sutures should be removed in 10-14 days even if absorbable. As the sutures dissolve, parts may start to rub the cornea. Unless the cornea has been damaged, we don't try to treat the eye topically. The difficulty in getting medications into the eye outweighs any benefit and may well cause damage to the eyelid repair.

Examples- Interactive videos

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Key Takeaways

Eyelid lacerations should be repaired primarily. They do poorly if left for second intention healing.

Don't debride or cut off pieces of eyelids.

Use soft small gauge suture material on a cutting needle. If nonabsorbable, remove in 10-14 days.

Use a pattern that keeps suture away from the cornea.

Don't use betadine scrub or chlorhexidine scrub near the eye, unless the eye is being removed.

RESOURCES

Ophthalmic emergencies in the field, 2021 VCNA Vol 37; pp 441-460

Equine eyelid disease, 2005 CTEP pg 96-97 – good resource for other eyelid surgeries (all species) and periocular sarcoids

Butorphanol twitches – video

Bonus : lion eye surgery

https://youtu.be/lMXwKCTbPes

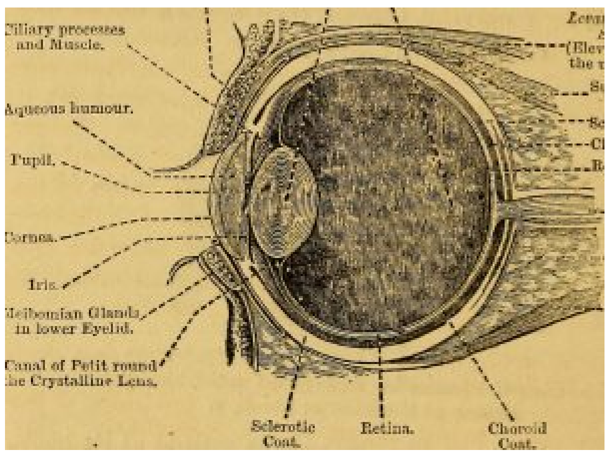
How to - Eyelid laceration repair

Indications

Eyelid lacerations require primary closure or exposure keratitis is likely.

Relevant anatomy

The eyelid margin includes meibomian glands and eyelid musculature.



Preoperative management

Food restrictions: NA. These are treated on an emergency

NSAIDs/analgesics: Preoperative NSAIDs are necessary for swelling management.

Antibiotics: Preoperative antibiotics are recommended.

Tetanus prophylaxis is recommended for horses.

Local blocks: The palpebral nerve is blocked to allow eyelid manipulation but does not provide analgesia. The supraorbital nerve is blocked to provide analgesia to the upper lid. Lower lid lacerations are usually blocked with regional anesthesia.

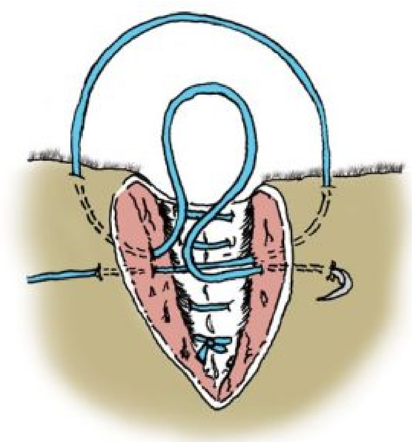
Position/preparation: Patients may be standing or under general anesthesia. Stacked haybales (covered with a blanket) or a dental stand can be useful to hold the head steady at an appropriate level. Eye lube is used to protect the cornea. The area is prepped using betadine solution rather than scrub. Avoid chlorhexidine (toxic to the cornea) and alcohol. Use saline to remove the betadine. The eyelashes may be trimmed if needed but rarely is further clipping required. Surgeons glove.

Surgery Supplies:

- Standard surgery pack
- 3-0 or 4-0 soft suture material, cutting and taper needles
- headlamp or surgery lighting

Surgical procedure

- Minimal to no debridement. Skin loss prevents eyelid reconstruction
- The subconjunctiva can be closed if accessible. Simple continuous pattern of 4-0 suture with knots placed superficially (away from the cornea).
- The eyelid margin is carefully reconstructed. The figure 8 pattern avoids suture knots on the cornea.



To do this pattern well, it is important to keep all bites very symmetrical. The bites crossing the top of the laceration exit/enter the area of the meibomian glands. The suture ends can be left a little long and then folded under adjacent suture to keep the ends away from the cornea.

The lid margin of the llama below was too uneven; this will cause corneal issues. The suture was removed and redone to better appose the laceration edges.

Once the eyelids are apposed, the remainder of the laceration can be closed routinely.

Postoperative care

- NSAIDs are continued for 3-5 days
- Patients should not be allowed to rub the eyes
- Suture removal in 10-14 days

Complications

- Corneal injury can occur related to the original injury, related to the surgery and/or to suture or tissue rubbing on the cornea
- **Dehiscence**

Videos

Figure 8 pattern using a lip as a bigger model

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Resources

J Gionfriddo. Skills Laboratory: Eyelid laceration repair: A step-by-step guide. DVM 360

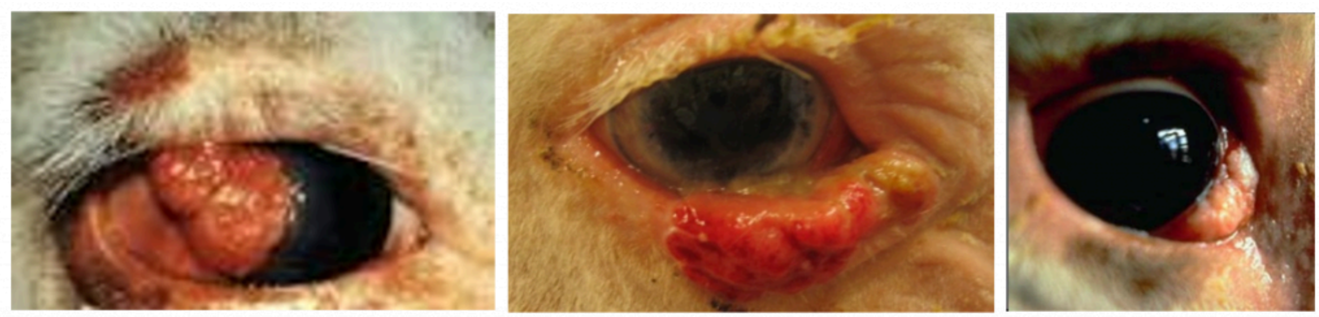
A Dwyer. Ophthalmic emergencies in the field, 2021 VCNA Vol 37; pp 441-460

Ocular Squamous Cell Carcinoma

Much of what you know about SCC (squamous cell carcinoma) in other species translates to cattle and horses, particularly in terms of risk factors and metastatic activity. SCC affects older, light skinned (white faced) animals exposed to UV radiation. Papilloma virus may start a lesion, particularly when combined with UV irradiation. SCC is locally invasive but very slow to metastasize. Local lymph nodes may be enlarged due to tumor spread or, more likely, related to local inflammation.

Common locations:

- Limbus (corneal-scleral junction)
- Third eyelid
- Upper and lower eyelid margins



Bovine ocular SCC

Equine SCC often starts in the lower lid or the third eyelid.

Male horses (stallions and geldings) with ocular SCC should be checked for penile SCC, as well. While UV light isn’t directly an issue, there is definitely a correlation.

Treatment options include

- hyperthermia, photodynamic or radiation therapy
  - only some referral institutions will have this capability
- mass removal – blade or laser
  - Lasers are typically only found in referral institutions
  - Surgical removal (cutting it out) can be very tricky to do effectively and leave functional eyelids that can close. A specialist is often indicated as the eyelids scar very easily and this deforms the lid margin.
- **cryotherapy**
  - Cryotherapy can also lead to scarring and deformed lid margins; this should also be used by specialists for both corneal and lid lesions
- **enucleation**
  - This is the primary field option

Cattle with cancer eye or with enucleations will be carefully inspected at slaughter. Generally the head will be condemned. The carcass is less likely to be condemned with a healed enucleation site.

Key Takeaways

- White animals are prone to SCC
- SCC tends to start on the lids or the limbus and is locally invasive but slow to metastasize
- Eye removal doesn't usually affect slaughter options unless the lymph nodes are enlarged; a nasty eye creates more issues

Resources

Bovine ocular SCC in Italy– VETERINARSKI ARHIV 84 (5), 449-457, 2014- same pathogenesis applies in the US

Bovine Ocular SCC – VCNA,2010- skim the headings to see which parts might help you answer questions

slaughter info-compilation of notes

Bovine welfare issues – eye disorders, 2010 VCNA

Enucleations

Overview

Enucleation methods are relatively similar across species.

Definitions

- **Evisceration** – removal of globe contents; leaving the globe, the extraocular muscles and other structures
    - Evisceration would be performed when the eye will be made to look normal with implants
    - Evisceration is unusual in veterinary medicine
- **Enucleation** – removal of the globe; leaving the extraocular muscles and other structures
    - Enucleation is indicated when the globe is damaged but there is no risk of neoplasia or infection that could be in the extraocular tissues
    - Enucleation may leave less of an empty socket as compared to exenteration
    - Enucleations may be performed subconjunctivally (dissect between the globe and the conjunctiva; eyelids open) or with the eyelids closed and between the globe and the muscles.
- **Exenteration** – removal of everything in the orbit
    - Exenteration is indicated when there is a risk of neoplasia or infection in the extraocular tissues
    - Exenteration is common in large animal species
- Orbital prostheses
    - In vet med, a gray silicone ball that is placed in the socket and covered by the eyelids which are sutured closed
    - The goal is to create a more normal appearance; it usually doesn't look at all normal
    - Foreign objects create a risk of persistent infection and should only be used in very clean situations

When we talk about cattle enucleations, we generally mean exenterations.

There are two other main differences between small and large animal enucleations:

- We typically perform surgery in the standing animal (safer for the animal than general anesthesia). Horses are sedated with detomidine/butorphanol or similar combinations. Cattle will often not require sedation; if needed, xylazine works well. Head restraint and local blocks are required in both species.

- We do not typically ligate the artery (with a complete bony orbit, this is hard). That means we have to create hemostasis in other ways. Cows like to clot well but this is an artery so even cattle will continue to bleed. By suturing the lids closed, we create a closed space. With enough bleeding, the pressure builds up and stops the arterial flow. The animal will have a bulging eye for a bit but this resolves after the bleeding stops. We typically skip the subcutaneous layer if bleeding is profuse and just close skin quickly.

If the artery is ligated, you can also try a trampoline suture. The premise is that this will minimize the sunken appearance by providing a scaffold for fibrous tissue.

Courtesy of Patrick Finlay

Watch this video as is first to get a general idea of how ocular SCC is handled surgically in cattle.

Then watch again with my comments (which doesn't work unless they remove the restriction)

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Whenever possible, stay close to the eyelid margins to enable closure! If closure isn't possible, packing or stenting (tieing on a bandage to provide pressure) will be needed to control hemorrhage.

Aftercare

Aftercare is routine for any surgery – sutures are removed in 10-14 days and any infection managed through drainage. The most common complication is infection.

Typically animals adapt well to unilateral enucleation. Some can even tolerate bilateral enucleation if maintained in a consistent environment.

Key Takeaways

- Exenteration is what we really perform in LA; we call it enucleation
- Rarely do we try to ligate the ocular artery; we close the skin fast to create pressure for hemostasis
- Complications include infection and dehiscence. Occasionally too much skin is removed and closure can be challenging.

RESOURCES

when to exenterate vs enucleate– human version

Field surgery of the eye and periorbital tissues, VCNA, 2008- nice step by step overview

Ocular field surgery in ruminants, Intl J Vet Med, 2015- see enucleation surgery blocks and techniques;. also discusses SCC risks

Bovine enucleations : case info and complications – CVJ, 2010- especially useful for finding out what complications are common

Surgical treatment of the eye in farm animals, 2010 VCNA pgs 460-462, 471-end- has a bit more about exenteration vs enucleation how to

Enucleation in companion animals ,Irish Veterinary Journal Volume 61 Number 2- the SA version

More videos

Horse enucleation

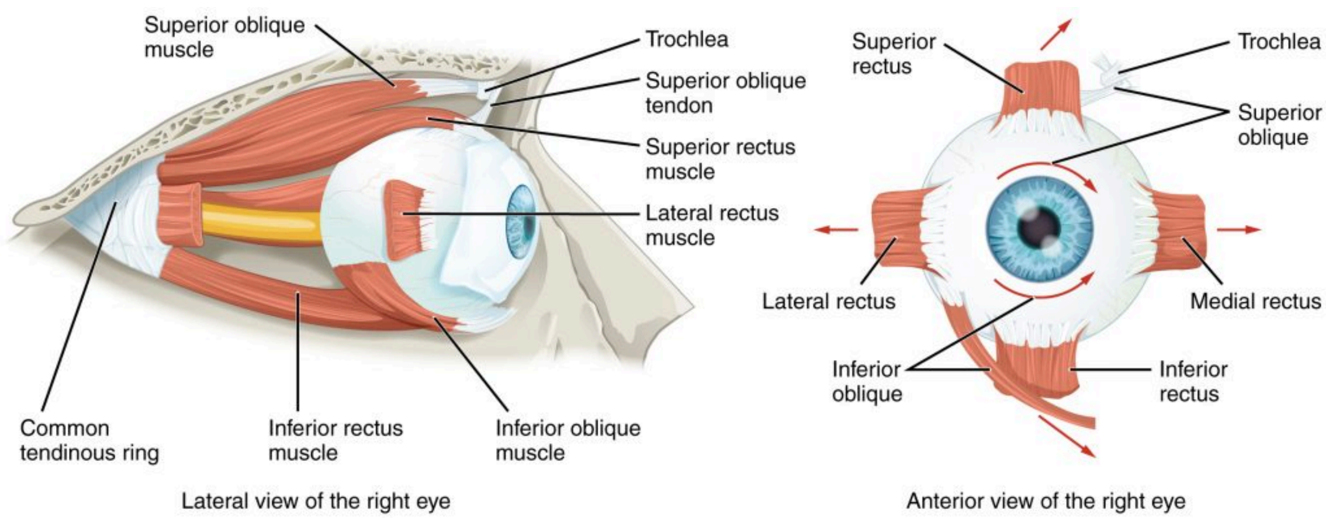
Indications

Eyes may be removed due to trauma, infection, neoplasia or pain (ulcers, glaucoma, uveitis). Enucleation may be the quickest way to a comfortable animal and can decrease the risk of spread of tumors or aggressive infections.

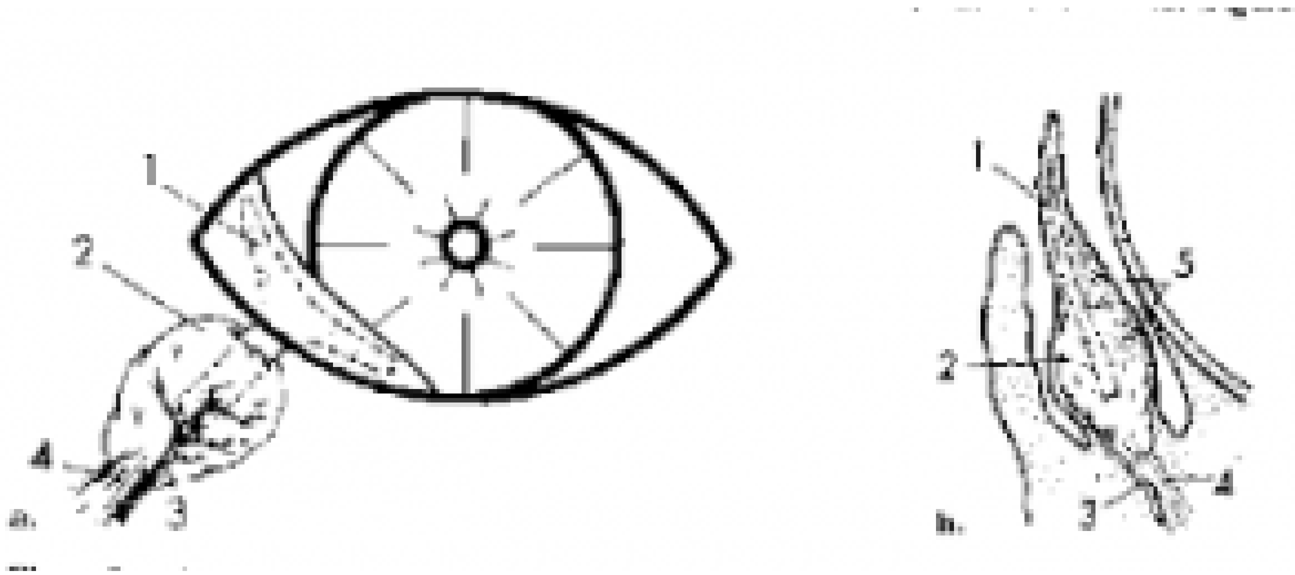
Relevant anatomy

The optic nerve should be blocked with local anesthetic prior to surgery, even with animals under general anesthesia. The optic nerve can be accessed in a variety of methods. See Ocular blocks.

Cattle have a deep bony orbit; horses have a complete bony orbit as well but it is wider so easier to access caudal structures. The ocular artery and optic nerve are at the back of the globe in the center of the orbit. The remainder consists primarily of extraocular muscles and the third eyelid.



The third eyelid and it’s gland should be removed or the animal will continue to produce tears.



Preoperative management

Enucleation can be performed standing in many horses and cattle. This increases the safety by decreasing the likelihood of extensive hemorrhage and the risks of anesthesia and recovery. In small ruminants, sedation is typically needed. General anesthesia may be needed in some horses with extensive SCC to enable more cosmetic reconstruction.

Food restrictions:

NA unless general anesthesia is indicated.

NSAIDs/analgesics:

Preoperative and postoperative analgesics are required.

Antibiotics:

As the eye is not a sterile environment, preoperative and postoperative antibiotics are indicated. Broad spectrum coverage is indicated but first line drugs are fine (penicillin + gentamicin (equine), cephalosporin, ampicillin).

Tetanus prophylaxis is recommended.

Local blocks:

Options to block the ocular nerve include various forms of retrobulbar block including the Peterson nerve block. All are effective if performed correctly. If blocked, the pupil should dilate.

Position/preparation:

The animal is positioned in stocks or head gate (standing sedation) or in lateral recumbency with the affected eye uppermost. A head tray or dental halter can help hold the head still and at a reasonable level. The eye is clipped and prepped.

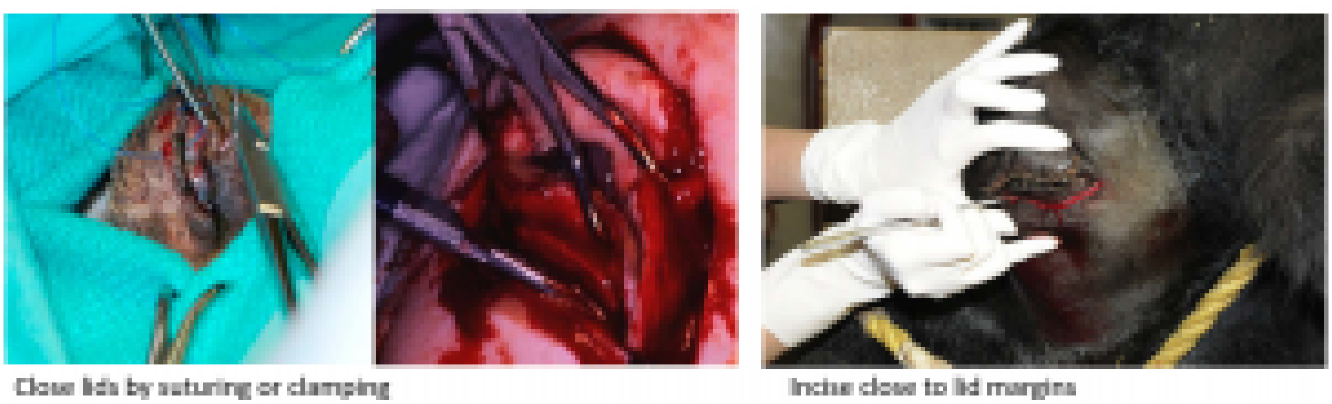
Surgery Supplies:

- Surgery pack
- Scalpel and handle
- Right angle hemostats (optional)
- Ecraseur (equine only)
- 2-0 or 0 suture on a cutting needle to close the lids
- 0 monofilament absorbable for the artery
- 0 suture on a cutting needle for the skin closure

Surgical procedure

The eyelids are sutured closed. The ends of the suture tags are left long as handles. Alternatively, towel clamps can be placed at each canthus. Towel clamps or allis tissue forceps are useful as they hold themselves closed; this is much easier on the surgeon as compared to holding tissue forceps closed.

A fusiform incision is made around the eyelids, pointy ends at the canthi, staying close to the lid margin. ** Incisions too far away from the lid margin can be challenging to close.**



Close lids by suturing or clamping. Incise close to lid margins

Continue dissection through the retrobulbar tissues using mayo scissors (scalpel dissection may be needed at the canthi). Stay close to the bony orbit, going deeper rather than across the surface. Whenever possible, use scissors instead of a scalpel. The tissue trauma associated with scissors activates the clotting cascade and bleeding is lessened.

Work around the full circumference, moving deeper with each pass. Cut anything in your way. Digital palpation helps identify what needs to be cut.

If the dissection exposes the globe, ensure you also remove the third eyelid and gland. This will come out naturally if the globe is not exposed.

Once the only structures left are at the caudal aspect of the eye, prepare your suture for closure. Typically we do not clamp the artery in large animal species. In horses, an ecraseur can be used to crush and sever the artery. This does not work in cattle due to the anatomy of the orbit. In cattle, cut the artery with scissors.

Closure: Trim the eyelid margins and close the lids in a simple continuous pattern with 0 suture material. The needle on 2-0 suture material makes it difficult to be efficient.

Postoperative care

- Antibiotics are often continued for 5 days; NSAIDs are continued for 3 days.
- Monitor the incision for any signs of inflammation or infection. Sutures can be removed to allow drainage if necessary
- Prevent the animal from rubbing the area. Fly masks work well.
- Suture removal in 10-14 days

Complications

Contamination

If the incision should not be closed fully due to contamination and risk of infection (eg you would create an abscess), the socket can be packed with betadine soaked gauze and closed partially. The partial closure and packing will put enough pressure on the artery to create hemostasis. The packing can be removed gradually over the next few days.

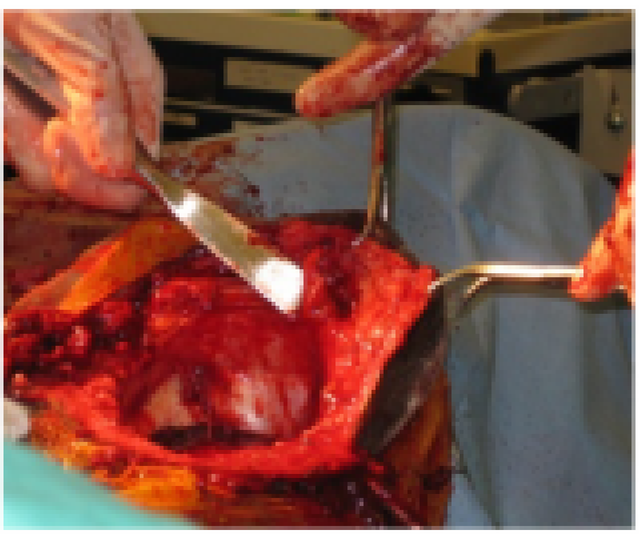
Infection

Open the suture line partially or completely to allow drainage.

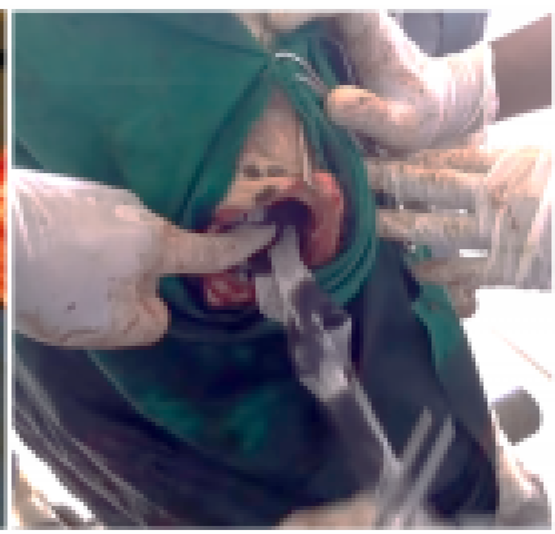
Incomplete closure

If the lids cannot be closed due to excess skin removal, the following options may help

- undermine and mesh the skin – make sure this area is over bone, not over the socket if hemorrhage is present
- remove brow bone – using an osteotome and mallet, this bone can be removed to create less of a bump
- leave it open – pack and cover with a stent bandage



Removing bone to enable closure



Packing with (incompletely) soaked betadine gauze

Tumor recurrence

Owners should be counseled to watch for growths or ulceration that could indicate tumor recurrence.

Videos – these are graphic!

In lab enucleation – didn't figure Youtube would ever let me post this one.

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Resources

Eye extirpation in cattle, the Australian way, U Queensland, 2013

Eyelid mass removal

Third eyelids are most often removed due to tumor involvement (usually SCC).

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Eyelid masses (generally SCC) may be removed using H plasty. It is important to maintain or recreate the eyelid margin. This surgery pulls up skin from lower on the face to create the margin. Really cool and works in all species.

Equine periocular sarcoids are generally not removable (removing them would leave a huge gap and cause exposure keratitis. We treat these with imiquimod (safe near the eye), cisplatin beads and/or other chemotherapeutic injections. Combination therapy can be useful.

RESOURCES

JS Harper. How to Surgically Remove the Third Eyelid in the Standing Horse. 2009 Vol. 55 AAEP PROCEEDINGS

B Welker et al. Excision of Neoplasms of the Bovine Lower Eyelid by H-Blepharoplasty. Veterinary Surgery, 20, 2, 133-139, 1991

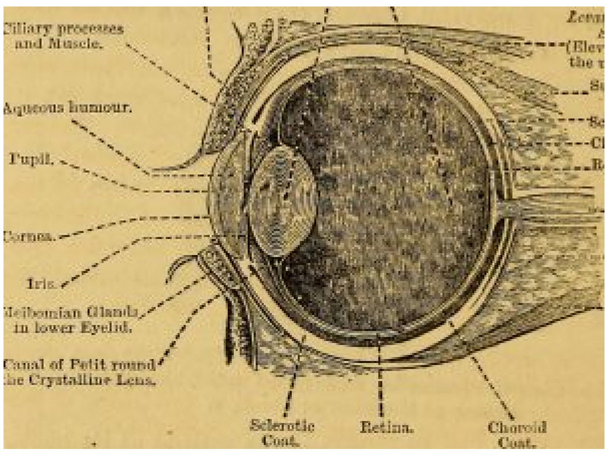
How to - Eyelid H plasty

Indications

H plasty can be used for periocular mass removal and is a means of recreating the eyelid margin. It may be used to control tumors or when the other eye is already enucleated.

Relevant anatomy

The eyelid margin includes meibomian glands and eyelid musculature.



Preoperative management

Food restrictions: 48 hours for cattle, 6-12 hours for horses

NSAIDs/analgesics: Preoperative NSAIDs are necessary for swelling management.

Antibiotics: Optional depending upon the tumor appearance and environment.

Tetanus prophylaxis is recommended for horses.

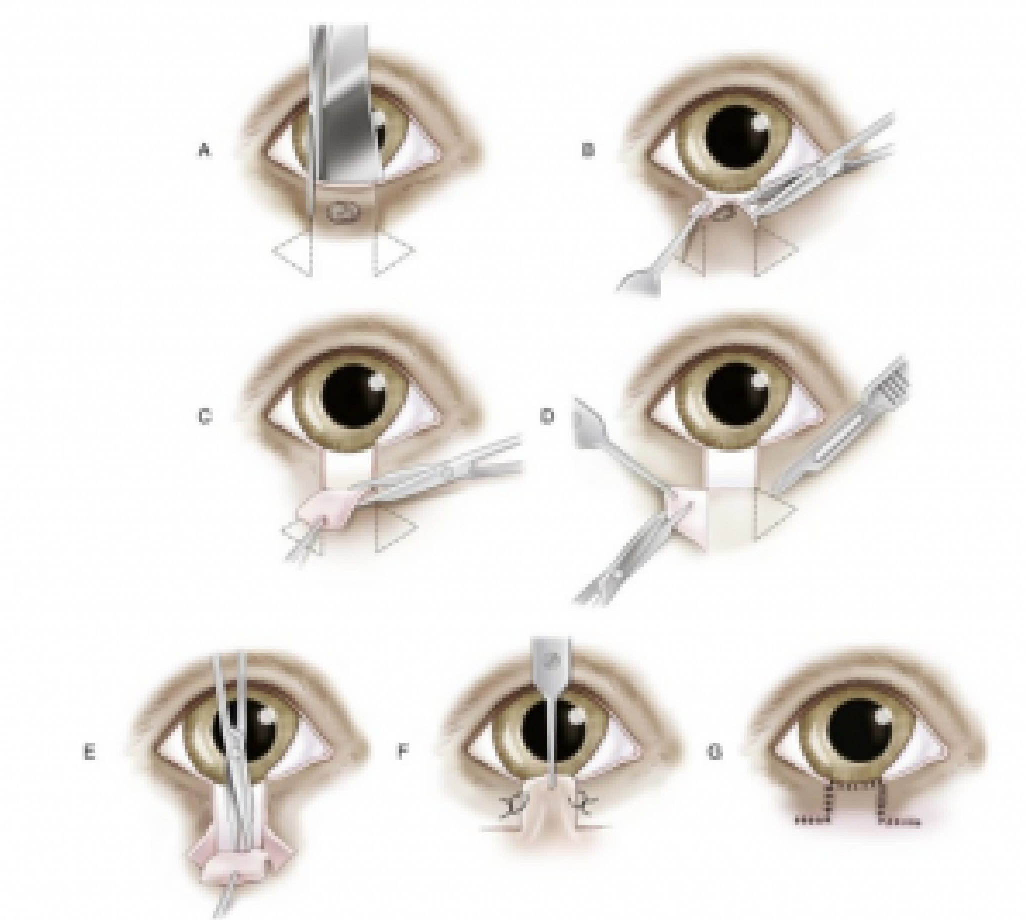
Local blocks: The palpebral nerve is blocked to allow eyelid manipulation but does not provide analgesia. The supraorbital nerve is blocked to provide analgesia to the upper lid. Lower lid lacerations are usually blocked with regional anesthesia.

Position/preparation: Patients are generally placed under general anesthesia. Eye lube is used to protect the cornea. The area is prepped using betadine solution rather than scrub. Avoid chlorhexidine (toxic to the cornea) and alcohol. Use saline to remove the betadine. The eyelashes may be trimmed if needed but rarely is further clipping required. Surgeons glove.

Surgery Supplies:

- Standard surgery pack
- 3-0 or 4-0 soft suture material, cutting and taper needles
- headlamp or surgery lighting
- tongue depressor (pushed under the lid to create a firm surface for incisions)

Surgical procedure



https://veteriankey.com/basic-ophthalmic-surgical-procedures/

The triangles should be 20% longer than the incision adjacent to the tumor (full length 120% of tumor).

The flap margins can be closed using the figure 8 suture pattern to avoid suture near the cornea.

Postoperative care

- Keep the patient from rubbing on the eye
- Suture removal in 10-14 days
- NSAIDs for at least 3 days to minimize swelling and **dehiscence**.

Complications

- tumor recurrence
- suture dehiscence
- keratitis from sutures or uneven eyelid margin

Videos

Resources

Basic ophthalmic surgery procedures, Veterian key

How to - Subconjunctival injection

Indications

Subconjunctival injections are used to provide ongoing medication to a patient that will not tolerate digital application of ointments or instillation of drops and is also not a candidate for various flush systems. This is typically cattle. The most common condition treated is pinkeye.

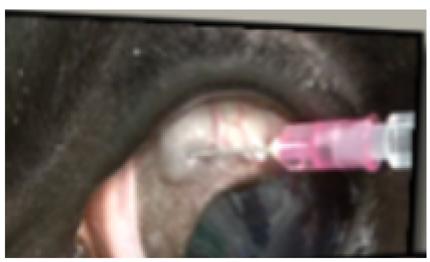
Antibiotics (or steroids) are injected under the conjunctiva of the upper globe. The drug will leak out slowly over time, bathing the cornea.

Method

Use a 25 or smaller gauge needle and a 3 cc syringe. Generally 1 ml of medication is used.

Provide topical anesthesia and palpebral block if indicated.

With the bevel up, insert the needle subconjunctivally until the bevel is fully covered. Inject slowly.



Videos

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He is injecting into the palpebral conjunctiva. Starts at the 7min mark.

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Resources

Pinkeye problems in cows, CSU extension

Practice

Level A

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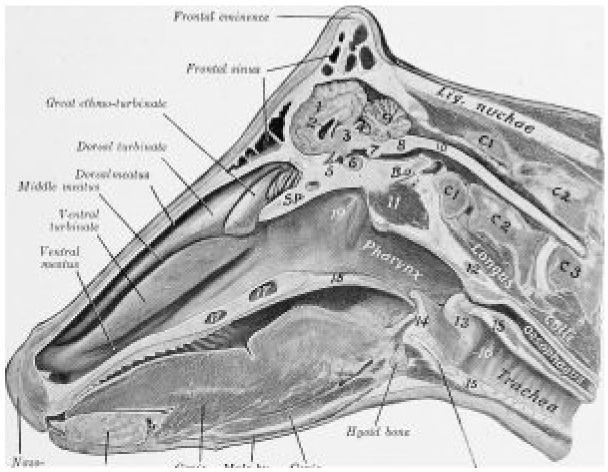
https://open.lib.umn.edu/largeanimalsurgery/?p=2314#h5p-163

LA Respiratory Issues

This chapter focuses on upper and lower respiratory disorders with a surgical emphasis. The conditions described are predominantly an issue in horses.

Nasal Discharge

Anatomy Review



[Nasal discharge anatomy powerpoint](https://open.lib.umn.edu/largeanimalsurgery/?p=805)

[Nasal discharge anatomy narrated powerpoint]()

Due to the complete nasal septum in horses, most unilateral discharge can be localized to the ipsilateral pharynx, sinus and paranasal region. Even though discharge from one guttural pouch opening or the ethmoid region could flow out the opposite side, it usually doesn't. Tracheal and pulmonary fluids do flow out both nostrils.

Exudates typically present in 3 flavors: serous (normal), hemorrhagic or purulent. A combination of hemorrhagic and purulent discharge can be seen with ethmoid hematomas, neoplasia and occasionally with strangles (Strep equi). Lack of airflow can indicate congenital lesions or acquired obstructions. The most common congenital cause of no airflow is choanal atresia (lack of nasal passageway development; next chapter).

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=805#oembed-1*

Often acquired obstructions are due to neoplasia or conchal cysts. Conchal cysts are congenital lesions that develop within the nasal turbinates; these grow slowly over time and can totally occlude the nasal passage.

Diagnostics include oral examination (looking for dental issues, particularly diastemata (gaps between teeth), radiographs (can be very difficult to interpret), endoscopy, and sinuscopy (scope via the sinus; this usually requires sinus lavage first).

Challenge Yourself

Level A

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Nostrils and nasal conchae

Horses are obligate nasal breathers. They don't have the option to breathe through their mouths unless other abnormalities are present. Nasal abnormalities can cause significant airway compromise. Alpacas and llamas are semi-obligate nasal breathers and can breathe for a bit through their mouths. However, they can't breathe and eat or drink at the same time. Camels are bit more unique. Cattle can breathe through their mouths but do not unless very hot, very distressed or have significant pathology in the nasal region.

Common nasal and nasal conchae abnormalities with surgical therapies:

Choanal atresia

Choanal atresia occurs when the nasal passage fails to develop properly. Embryonically, the passage opens from both directions. With atresia, the passages fail to meet in the middle, leaving an obstruction. This means airflow does not reach the trachea from the nostril. If unilateral, symptoms are mild until the animals is older and/or exercising. If bilateral, it means a quick death for foals and respiratory distress for camelids. A candidate gene has been identified in camelids. Treatment is not recommended, affected animals should not be bred and the breeding that led to the cria should not be repeated. The contrast radiograph to the left (contrast inserted into the nostril) outlines the blind end of the nasal passage.

Nasal epidermal inclusion cyst

Nasal epidermal inclusion cysts occur in the false nostril (nasal diverticulum) of horses. These were previously identified as atheromas. While surgery was recommended in the past, the best treatment at this time is to inject the cyst with formalin. Formalin dries up the secretions and the dried out sack can removed digitally but usually falls out of the nostril on its own.

Conchal cyst

Conchal cysts are congenital anomalies that develop in the nasal conchae (scrollwork). These cysts can be very slow to develop and may not be identified until animals are adults. Clinical signs are associated with blockage of the nasal passage (lack of airflow, drainage issues) and deformation of the skull. Treatment involves surgical removal of the cyst, generally with a nasal flap procedure performed standing. A circular opacity can be seen in the center of the radiograph to the left.

Wry nose and wry face

Wry nose is observed in newborn foals, calves and crias and is a severe malformation of the head. The nasal septum is deviated with malalignment of the jaws and teeth. Generally the maxilla is most affected. While surgery is possible to improve the condition, affected animals continue to have restricted airflow and problems with dentition. Nasal septum changes can also occur with trauma to the nose. Most affected animals are euthanized due to ongoing issues with breathing, chewing and dental related issues.

Nasal tumors

The most common nasal tumor is horses is a polyp, generally believed to develop from chronic irritation. Other tumor types can develop from the various tissues in the nose, including adenocarcinomas, adenomas, chrondromas, lymphosarcomas, osteosarcomas, and others. Enzootic nasal adenocarcinomas is a transmissible tumor of sheep and goats caused by a retrovirus. This tumor can occur in very young animals. Clinical signs include poor airflow/exercise intolerance, nasal discharge, nasal bone deformity and odor. Differentials for nasal tumors include granulomas and amyloidosis.

Resources

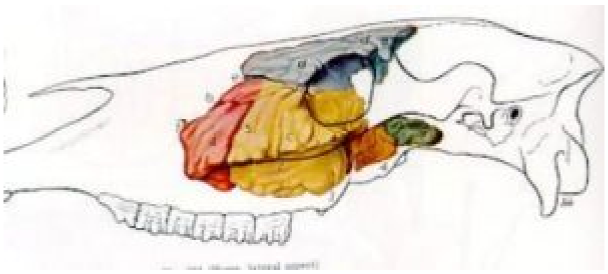
Disorders of the paranasal sinuses, Tremaine and Freeman

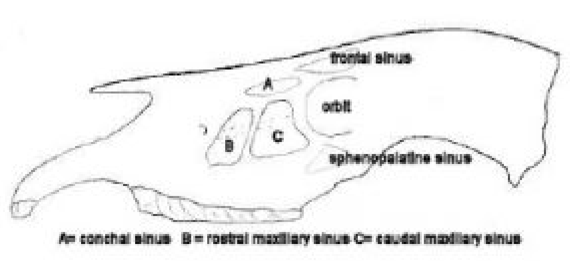
Diseases of the nasal passages in horses, Merck Manual

Respiratory distress in the adult and foal, VCNA (2021) 37:311-325

Paranasal sinus disease

Large animal species have [complex sinus anatomy](), supposedly related to decreasing the weight of the head but mostly serving to create pockets of infection. The equine frontal and maxillary sinuses drain through the nasomaxillary opening in the rostral maxillary sinus.

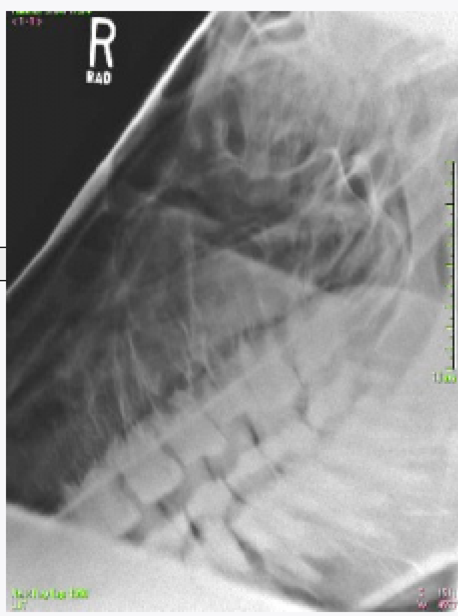




Viscera of domestic animals.

Common paranasal sinus disorders with surgical therapies:

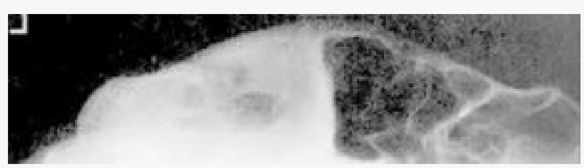
Primary sinusitis



Sinusitis results from infections and when the nasomaxillary opening is obstructed and drainage is impaired. Radiographs are useful to identify fluid in the sinus(es). Note two separate fluid lines in the radiograph to the left. Surgical treatment involves flushing the sinus and/or creating drainage into the middle nasal meatus. Warning: Streptococcus equi should be considered as a possible cause.

Traumatic sinusitis

Sinus

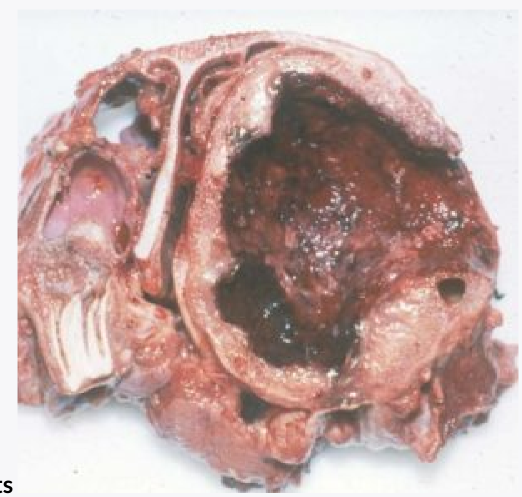


Frontal sinuses of a bull

trauma, including dehorning trauma, can lead to sinusitis. Drainage can be problematic if the trauma affects the frontal sinus. The frontal sinus needs to drain into the maxillary sinus before it can drain out the nasal passages. Blockage along the way can occur due to other consequences of trauma or to inspissated pus. Drainage may be through sinus trephination, through enlargement of the nasomaxillary openings or creation of new openings into the nasal passageway.

Tooth root infections

The maxillary sinuses of adult horses contain roots of 108-111, 208-211. These teeth can become infected and lead to secondary infection of the maxillary sinus. Tooth root infection should be suspected with unilateral sinusitis. While radiographs are useful to identify sinusitis. CT (computed tomography) is the gold standard for determining if a tooth (teeth) are infected. In the radiograph to the left, diastemata (gaps) are visible between multiple teeth and teeth are missing or abnormal in shape.



Sinus cysts

Sinus cysts are similar to conchal cysts in development, clinical signs, and therapy. Radiographs and CT examinations are useful for diagnosis.

Ethmoid hematomas

[Progressive] ethmoid hematomas develop off the ethmoid turbinates and may or may not end up in a sinus. Horses are generally at least 6 years of age and can have bilateral ethmoid hematomas. Potentially related to trauma, ethmoid hematomas often lead to a foul smelling discharge due to pressure necrosis on nearby tissue. The discharge is intermittently hemorrhagic and purulent in many cases. Epistaxis is low grade and spontaneous (not associated with exercise). Airflow is often reduced. Despite the location caudal to the septum, unilateral discharge is common with unilateral lesions. Horses can have bilateral hematomas. Endoscopy combined with radiographs or CT is useful for diagnosis and evaluation of size and location. Treatment options include laser therapy, formalin injections and/or surgery (sinus flap to remove it). Recurrence is common. This is a horse thing. No one is quite sure why these don’t just resolve like most hematomas.

Sinus tumors

Sinus tumors are uncommon but include squamous cell carcinoma and tumors of dental origin. Clinical signs are related to bony remodeling, tissue necrosis and impairment of nasal discharge. Sinus flaps may be needed for diagnosis and therapy. Tumors are often advanced by the time of diagnosis.

Challenge Yourself

Level A

Dental disorders are common. Work your way through the following exercise to review the topic.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=626#h5p-59

PRIMARY RESOURCES

Disorders of the paranasal sinuses, Tremaine and Freeman – great pictures and explanations

Paranasal sinus disease, 2011 Compendium- another great resource for common diseases

SECONDARY RESOURCES

Respiratory distress in the adult and foal, VCNA (2021) 37:311-325

How to perform a minimally invasive sinus flush, 2008 AAEP – very handy skill if doing equine practice

Sinusitis in horses, ACVS -short and sweet with a surgery perspective

Review of paranasal sinusitis, 2012 EVE -diagnosis and treatment

Cheek teeth diastemata, 2015 EVE -more than I ever wanted to know

Manual of Clinical Procedures in the Horse

Frontal sinusitis in adult beef bulls, JAVMA 2019

Focus on Dentistry, 2011 pg 4

Diagnostics

Respiratory disorders should first be localized using history and physical examination findings. Definitive diagnosis may require additional evaluation using cultures, radiography (plain and/or contrast), endoscopy, CT scans, ultrasound, and occasionally MRI or scintigraphy. Skull radiographs are challenging to interpret, making CT scans the gold standard for many lesions in the head, particularly tooth and sinus disease.

Endoscopy of the nasal passages and throat can be performed standing or in the moving horse. Standing examinations are much easier to perform; however, some abnormalities seen on standing examinations may disappear during exercise while different lesions appear. In general practice, the primary goal is generally to determine if advanced diagnostics are indicated and provide options to the client.

A sinus flap can be useful for both diagnostics and therapy. See this youtube video

Exercises

Level B

Organize the steps needed to sample a sinus:

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=657#h5p-58

RESOURCES

Respiratory Disease Diagnostics in the Horse, VCNA: Equine Practice, August 2015, Vol.31(2), pp.307-336

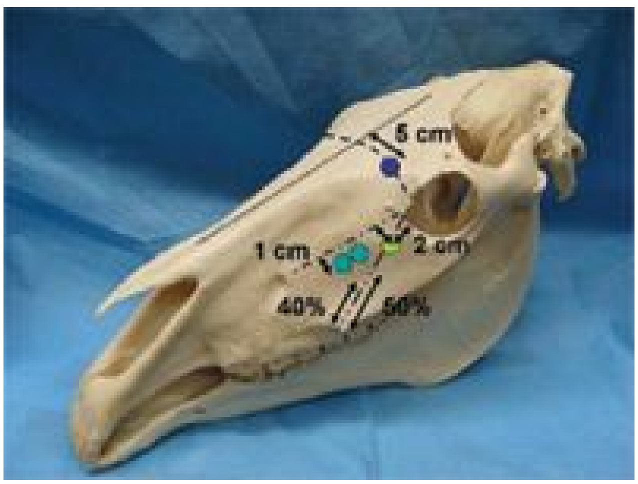
Field Examination of the Equine Patient with Nasal Discharge, VCNA: Equine Practice, Volume 13, Issue 3, December 1997, Pages 561-588- don't laugh too hard

Sinuscopy video

Indications

Diagnostic or therapeutic trephination is indicated in cases of unilateral purulent nasal discharge with primary signs associated with the paranasal sinus. Sinusitis may be associated with dental disease, tumors, or primary infection. Diagnostic trephination can confirm the presence of pus in the sinus; permits aspiration of sinus contents for cytology, biopsy, or culture ands sensitivity testing; and provides a portal for therapeutic irrigation

Relevant anatomy



https://www.dvm360.com/view/paranasal-sinus-anatomy-and-trephination-technique-proceedings

Preoperative management

Food restrictions: NA

NSAIDs/analgesics: Recommended

Antibiotics: NA; sample collection for culture is probably indicated

Tetanus prophylaxis is recommended.

Local blocks: Local infiltration

Position/preparation:

Usually performed with the horse standing using local anesthetic infiltration and chemical restraint when needed. Clip and prep the intended area. Anesthesia is provided by local infiltration of a 2% solution of lidocaine. The boundaries of the maxillary sinus are: a line drawn from the rostral end of the facial crest to the infraorbital foramen, the dorsal margin is a line from the infraorbital foramen to the medial canthus of the eye, the caudal margin is a line (parallel to the rostral margin) from the medial canthus of the eye to the caudal aspect of the facial crest, and the ventral margin is the facial crest. These boundaries provide maximal exposure of he maxillary sinus while protecting the vulnerable infraorbital canal and nasolacrimal duct.

Surgery Supplies:

- Michele trephine or steinman pin and chuck.

Surgical procedure

A 1-cm stab incision of the skin and periosteum is sufficient for diagnostic trephination. A Steinmann intramedullary pin, 3/16 or 1/4 inch in diameter, is used to penetrate the bone. The pin should be checked with just sufficient trocar point exposed to penetrate the bone, but without risk of damaging deeper structures. In standing horses the pin and handle can be thrown violently if the horse jerks its head, be careful! The portal provides access for aspiration, biopsy instrument, a 4-mm arthroscope, or a lavage catheter. The sinus should be irrigated with warm sterile, polyionic solution and discharge from the nostril examined

Postoperative care

- The portal remains open for 10 to 12 days for repeat irrigation. The incision should not be sutured but allowed to heal by second intention. Larger holes heal within 3 to 4 weeks.

Complications

- Iatrogenic damage to the nasolacrimal duct is possible

Videos

Resources

Paranasal sinus anatomy and trephination technique (Proceedings)

Upper respiratory endoscopy

Endoscopy can be performed standing or in the moving horse. Standing examinations are much easier to perform; however, abnormalities seen on standing examinations may disappear during exercise while different lesions appear. In general practice, the primary goal is generally to determine if advanced diagnostics are indicated and provide options to the client.

Anatomy and physics of the upper respiratory tract- narrated powerpoint

ABNORMALNOISE-anatomy ppt

These videos give you a bit of an overview on normal endoscopy

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=815#oembed-1

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=815#oembed-2

Level A

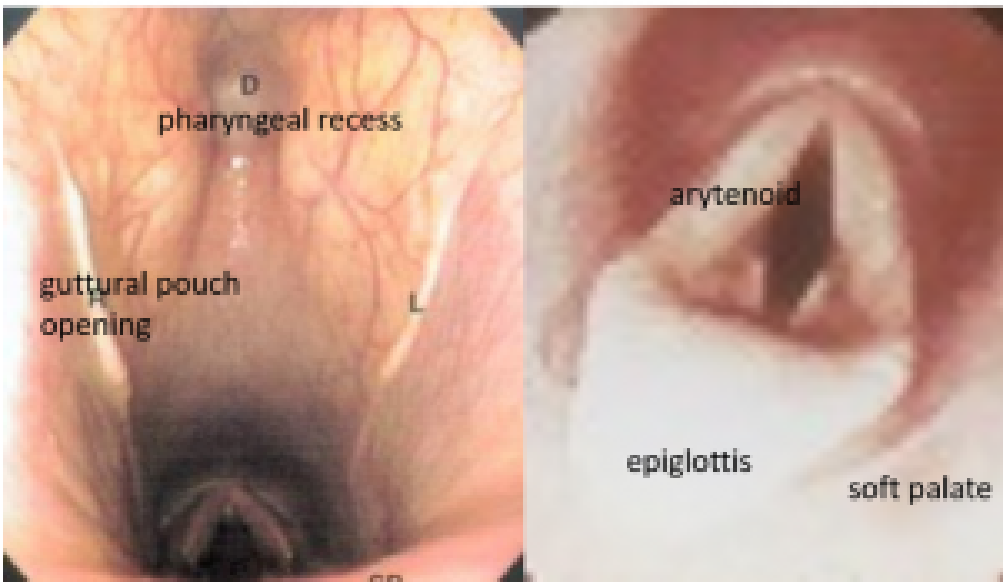
An interactive H5P element has been excluded from this version of the text. You can view it online here: https://open.lib.umn.edu/largeanimalsurgery/?p=815#h5p-109

RESOURCES

Upper Airway Conditions affecting the Equine Athlete, VCNA: Equine Practice, August 2018, Vol.34(2), pp.427-441

Pharyngeal disorders

The pharyngeal region includes the soft palate, extensions of the palate into the walls and roof of the pharynx, openings into the guttural pouches and to the larynx. Pharyngeal dysfunction is an important cause of poor performance and noise associated with exercise. The muscles of the pharynx are essential to maintaining an open airway despite high negative pressures during inspiration.



Common disorders:

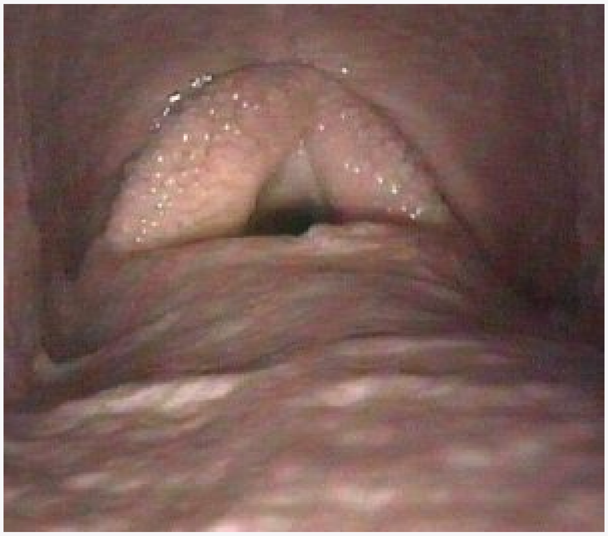
Cleft palate

Cleft palates occur as congenital anomalies in most species. The earliest clinical sign is usually milk drainage from the nostrils. Careful digital evaluation of the palate should be performed in all neonates to ensure the palate is complete. Surgical repair is challenging and success depends on how much of a defect is present and whether or not aspiration pneumonia develops. If treatment is an option, affected animals should be hospitalized as soon as possible to minimize the risk of aspiration through feeding tube placement and antibiotic therapy. The image above is an endoscopic view of a cleft palate as seen from the nasal passages.

Pharyngeal lymphoid hyperplasia

The lymphoid tissue in the pharynx can become inflamed in young horses leading to numerous bumps visible endoscopically. Pharyngeal lymphoid hyperplasia (PLH) may lead to symptoms of a sore throat but is often identified incidentally. This is most common in race horses being "scoped" to figure out why they aren't running as fast as the trainer/owner had hoped. There is no noise associated with PLH unless the inflammation leads to other problems. Treatment is not usually required but throat sprays containing an anti-inflammatory agent may help.

Dorsal displacement of the soft palate



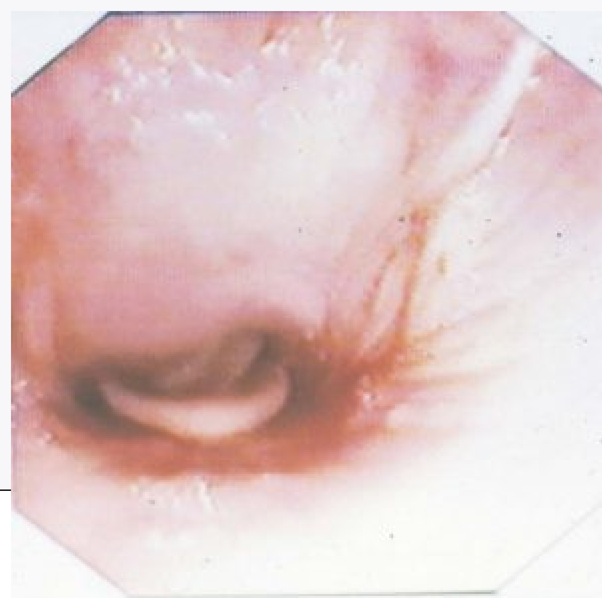
DDSP

In the horse, the soft palate merges into the walls of the pharynx, totally separating the oral cavity from the nasal cavity. The larynx connects with the nasal passage through an opening in the soft palate. When the horse swallows, the palate moves up to allow food to access the esophagus (lives dorsal to the larynx). With DDSP, the palate moves up during exercise, blocking part of the airflow. Diagnosis is through exercise endoscopy. The most common presentation is a horse that “stops” abruptly during intense exercise. A gurgling noise is often associated. The stopping is due to the displacement of the palate over the airway, preventing sufficient air and oxygen flow. The gurgling is due to vibration of the palate on exhalation. Multiple causes of DDSP exist, leading to various treatment options. As one of the main contributing factors is inflammation in the throat or guttural pouch inflammation, NSAIDs and steroid throat sprays are typically the first line of treatment. If anti-inflammatory treatment does not help, the preferred surgery is a “tie-forward” procedure to keep the larynx positioned within the ostium (opening in the soft palate). Tongue-ties, while not supported by clinical trials, are common in racing horses and are designed to prevent DDSP by preventing swallowing during racing.

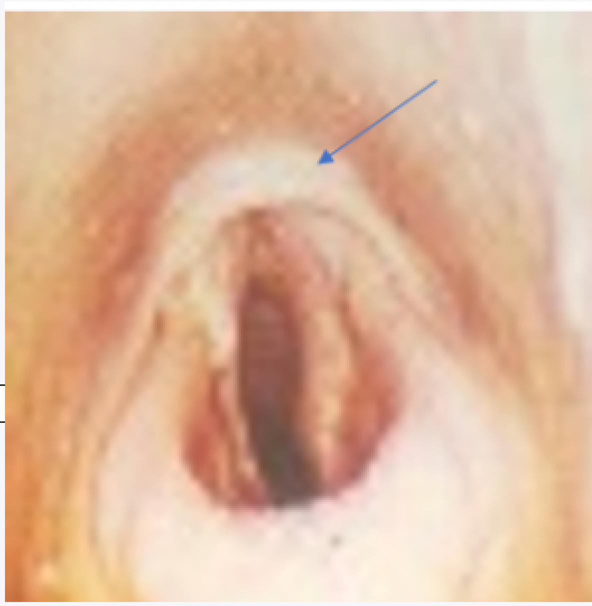
Pharyngeal collapse

Pharyngeal collapse results from the large negative airway pressures and is a common cause of poor performance. Treatment is nonspecific and often not very helpful. Diagnosis is through endoscopy during exercise. Any inflammation and other disorders should be treated. The prognosis is poor for most performance horses.

Note : pharyngeal collapse can occur in young animals with muscle disorders (lack of tone in the pharyngeal muscles). Pharyngeal narrowing can also occur due to pressure from outside structures (full guttural pouch, enlarged retropharyngeal lymph nodes). This type of narrowing is visible on standing endoscopy and lateral head radiographs.



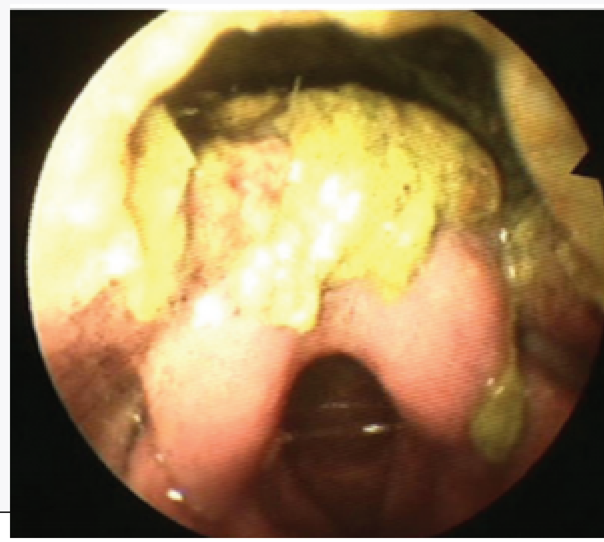
Rostral displacement of the palatopharyngeal arch



The palatopharyngeal arch borders the opening to the larynx. When rostral displacement occurs, the opening the larynx is partially obstructed. This is a congenital lesion leading to impaired laryngeal function (required for performance) and swallowing. The arytenoids can't abduct (open) properly due to the restrictive band. Many of these horses have 4-BAD – 4th branchial arch defect. Treatment is often unrewarding.

Pharyngeal trauma

Pharyngeal trauma is relatively common in cattle, often due to medication administration with bolus guns. The bolus can be pushed through the oropharynx, causing cellulitis. Cellulitis is in this area can lead to dysphagia, dypsnea and medistinitis. Diagnosis often requires radiographs and endoscopy; oral palpation can be useful in larger patients. To treat, the foreign body is removed, any abscesses are drained surgically and the cellulitis treated with systemic antibiotics. A rumen fistula may be needed for feeding and a tracheotomy needed for breathing in more severe cases. Due to the location, drainage of the abscesses can be tricky and is best done at a referral hospital if possible.



https://veterinaryrecord.bmj.com/content/172/26/685

RESOURCES

Respiratory distress in the adult and foal, VCNA (2021) 37:311-325

Upper airway conditions affecting the equine athlete, VCNA: Equine Practice, August 2018, Vol.34(2), pp.427-441

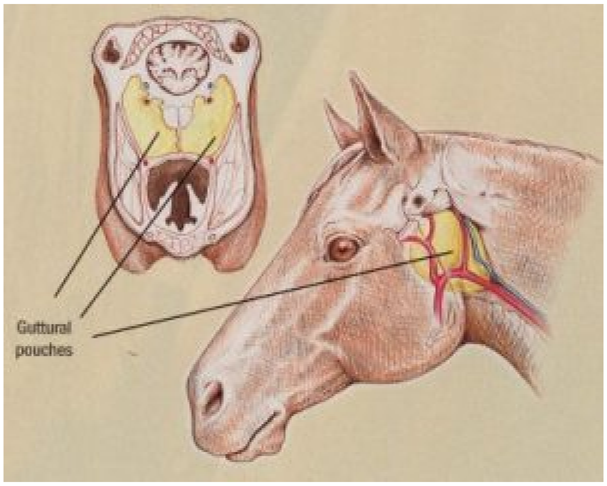
Update on diseases and treatment of the pharynx, VCNA: Equine Practice, April 2015, Vol.31(1), pp.1-1

Surgery of the Equine Upper respiratory tract : focus on dynamic disorders.

Respiratory Surgery, Vet Clin Food Anim 32 (2016) 593-615

Guttural pouch disorders

The guttural pouches are unique to a small number of species, including the horse. The guttural pouches are expansions of the Eustachian tube and are theorized to help with brain cooling. Diagnosis of guttural pouch disorders often includes endoscopy of one or both pouches.

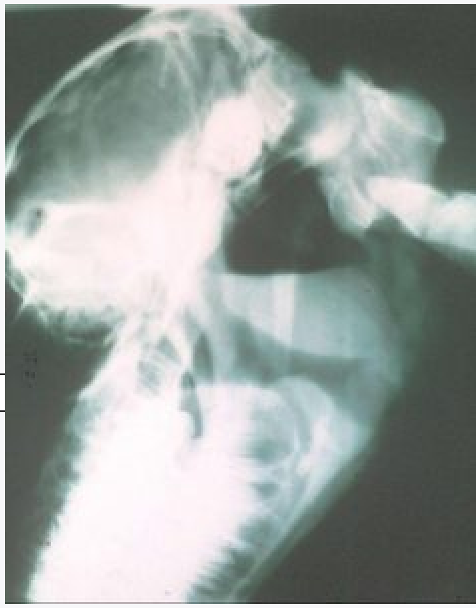


The Horse, Jan 2010

Even though the openings are caudal to the nasal septum, discharge tends to remain unilateral unless severe or chronic. Why they don't cause bilateral drainage isn't entirely clear. Perhaps related to normal head position or the dorsal position of the openings?

Guttural pouch disorders with surgical options:

Guttural pouch empyema



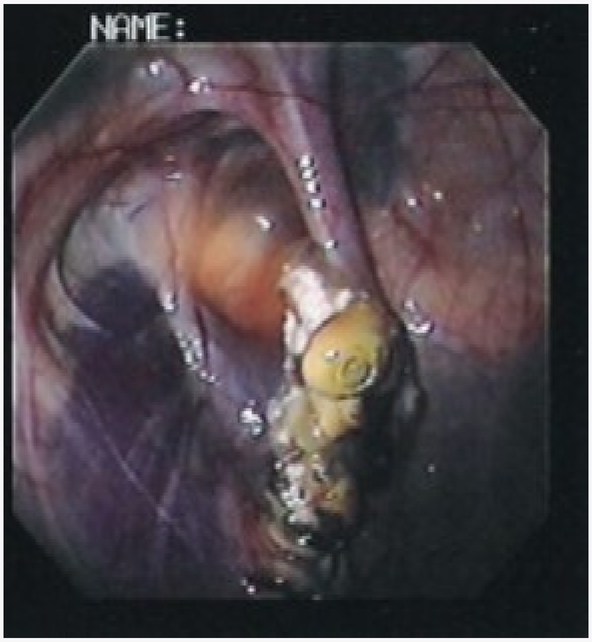
Guttural pouch empyema, or pus in the guttural pouch, is frequently related to strangles (Streptococcus equi infection). Affected horses are often infectious. Drainage from the guttural pouch openings may be seen on endoscopy. Treatment generally involves lavage of the guttural pouch combined with systemic and/or local antimicrobials. Antibiotics alone are not usually sufficient. Retropharyngeal lymph node swelling or full guttural pouchescan compress the pharynx (“stranngling” the horse). Tracheotomy may be needed.

This radiograph shows a fluid line in the guttural pouch.

Guttural pouch chondroids

Chondroids develop when the purulent material from guttural pouch empyema dessicates. These “stones” of pus may need surgery for removal. NO agents have been found to dissolve the stones and many compounds lead to severe trauma to the guttural pouch. Chondroids generally have to be flushed out or removed manually. This is not an easy process. Surgery may be necessary but has lots of risks due to the related inflammation that occurs near all sorts of named arteries and nerves. There is no easy ventral drainage of the guttural pouch. As most animals don’t have guttural pouches, this is a horse thing.

Guttural pouch mycosis



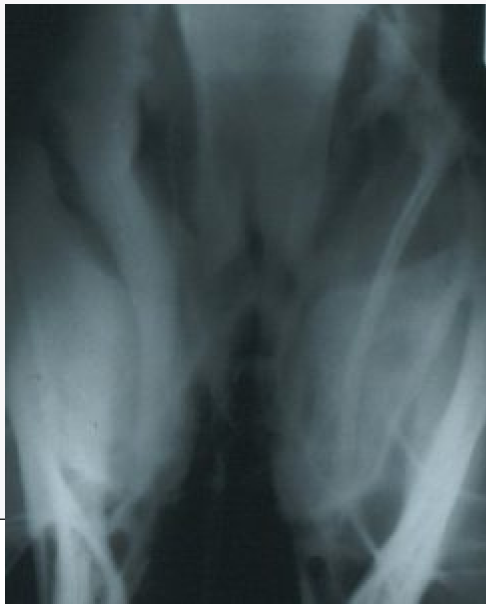
Guttural pouch mycoses are fungal infections, generally involving Aspergillus fumigatus. This opportunistic fungus lives in environment and attaches to an artery in the guttural pouch for nutrition. It can erode through the arterial wall, leading to bleeding (often severe). If the fungus is on an artery, surgical occlusion of the artery is the preferred therapy. This requires both proximal and distal occlusion due to the Circle of Willis . The Circle of Willis is a circle of arteries around the brain. This loop leads to the potential for blood flow from both ends of the artery. Due to access issues, a balloon or coils are used to block off the far end while a ligature is used on the artery outside of the pouch. If the fungus is on a bone or non-arterial structure, it can be scraped off or treated with topical antifungals. Due to the risk of fatal hemorrhage, those options are not recommended for fungal infections involving an artery. Antifungal agents are not required if surgery is used as the fungus cannot live without the arterial oxygen supply. Once the artery is occluded, the fungus dies off.

Bilateral infections are possible. Horner's syndrome can develop due to involvement of the vagosympathetic trunk. The infections can also lead to dysphagia as the fungus affects nerve function to the tongue and swallowing muscles. Typically, the horses with swallowing issues have a very poor prognosis.

Guttural pouch tympany

Guttural pouch tympany is a non painful fluctuant swelling of one or both guttural pouches, particularly in Arab and German warmblood fillies. Air collects in the pouch as the opening operates as a one way valve rather than allowing bidirectional airflow. Respiratory distress is uncommon. Diagnosis is not difficult but it can be more challenging to determine if the disorder is unilateral or bilateral. On endoscopy, an abnormal guttural pouch opening is often evident. Medical treatment (NSAIDs) may resolve some cases. Surgery involves using a laser to create an opening either into the normal guttural pouch to allow air to exit the normal side or creating an opening into the pharynx. Prognosis is good if treated prior to the development of infection inside the pouch.

Temporohyoid osteopathy



deformed stylohyoid on left

Temporohyoid osteopathy (THO) is incompletely understood but involves proliferation of bone around the temporohyoid joint and can result in fusion of the joint between the stylohyoid bone and inner ear. With movement of the head or tongue, pain results and the stylohyoid bone can fracture. Remodeling of the joint and/or bone can be seen radiographically and endoscopically. The remodeling is suspected to result from local (inner ear) infection. Damage to local nerves can also result in poor tear production, dry eye and corneal ulcers. Surgical treatment involves cutting the ceratohyoid bone in the hyoid apparatus to relieve pressure on the joint and stylohyoid bone. Cutting the ceratohyoid bone is much easier and much less dramatic than cutting the stylohyoid bone and has the same result of disconnecting tongue and inner ear. Horses can be affected bilaterally. Prognosis depends upon the degree of dysfunction identified prior to surgery.

Guttural pouch anatomy

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=636#oembed-1

Normal guttural pouch anatomy – see [youtube video]()

- **An interactive H5P element has been excluded from this version of the text. You can view it online here: https://open.lib.umn.edu/largeanimalsurgery/?p=636#h5p-88**

PRIMARY RESOURCES

Guttural pouch diseases in horses, Merck Manual – a little too short and sweet

Guttural pouch disease causing neurological dysfunction, 2011 VCNA – table with really excellent explanation of nerves and side effects of guttural pouch disease

Update on disorders and treatment of the guttural pouch, VCNA: Equine Practice, April 2015, Vol.31(1), pp.63-89- explains how to drain chondroids surgically and goes into more detail about other procedures.

SECONDARY RESOURCES

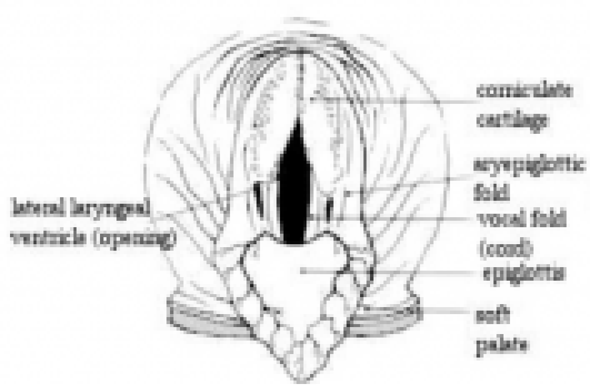
Respiratory Disease Diagnostics in the Horse, VCNA: Equine Practice, August 2015, Vol.31(2), pp.307-336- medical and surgical diagnostics

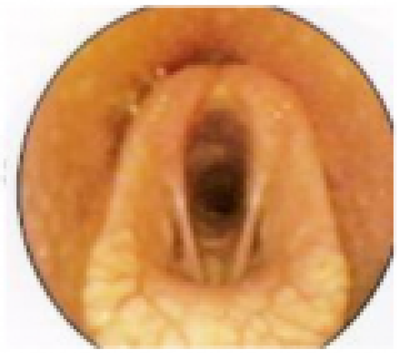
Diagnosing guttural pouch disorders and managing guttural pouch empyema in horses, Vet Folio 2003 – need to register for student access

Guttural pouch diseases, UFL- client perspective

Laryngeal disorders

The larynx includes the epiglottis, paired arytenoids and other laryngeal structures. The larynx connects the pharynx to the trachea.





Dysfunction of the larynx leads to swallowing disorders and impaired performance due to decreased airway diameter. Exercise endoscopy is required to accurately evaluate these disorders in horses. These disorders, while sometimes present, are generally not an issue in other species. Calves and young feedlot cattle do get necrotic laryngitis; temporary tracheotomy may assist in treatment.

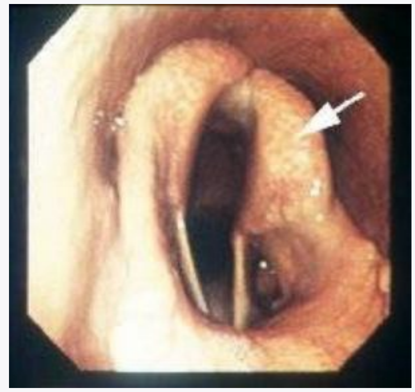
Laryngeal disorders

Epiglottic entrapment

The epiglottis moves up during swallowing to protect the airway. The extra tissue below the epiglottis that permits this movement can also "entrap" the epiglottis in a pillowcase type sheath. This can happen due to congenital abnormalities in the epiglottis and/or membrane and with throat inflammation. The entrapping tissue catches air on exhalation. The trapped air billows the tissue, creating turbulence and noise. The entrapment also prevents normal movement of the epiglottis. Horses often present with exercise intolerance and cough. Diagnosis is made on endoscopy and/or radiographs. With the preferred treatment, a laser is used to split the membrane, releasing the epiglottis from the membrane.

In the image note that you can't see the scalloped edges or vessels of the epiglottis. It looks like it has a pillowcase over it. Compare this to DDSP in which there is no epiglottic outline visible.

Laryngeal hemiplegia



Both arytenoids should adduct during exercise to open the airway for maximal airflow. In the image to the right, the left arytenoid isn't moving properly. With laryngeal hemiplegia, generally the left arytenoid doesn't work at all or doesn't work well. The laryngeal branch of the vagus nerve is the longest nerve in the body and appears to degenerate fairly often. This degeneration leads to neurogenic atrophy of the CAD (cricoarytenoideus dorsalis) muscle. The CAD muscle is responsible for adduction of the arytenoid during exertion. When the arytenoid doesn't adduct properly, it vibrates during exercise and impairs airflow, leading to poor performance. Diagnosis is via exercise endoscopy. Surgery involves replacing the CAD muscle with a suture to adduct the muscle, removing the arytenoid or transposing a nerve to reinnervate the muscle. Performance will usually improve after surgery but horses are more prone to upper airway inflammation, swallowing disorders and recurrent airway compromise. The condition usually develops in young horses and seems to be familial.

Arytenoid chondritis

Inflammation of the arytenoid leads to malformation and dysfunction of the arytenoid. Medical treatment is sometimes effective but often the arytenoid must be removed to open the airway. When the arytenoid is removed, horses are at risk of food aspiration and persistent coughing. In the image on the left, note the enlarged right arytenoid with a protuberance extending across the airway. Look for arytenoid chondritis if you see signs of right side arytenoid dysfunction.

In calves, arytenoid chondritis can develop with oral necrobacillosis due to *Fusobacterium necrophorum*.

Aryepiglottic fold collapse 

The negative pressures in the upper airway of the horse can lead to collapse of soft tissue structures. The tissue between the epiglottis and larynx can be pulled into the airway. Horses present with exercise intolerance and noise. Laser surgery may help.

Subepiglottic cysts

Cysts can develop in the larynx and interfere with function of the epiglottis. Problems with the epiglottis lead to swallowing disorders and feed aspiration. Cysts can be treated by laser or formalin injections.

Resources

Respiratory distress in the adult and foal, VCNA (2021) 37:311-325

Update on laryngeal disorders and treatment, VCNA: Equine Practice, April 2015, Vol.31(1), pp.13-26

Upper airway conditions affecting the equine athlete, VCNA: Equine Practice, August 2018, Vol.34(2), pp.427-441

Laser cordectomy – just for fun

Performance limiting laryngeal disorders– Vetfolio subscription required

Respiratory Surgery, Vet Clin Food Anim 32 (2016) 593-615

Practice Level A

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=5578#h5p-62

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An interactive H5P element has been excluded from this version of the text. You can view it online here:
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Video quizzes

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Practice Level C

Use the following exercises to review the material presented in this section.

Challenge Exercises

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https://open.lib.umn.edu/largeanimalsurgery/?p=681#h5p-93

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https://open.lib.umn.edu/largeanimalsurgery/?p=681#h5p-148

Video quizzes

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=681#h5p-61

Practice Endoscopy 1

Level C

Bugsy 1

"Bugsy" is a 2 yo Thoroughbred racehorse. He is not living up this potential and is making noise when racing. You are asked to evaluate him and identify treatment options.

Your boss just bought a scope so you pull it out and scope the horse:

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For comparison, this one is normal:

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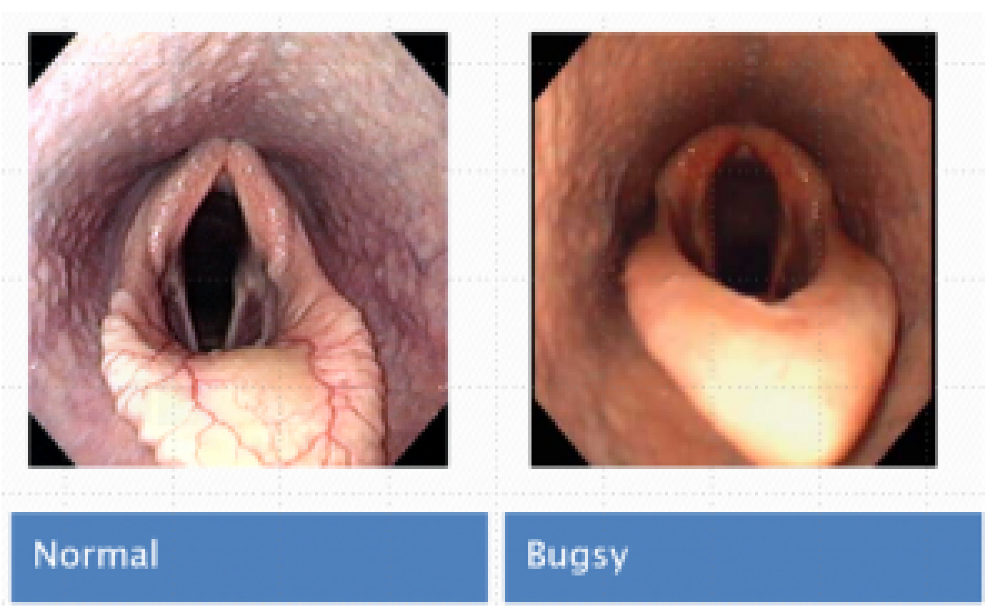

What does the epiglottis do? How and when does it move?

Noise is caused by narrowed airways or vibrating structures (think heart murmurs).
What type of noise would you expect from this lesion?

1. No noise
2. Vibration – > noise
3. Narrowed airway -> noise

How would you confirm your hypothesis?

You find :

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What treatment would you recommend to the owner? Use lay terminology as if you were speaking to the client.

What treatment did you **not** recommend to the owner? Why did you skip that one?

What resource did you use for this question?

Practice Endoscopy 2

Level C

Bugsy 2

You scope Bugsy and see this instead:

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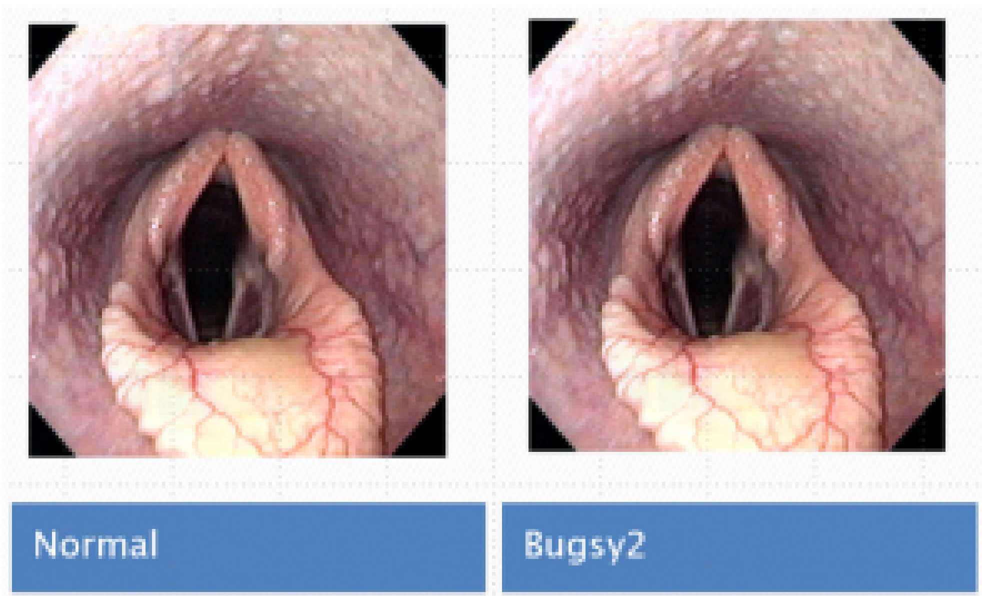

He is still making noise. You tell the client you need to put him on the treadmill and you see

What are your odds of seeing something different at exercise vs standing?

What resource did you use to answer that?

You see

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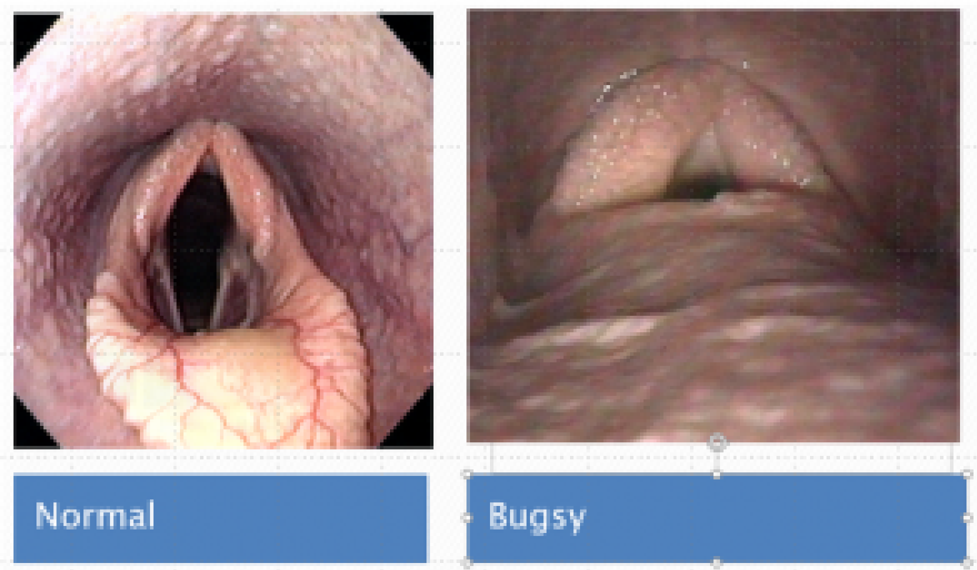
Next time you scope him standing you see :



What is your diagnosis?

What treatment do you recommend? Use lay terminology as if you were speaking to the client.

What treatment do you not recommend and why?

Resource used:

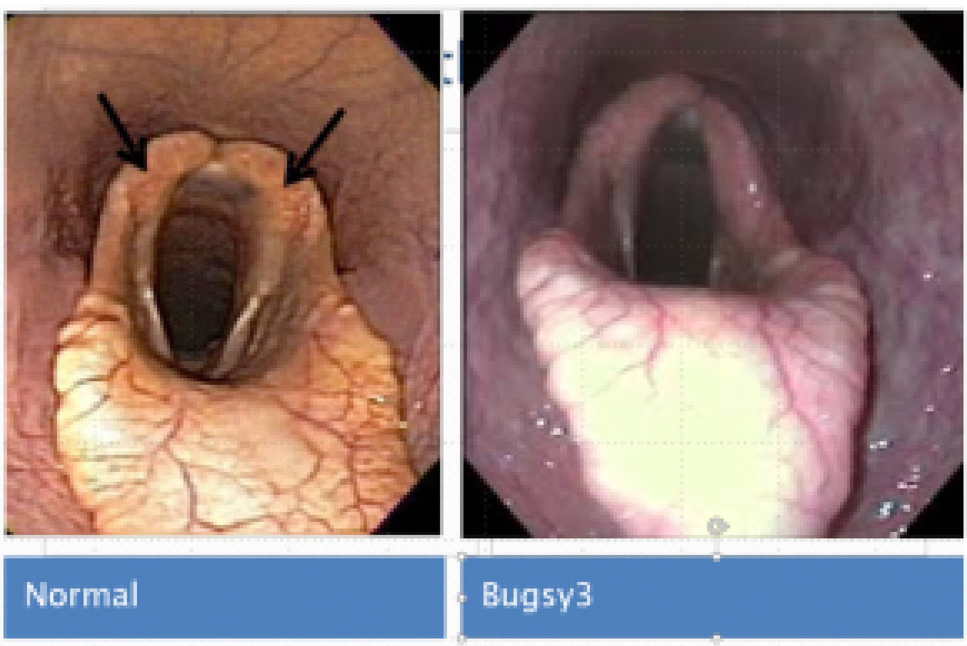
Practice Endoscopy 3

Level C

Bugsy 3

When you scope Bugsy3 you see

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2584#oembed-1*



What is your diagnosis?

What is your treatment recommendation? Use lay terminology as if you were speaking to the client.

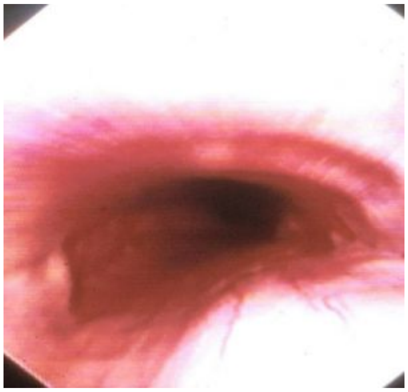
What did you not recommend and why?

Resource:

****

Bugsy answer key

Tracheal disorders


collapsed trachea

Tracheal disorders are rare in horses with the exception of tracheal collapse in miniature horses. Tracheal collapse leads to respiratory noise and exercise intolerance. Surgical stenting has been performed as in small animals, with limited success.

Tracheal perforation can occur with trauma and is treated conservatively and/or with a temporary tracheotomy.

Resources

Disorders of the trachea in horses, B. Ohnesorge, H. Gehlen and E. Deegen IVIS 2002

Respiratory Distress in the Adult and Foal, 2021 VCNA Vol 37 pp 311-325

Pleural space disorders

In cattle, pleural abscesses and pericarditis occur secondary to hardware disease. Prognosis is grave and treatment is not recommended. The surgery is cool, though, and is aided by the bovine complete mediastinum which generally prevents bilateral pneumothorax.

Pleural abscesses in horses are generally secondary to pleuritis and can be treated through drainage once consolidated. Generally pleural surgery is best performed in a referral hospital due to the risk of bilateral pneumothorax and collapse.

Thoracic wounds

Thoracic wounds are the most common cause of pleural space disease in horses. A wound between the ribs can enter the thoracic cavity, the peritoneal cavity or both. Due to the curve of the diaphragm, any wound after the 6th intercostal space could enter the peritoneal cavity; this often means both the thoracic and peritoneal cavities should be evaluated carefully. With trauma, pneumothorax, pleuritis and peritonitis can develop with significant consequences. Horses with pneumothorax show signs of distress with rapid and often shallow breathing. Pneumothorax requires air removal and prevention of more air into the cavity. Trying to remove the air in the field is challenging! A wound may be sutured temporarily or bandaged with an impermeable product until the horse reaches the hospital. A stent bandage (bandage sutured in place) can be easier to place than banding a horses full thorax.

Pleuritis can be very painful. It is treated with antibiotics and/or abscess drainage. Both peritonitis and pleuritis can be fatal.

Axillary wounds are also common and can lead to pneumomedistinum and subsequently to pneumothorax:

Axillary wounds in horses and the development of subcutaneous emphysema, pneumomediastinum and pneumothorax

A. Joswig J. Hardy
EVE Vol 25 (3): 139-143, 2013
Summary

Equine axillary wounds are common in horses. Severe and potentially life-threatening complications that can result from axillary wounds include subcutaneous emphysema, pneumomediastinum and pneumothorax. This report describes the occurrence of these complications and appropriate treatment. Case records of 7 horses after sustaining an axillary wound are reviewed. Of these cases, all 7 developed subcutaneous emphysema, 5 developed a pneumomediastinum and 4 developed a pneumothorax. The time between the wound occurrence and the development of subcutaneous emphysema was able to be determined in 5 of the 7 cases. The mean ± s.d. time for the development of subcutaneous emphysema following initial injury was 3.2 ± 0.84 days (range 2–4 days). Resolution of subcutaneous emphysema was not achieved until the treatment included packing the wound to stop it from acting as a one-way valve. Horses with a pneumothorax in respiratory distress were managed with thoracocentesis or placement of thoracic drains. Horses with a pneumothorax but without respiratory distress were treated with conservative management. All horses survived to discharge.

Pneumomediastinum has no associated clinical signs.

Neck wounds can also lead to pneumomediastinum. Typically both axillary and neck wounds lead to subcutaneous emphysema which can track into the mediastinum. Typically subcutaneous emphysema is left to resolve on its own; more attention is paid to minimizing its development by minimizing movement of the horse. The horse’s body temperature should also be monitored as subcutaneous emphysema has an insulating effect.

Rib Fractures

Rib fractures can occur in foals during the parturition process. These are often undiagnosed. The fracture ends can cause lung lacerations, cardiac lacerations and diaphragm damage. Approximately 10% of neonatal deaths are due to rib fractures. Diagnosis is made by putting the foal on its back and checking for symmetry and/or by ultrasounding the ribs. Treatment is stabilization. Stabilization is performed by keeping the affected side down, splinting the ribs and with oxygen supplementation. Bandaging is contraindicated with a flail chest (flail =both sides fractured)!

Practice

Level B

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https://open.lib.umn.edu/largeanimalsurgery/?p=655#h5p-172

PRIMARY RESOURCES

Axillary wounds in horses, EVEVol 25 (3): 139-143, 2013

How to manage penetrating wounds in the field, AAEP 2012

Thoracic trauma in horses, Volume 31, Issue 1, April 2015, Pages 199-219- denser and more thorough

SECONDARY RESOURCES

Treating thoracic injuries, Vet Folio 2009 -worth subscribing

Hardware disease in the bovine, 2015 Acad J of Animal Diseases (we don't treat as many as they do)

Diagnosis and treatment of hardware disease, 2017 VCNA

STUDY BREAK

Study break: This is what goes on at our house

Indications

Temporary tracheotomies are performed when airflow is significantly impaired through the upper airway. The obstruction MUST be proximal to the tracheotomy for it to help. Indications of airflow obstruction include nostril flaring, open mouthed breathing, no flow through nostrils, audible respiratory noise and inability to eat and breathe at the same time.

Temporary tracheotomies are also used for intubation for upper airway or dental surgery and when airway access need is immediate (eg animal acutely needs to be intubated).

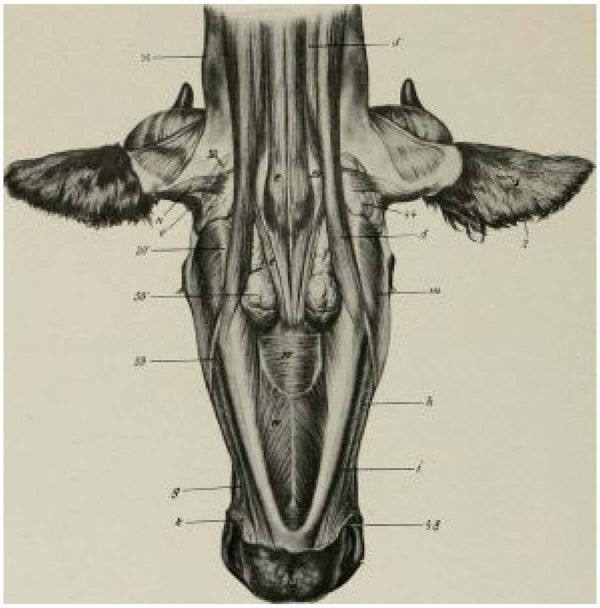
Tracheotomies can also be useful for diagnostics. The diagnostics may further impair the airway and/or an endoscope can be inserted via the tracheotomy to visualize the inner aspect of the larynx.

Relevant anatomy

The proximal aspect of the trachea is the larynx. Cut distal to this unless you are performing a laryngotomy.

The tracheal rings are cartilaginous. If cut, they tend to form chondromas. Chondromas can obstruct airflow. In LA species, we try really hard to NOT CUT the cartilage. Cut between the rings, not through them. Yes, the jugulars are in the same ballpark but not really that close. The closest important structure is the esophagus.

The neck strap muscles cover the surface of the trachea. The muscles do not cross midline. If your incision is centered, you can (and should) separate the muscle bellies and avoid cutting any muscle.



Preoperative management

Food restrictions: Not required

NSAIDs/analgesics: Preoperative NSAID is recommended

Antibiotics: Not required

Tetanus prophylaxis is recommended.

Local blocks: Lidocaine line block if the animal is conscious

Position/preparation: Standing is easiest. The head can be elevated in a dental harness. Standing isn't always an option. Having the animal's neck as straight as possible helps keep the incision midline. If the animal is conscious, the area is clipped and prepped routinely. If the animal has collapsed, just make an incision.

Surgery Supplies:

- Scalpel blade
- Hemostats (mosquitos or kellys)
- Tracheotomy tube or endotracheal tube

Surgical procedure

- Make a 10 cm vertical incision centered at the junction of the proximal and middle thirds of the palpable trachea (ignore the thoracic component). Incise through skin to the muscles.

Local block and Dr. Nicholson finding the right center spot

Vertical skin incision

Dissect bluntly between the muscle bellies until the tracheal is directly palpable and visible

- Insert a scalpel blade between the cartilage rings and incise 180 degrees horizontally between the rings.
- Repeat if you didn't actually do that

Dissecting between the muscles; incising the tracheal membrane horizontally

- Push the tracheotomy tube or endotracheal tube into the area. The hemostat can be used to open the site first, providing a guide. Make sure the tube has gone into the trachea rather than subcutaneously.

Inserting the tracheotomy tube and verifying it is in the trachea, not just SQ

- Secure the tube in place.

Postoperative care

- The tube should be cleaned twice daily for the duration or at least the first two weeks. It is safe to remove the tube and clean it.
- Many clinician perform to trade out 2 tubes so that one can soak while the other is in use. Soaking helps clean off the cement-like exudate.
- Avoid ponds and baths – no water into the tracheotomy site.
- When the animal has recovered, the tracheotomy tube is removed and the wound left to heal by second intention. No closure.

Complications

If the skin incision is made off midline, the animal may suck the muscles/skin over the tracheotomy opening when the tube is removed. This may make changing the tube more challenging. A second set of gear is helpful so that the airway can be maintained open even during cleaning.

The airway is compromised. Larger particles can make it into the lungs and cause respiratory illness. Water could get into the airway and cause drowning.

Videos

Narrated tracheotomy

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=720#oembed-1

Key Takeaways

If the animal is dying, skip the clip and prep

Make a vertical incision in the skin, staying on midline

Make a horizontal incision between the rings, extending about 1/2 way around.

Do NOT cut cartilage.

Leave to heal by second intention.

Resources

Tracheostomy, Merck- PS Chondritis is usually unilateral and doesn't often require a tracheotomy unless severe or surgical treatment

Tracheotomy and tracheostomy tube placement in cattle, 2008 VCNA- how to reference for cattle

Manual of Clinical Procedures in the Horse – great how to reference for horses

More tracheotomy videos -vet students in action

Study break :sloths – really worth the time

Practice - tracheotomies

Level A

Challenge Quiz

Take the following quiz until you are comfortable with tracheotomies. You don't always have time to look this one up.

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https://open.lib.umn.edu/largeanimalsurgery/?p=728#h5p-64

And then try:

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https://open.lib.umn.edu/largeanimalsurgery/?p=728#h5p-65

LA umbilical disorders

Patent urachus, hernias and umbilical infections

Umbilical hernias

Equine umbilical hernias- overview

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Umbilical hernias are typically seen in young animals and are typically are either (1) inherited or (2) develop due to umbilical infections. A few develop due to traumatic separation of the umbilical cord. Congenital hernias are likely inherited if there is no sign of infection. Quarterhorse fillies, Holstein calves and pigs are predisposed. Some foals develop hernias within the first 2 months of life; these are also assumed to be due to a genetic cause.

Ventral hernias can also develop as incisional complications or direct trauma. These commonly occur when exercise is allowed too soon after abdominal surgery. The adult horse body wall takes 60 days to regain strength. Unfortunately, no absorbable suture lasts that long.

If a hernia develops due to trauma or incisional dehiscence, it is important to wait until a good firm fibrous ring develops before attempting repair. This generally requires about 60 days. Most of these should be referred to a surgery facility.

Smaller hernias (<5cm diameter) in foals may resolve on their own and this usually happens within the first 3 weeks of life. If a hernia is still present at 4 months of age, it probably isn't going to resolve on its own. Surgery is usually delayed until the foal is weaned and is 4-6 mo of age.

Small hernias are most dangerous as intestines can slip into the hernia and get stuck. Large hernias may not need fixing as intestines slide in and out.

Treatment options include hernia clamps, belly bands and surgery. Hernia clamps are cheap and are designed to cause necrosis and scarring. Complications include sepsis and evisceration. Hernia belts may or may not work better than mother nature; research is limited to non-existent.

Surgery can be performed in the field under the right conditions. Surgical repair can be done either closed (keep the hernia sac and peritoneum closed) or open (open the hernia sac and open the peritoneal cavity). Closed repair is frequently performed in horses. A fusiform incision is made around the hernia and the hernial sac dissected free of the skin (which is removed). The sac is pushed into the abdomen and the hernia sides closed over it.

Open repair is advised for bovine hernias since infection is often the cause of the hernia. After dissection to the abdominal wall, a stab incision is made into the abdominal cavity and then the hernia sac opened carefully, following the hernial ring. The stab incision should be made to one side to avoid the umbilical vessels that traverse cranially and caudally. These vessels should not be patent at this stage but may contain pus!

Body wall closure should be done with relatively large, long lasting suture in a simple continuous pattern. We use #2 PDS for most weanlings. Babies like to bounce. Bouncing is hard on the incision. PDS is the longest lasting absorbable suture we have. It maintains strength for about 45 days. Continuous patterns have been shown to be more secure under tension than interrupted patterns:

> Many of us were taught to close hernias with a vest-over-pants suture or a bunch of cruciates. That was bad advice. The goal was to strengthen the closure or minimize the risk of it falling apart. A vest-over-pants (or Mayo mattress suture) creates an overlapping body wall. The problem is that the body wall doesn't heal that way. The multiple cruciates were done in the hopes that, if one failed, the others would hold. That isn't true either. Once one pops, all of them pop. Simple continuous suture redistributes pressure as needed. Yes, you need to tie good knots but that is true for all of them.
>
> See details in the Umbilical infection chapter

Many postoperative complications are similar across species for abdominal surgery and include infection, peritonitis and hernia recurrence. The body wall is fascia and is poorly vascular. In the adult horse, it takes approximately 60 days for the hernia repair to have moderate strength. No absorbable suture lasts that long so restricted exercise is important.

Richters and entrapped hernias

If the intestines are stuck, the animal will usually show signs of colic initially. Eventually the animal may become depressed. In a normal hernia, the intestines can be shoved back into the belly; if entrapped, the hernia is not reducible. The hernia area may be painful on palpation. The area may be warmer or colder than surrounding areas.

With a Richter hernia, only part of the intestinal wall is entrapped vs the full width of the intestine being entrapped. This part of the intestinal wall can become devitalized and leak, resulting in an intestinal fistula.

Key Takeaways

- Umbilical hernias are often associated with umbilical infections in calves.
- Pigs and foals just get hernias (not always infections) and these are likely hereditary. We still do surgery on foals but owners should be advised about inheritance risk. We try to avoid surgery in show pigs.
- Use fusiform incisions, enter abdominal cavity to the side (not cranial or caudal).
- Foals with umbilical infections are sick. Since the diagnosis occurs fairly early, these animals do respond to antibiotic therapy.
- The body wall heals really slowly. Early exercise will increase the risk of hernia recurrence.

Supplemental Resources

Management of umbilical disorders in the foal, In Practice, 2008- more details; nice reference for your files

Tissue Strength and Wound Morphology of the Equine Linea Alba After Ventral Median Celiotomy, Vet Surg 2000- evidence regarding how long the body wall takes to heal after surgery

Video: bandaging a hernia to keep it reduced

Video: field anesthesia for hernia repair – designed to give you an mental image of the procedure

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=878#oembed-2

Video : Simple hernia repair in a horse (or dog, pig, calf, etc)- more specifics for those that want them

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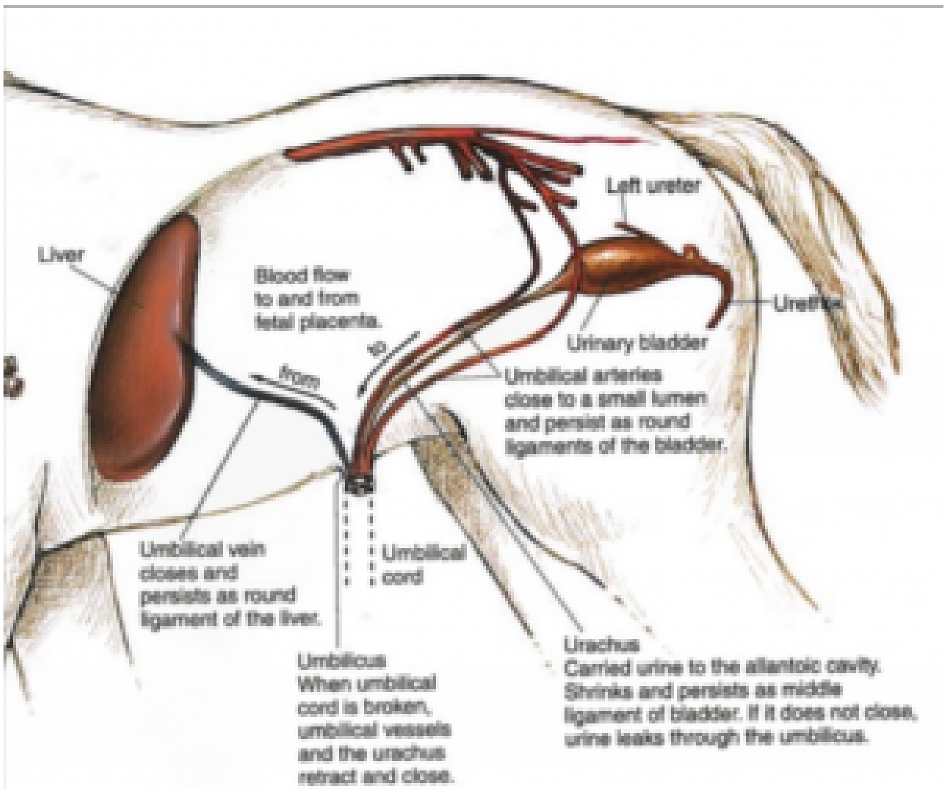
Video: protecting the intestines during body wall closure – cool technique that applies to all species; youtube link

Umbilical infections

Umbilical infections are most commonly seen in calves. Camelids and foals can also present with umbilical infections; these animals tend to be much sicker and present at a younger age.



Umbilical structures. The "round ligament of the liver" is also known as the "falciform ligament".

Normally the urachus dissolves and is not present at birth. The umbilical arteries turn into the round ligaments of the bladder. The umbilical vein becomes the falciform ligament (aka the round ligament of the liver).

Any of the umbilical structures can become infected (and not follow the normal patterns). Urachal infections are the most common; umbilical vein infections the least common.

Diagnostics

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https://open.lib.umn.edu/largeanimalsurgery/?p=862#h5p-135

Camelids and foals get very sick if the umbilicus is infected and are generally treated with systemic antimicrobial therapy.

Calves tend to have more chronic infections and are treated by removal or drainage of the infected structure. If possible, we remove the infected stalk without opening it or rupturing it. In calves, open hernia repair* is preferred over closed repair to evaluate for any signs of infected umbilical structures or adhesions that might be hiding in there. The infected stalk is identified and, ideally, removed.

Calves with umbilical vein infections often have liver involvement. This makes them higher anesthetic risks and poor doers.

Calf hernias intro (consider this required viewing)- youtube link

*Open hernia repair- the hernial sac is opened for abdominal exploratory

Closed hernia repair – the hernial sac is inverted into the abdomen and is not opened.

Key Takeaways

- Urachal infections are the most common form of umbilical infection in calves. Surgery to remove the stalk includes amputating the end of the bladder.
- Close the bladder in 2 layers with **inverting** suture patterns. Avoid suture in the lumen of the bladder (nidus for stone formation). 3-0 monocryl works well in foals, goats and other smaller patients.
- Umbilical artery infections can usually be removed en bloc (cut after the mushroom cap and where the “artery” is thin. No blood flow to worry about.
- Umbilical vein infections -> liver and have a poor prognosis. Surgery involves marsupialization.
- Keep these animals on restricted exercise for 6-8 weeks to avoid recurrence of the hernia.
- No matter what you read, don’t do a vest over pants or a Mayo mattress suture for these. **Appositional** continuous pattern is best!
- Use suture material that will last the 6-8 weeks and use large enough (#1 or #2 PDS or nylon usually) suture

Supplemental Resources

Umbilical masses in calves, ACVS- nice review; client focused

Calf umbilical surgery,-nice details if you will be doing these in the future – save for your files

> We do recommend continuous patterns for all 3 layers of the body wall closure. I also agree with her suture removal time (14 days) but really keep calves and foals restricted for much longer than 14 days. Think about it. How long does your suture last (PDS? Vicryl?) and how long does it take the body wall to heal (60 days for adult horse)? What can happen if they bounce in the time frame between when the suture is no longer strong and body wall is still weak?

This study is one of my favorites:

Vet Surg. 1999 Nov-Dec;28(6):442-7.

Comparison of incisional bursting strength of simple continuous and inverted cruciate suture patterns in the equine linea alba. Magee AA[1], Galuppo LD.

OBJECTIVE:To determine the bursting strength of ventral median abdominal incisions closed by either simple continuous or inverted cruciate suture patterns.

METHODS:A 25 cm ventral median incision was made through the linea alba and a 200 L polyurethane bladder was placed within the abdomen. Either a simple continuous or an inverted cruciate pattern using 3 polyglactin 910 with a bite size and suture interval of 1.5 cm was used to close linea incisions. Closure time was recorded for each pattern. The bladder was inflated with air at 40 L/min, and the pressure at body wall failure recorded. The length of suture used for wound closure and the wound failure modes were recorded. Deviation from the linea (cm), total suture length (cm), suture length to wound length ratio (SL:WL), closure time (min), bursting pressure (mm Hg), and failure modes were compared between groups using Welch-Aspin t-tests. The effects of independent subject variables were assessed for possible effects on bursting strength using analysis of covariance.

RESULTS:Mean bursting pressure was significantly greater for the simple continuous pattern than for the inverted cruciate pattern ($P = .01$). Significantly less suture material ($P = .0002$) was required with the continuous pattern than with the inverted cruciate pattern. Mean closure time, SL:WL, deviation from the linea, and failure modes were not significantly different between groups. No significant effects were noted for independent variables in both groups on bursting strength.

CONCLUSIONS:In this model, a simple continuous closure pattern for ventral median abdominal incisions was stronger than an inverted cruciate pattern. A simple continuous pattern leaves less foreign material in the wound, which may be of benefit in reducing incisional complications.

CLINICAL RELEVANCE:Use of a continuous closure pattern for the linea alba may offer greater wound security during episodes of increased intra-abdominal pressure in horses.

Comparison anesthesia techniques in calves undergoing umbilical surgery, Vet Anes Anal 2012 – for future reference

More visual details for those of you interested: youtube link

Indications

Herniorrhaphy should be performed for smaller hernias where bowel entrapment is present or possible. It is commonly performed for most umbilical hernias and many incisional hernias. A firm hernial ring must be present prior to attempted repair. This can take 60 days after injury.

If external infection is present, this should be drained prior to surgery. Allow 5 days after drainage to allow granulation tissue to develop. To minimize infection, surgery should not be performed until granulation tissue is present.

Relevant anatomy

With a hernia, the linea alba is split, leaving a body wall defect in the center.

Preoperative management

Food restrictions: Withholding food makes hernia closure easier, particularly in ruminants. Food can be withheld for 48-72 hours in ruminating animals.

NSAIDs/analgesics: Preoperative NSAIDs are recommended.

Antibiotics: Antibiotics are given preoperatively if infection is possible (calves often have internal abscessation). Penicillin, ceftiofur or ampicillin are reasonable choices in food animals.

Tetanus prophylaxis is recommended in horses.

Local blocks: Inverted U shaped line block

Position/preparation: The animal is positioned in dorsal recumbency. The ventral abdomen should be clipped to allow possible incision extension to the liver or to the bladder. The surgeon should be prepared for deeper exploration.

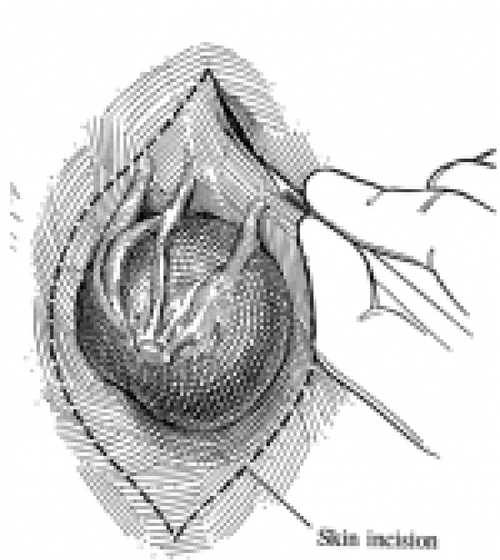
Surgery Supplies:

- Standard surgery pack
- #2 PDS or nylon for body wall closure

- 0 absorbable suture, taper needle, SQ
- 0 or 1 suture, cutting needle, skin

Surgical procedure

- A fusiform incision is made over the hernial ring, leaving enough skin for closure. Alternatively, an inverted V can be made around the prepuce in males with the prepuce reflected to expose the body wall



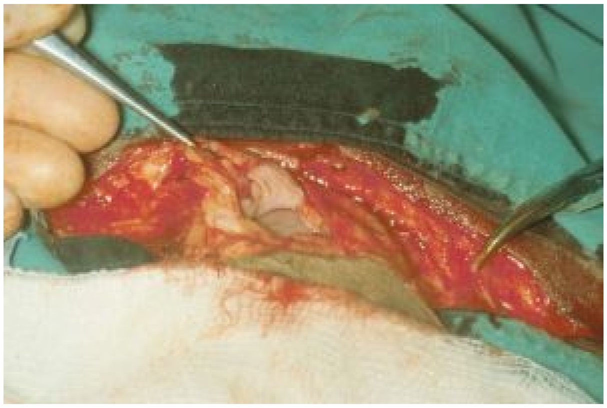
12-4B

Turner & McIlwraith, Large Animal Surgery

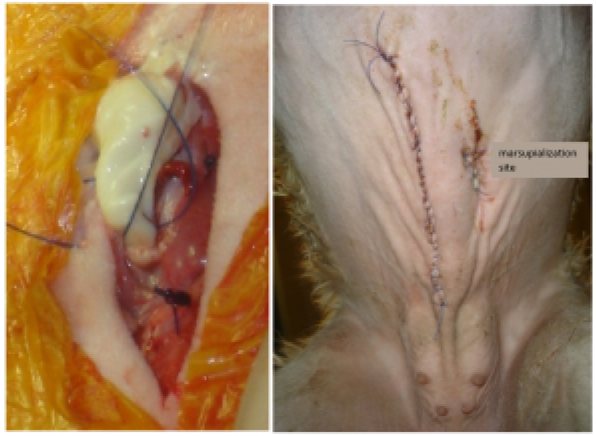
Baird; VCNA 32:673-685, 2016

- Dissect loose connective tissue off the body wall.
- Incise the ring on the lateral aspect (avoiding umbilical structures cranially and caudally), creating an incision into the peritoneal cavity large enough for a finger to enter.
- Palpate the ring as much as possible, identifying any stalks.
- Incise the body wall, following the ring on its inner aspect. Incise only those areas that are palpably normal (no infected stalks). Once the incision is large enough to visualize the umbilical structures, dissect around any stalk.

- In uninfected cases this will result in a circular opening into the peritoneal cavity and the hernia skin will be totally removed.



- If there is a stalk, continue circling the stalk until it is freed. Incise the skin to follow the stalk into the abdomen.
    - If the infection continues to the bladder, remove the end of the bladder to remove the infection. Close the bladder in a two layer **inverting** pattern.
    - If the infection continues to an umbilical artery, it will usually end in a bulb. Resect proximal to the bulb.
    - If the infection continues to the liver, it may need to be marsupialized. For marsupialization, the infected vein is exited through a small incision made laterally. The vein is tacked to the skin. The infection will drain when the animal is standing. Note: these animals are high risk anesthesia patients and will usually develop a hernia at the marsupialization site.



- Closure
    - Close the body wall with #2 PDS or nylon, simple continuous pattern
    - Close the subcutaneous tissues with 0 absorbable suture, simple continuous pattern
    - Close the skin with 0 or 1 nonabsorbable suture, Ford Interlocking pattern

Postoperative care

- Stall rest with handwalking for 60 days (adult) or at least 3 weeks (young animal) to permit body wall healing
- Continue antibiotics if any contamination
- Continue NSAIDs 2-3 days
- Refeed slowly

Complications

- Peritonitis- fever, depression, poor motility
- Hernia reformation
- Incisional infection or **dehiscence**– signs of inflammation or intestines protruding from the incision

Videos

- Simple hernia: youtube link
- Approach to a more complex hernia: youtube link

Resources

AN Baird. Surgery of the umbilicus and related structures. VCNA 32:673-685, 2016

Practice- Level A

Challenge yourself!

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=911#h5p-69

Patent urachus

Generally a patent urachus in 1-2 week old foal means the foal is systemically ill. Treat the systemic illness (administer broad spectrum antibiotics), not the urachus. Once the foal is improved, the urachus will close over. Treatment with silver nitrate or other cauterizing agents does not help and may lead to infection. If the urachus does not respond quickly to medical treatment, surgery to remove the urachus is probably indicated. Due to the anesthesia risk, this is a referral surgery.

Other reasons the urachus fails to close may be due to congenital anomaly, abnormal tension on the cord at parturition or partial urethral obstruction at parturition.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=919#oembed-1

The treatment recommendations are currently changing; a consultation is recommended if you are managing such a case.

Review
Tierarztl Prax Ausg G Grosstiere Nutztiere 2021 Aug;49(4):275-280.
[Urachal patency in neonatal foals – a review of the literature]

Abstract

in English, German

Urachal patency is an umbilical disease in newborn foals. Etiologically, either the closure of the urachus remains absent after birth (persistent urachus) or the urachus was already closed and reopens at a later time (patent urachus). The most common causes of patent urachus are congenital defects, tearing of the navel above the predilection site, trauma, increased intravesical or abdominal pressure and umbilical infections. Patent urachus occurs more frequently in premature or weak and immunocompromised foals. Colts are more often affected than fillies. Typical clinical signs are apparent immediately after birth (persistent urachus) or 7-14 days postpartum (patent urachus). These include either dripping or a stream of urine through umbilicus during micturition as well as a moist umbilical area. The diagnosis is usually unambiguous. Typical laboratory findings are not described for patent urachus. Conservative treatment such as obliteration, cauterization or cryosurgery may be employed in cases lacking an inflammation of the urachus or other umbilical structures and when the urachal lumen measures less than 6 mm. Surgical treatment is indicated in foals with large urachal lumen, an umbilical infection or sepsis as well as when no therapeutic success is attained after a conservative treatment of 5-7 days. In most cases, prognosis is good, however complications such as umbilical inflammation, disseminating infections, and secondary joint diseases may significantly impair prognosis.

Supplemental Resources

Short term outcome and risk factors for postoperative complications following umbilical resection in foals. EVJ 2018

Study Break

http://www.smosh.com/articles/20-ridiculously-stupid-warning-labels

http://rinkworks.com/said/warnings.shtml

Bladder, Urethra and Ureters

This unit focuses on urolithiasis, urethral ruptures and bladder ruptures.

Ectopic ureters

Rather than inserting into the bladder, ectopic ureters insert into other parts of the urinary tract. Most insert distal to the trigone and empty urine into the vaginal vault. Ectopic ureters in horses are unilateral in 75% of the cases and bilateral 25% of the time. Ectopic ureters have been diagnosed in camelids and are treated with unilateral nephrectomy.

Clinical signs typically include urine scalding from birth, particularly in fillies. Normal urination is possible if the animal has unilateral ectopia or if the bladder fills due to urethrovesicular reflex (backwards flow). Colts may not be incontinent since retrograde filling of bladder will often occur.

Diagnosis is confirmed by a combination of contrast studies, ultrasound and endoscopy. Intravenous urography doesn't usually work well due to dilution of the contrast media in horses (just can't see it). Retrograde urethrocystography is performed by inserting a balloon tipped catheter into the bladder and infusing enough media to distend the bladder and hopefully fill up the ureters. Injection of contrast directly into the renal pelvis, creating an excretory urogram, was successful in a case seen at the UMN. Ultrasound may identify dilated ureters and/or a dilated renal pelvis. Using videoendoscopy, the ureters can be watched for urine flow. A papilla may be seen in the vagina that is the exit site of the ectopic ureter. Colored dyes may also be given orally that change urine color, making the ectopic site more readily identified.

- indigoermine 0.25 mg/kg
- phenolsulfonphthalein 0.01 mg/kg
- sodium fluorescein 11 mg/kg
- neoprontosil 0.05 ml/kg

It is important to evaluate for hydroureter and hydromephrosis as either will affect treatment and/or prognosis.

Treatment of ectopic ureters is by either ureterovesical anastomosis (as performed in small animals) or nephrectomy. Nephrectomy is recommended for unilaterally ectopic ureters; obviously this doesn't work well for bilateral cases. Early treatment decreases the risk of hydronephrosis and ascending infection.

The most common causes of hematuria in horses are penile SCC and urolithiasis.

Renal hemorrhage

Kidney disorders are rarely treatable in the horse. Luckily, renal failure progresses slowly in the equine and diagnosis of renal disorders may not be imminently fatal. However, diagnosis of kidney disease is often delayed due to the lack of clinical signs prior to the onset of renal failure. Renal hemorrhage (hematuria due to blood coming from the kidneys) is considered idiopathic and usually becomes bilateral with time. It may be due to toxins causing medullary crest necrosis. This disorder is considered not treatable; surgery on the kidneys is rarely performed.

Bladder neoplasia

Solitary lesions of the bladder apex can be treated by resection cystoplasty (cut off end of bladder and close). However, neoplasia is usually advanced by the time of diagnosis and cutting off the end of the bladder is usually not sufficient to resolve the problem.

Urethral hemorrhage

Stallions with urethral hemorrhage present for hemospermia associated with pain on ejaculation. Geldings are presented for hematuria with minimal other clinical signs. On endoscopy, linear urethral defects are found at the level of the ischial arch (near openings for accessory glands). It is theorized that the bleeding is due to “blow out” of the corpus spongiosum penis. Blood is seen at end urination when the bulbospongiosus muscle contracts to expel urine (and there is an increase in pressure in the corpus spongiosum).

Treatment involves prolonged sexual rest and/or temporary perineal urethrostomy. By opening the corpus spongiosum penis, pressure does not build up and bleeding is minimized. Because the CSP is the suspected culprit, the PU may not need to enter the urethral lumen but may just extend through the CSP.

Urethrorrhexis (urethral laceration)

The urethra is relatively superficial in the perineal and inguinal region. Trauma from kicks, barbed wire, and jumping fences can lead to laceration of the urethra. The penis has also been lacerated accidentally in castration procedures. Following trauma, urine leakage leads to a pronounced soft tissue inflammatory reaction with secondary edema of the prepuce, inguinal region and hindlimbs.

Diagnosis may be difficult. Ultrasound and endoscopy can be useful. Fluid aspirated from the tissues will have an ammonia smell, particularly if heated. Dyes and positive contrast radiographs may be needed.

Treatment goals :

- control regional inflammation with NSAIDs, hydrotherapy, antibiotics
- surgical resection of damaged tissue
- divert urine flow (typically by a perineal urethrotomy above the laceration)

Urolithiasis

Horses tend to have a single stone in the bladder. The presenting complaint is hematuria, generally associated with exercise. It is rare for the stone to move more distally than the pelvic urethra. However, if the stone does lodge in the urethra, those horses can develop ruptured bladders. Many horses with bladder stones do have nephroliths, as well.

Bladder stone removal may be accomplished through the urethra (standing) or via cystotomy (general anesthesia). Gradual urethral sphincter dilation and/or sphincterotomy can allow stone removal in mares. Stones in males are often removed via perineal urethrotomy or, less commonly, via a perirectal incision. In both cases, stones may need to be broken up prior to standing removal. Other options include stone buster lasers, laparoscopy and lithotripsy. Standing removal is most common and can be done in the field with proper facilities (stocks are advisable).

Laparocystotomy

Removal of stones via cystotomy under general anesthesia is considered by many to be the procedure of choice. This method allows intact stone removal, culture of the bladder wall, and removal of all stone debris. Leaving stone debris can lead to future obstruction and/or stone formation. However, bladder access is difficult in adult horses and is occasionally impossible. General anesthesia and laparotomy is also the most expensive option with the longest associated recovery period.

Laparoscopic cystotomy

This method of removal has been reported. It does require experience with laparoscopy and specialized instrumentation. The stone needs to be caught in a bag and it is difficult to close the bladder with inverting sutures that don't penetrate the lumen. Having suture penetrate the lumen predisposes to more stone formation and unhappy client. It is possible to remove stones up to 6-8cm in diameter using this method.

Perineal urethrostomy (males)

Stone removal is performed in the standing animal under epidural anesthesia. Access to the stone is obtained through the PU. The stone is manipulated per rectum and removed via the PU using a grabbing forceps (lithotrite or other). In some instances the stone must be broken up to allow removal. Fragments of stone are often left behind and need to be flushed out to minimize the risk of stone recurrence. Trauma to the rectum, urethra, and testicles (if present) is possible.

Pararectal cystotomy (Gokel's operation)

This procedure is not often used but may be an economical approach for removing large cystic calculi. It has been recently suggested to be a useful method with lower risks than PU's. *Vet Surg 39:654-659, 2010*

Electrohydraulic lithotripsy

Lithotripsy is performed via a PU. The bladder is emptied and the calculus identified via cystoscopy. The lithotripsy probe or lithotrite is passed into the bladder via the urethrostomy and electrical current applied to fragment calculus. The pieces of calculus are removed manually or by lavage. Regular shockwave machines have also been used to do lithotripsy via a special handpiece.

Laser treatment

Pulsed dye or "stone-buster" lasers are used to vaporize stones and allow them to be flushed out. The laser is inserted via a PU. The laser creates a plasma layer at the surface of the stone and the stone disintegrates. These lasers require a fluid medium to work and this can be tiresome in the standing horse (takes a lot of time just to maintain a fluid bath). Lasers can be rented from human hospitals or laser supply organizations. Not much advantage over standing procedures. (Holmium : YAG lasers are cheaper– $500/day vs $1500/day–and work in people but don't work on many equine stones. These work via a photothermal mechanism.)

Manual removal ± sphincterotomy (females)

Mares aren't as prone to stones but they do occur. Most can be removed standing.

Method :

- gradually dilate sphincter by inserting one finger, then two, etc
- if need more room, incise sphincter on dorsal and cranial aspect by inserting a blade into the urethra and cutting from inside the urethra out into the vestibule/vagina
- grab stone with lithotrite, using hand in rectum to manipulate stone
- may need to crush large calculi prior to removal
- follow with copious lavage (can use endoscope to see if all debris removed)
- close sphincter (if cut) with monofilament absorbable suture material

Sabulous urolithiasis

This is more a collection of sediment than a true stone. Sabulous uroliths develop due to abnormal bladder emptying. These are poorly responsive to medical or surgical treatment.

Urethral calculi

Urethral calculi are frequently associated with bladder rupture unless a PU is performed. Stones are typically found in the proximal urethra and removal is as for a bladder stone. Distal stones may be removed with a similar incision over the stone or just proximal to it. The procedure is performed under GA in dorsal recumbency. A tourniquet may be applied to assist with hemostasis, particularly with penile stones. The incision is made in through the CSP into the urethra (identified by a urinary catheter). Grasping forceps are used to remove the stone. The surgery site is closed with 3-0 absorbable suture if in the sheath due to the risk of adhesion formation. Other sites may be best left open due to tissue trauma and contamination.

Nephroliths

Removal of nephroliths can be performed via nephrectomy or nephrotomy but is uncommon (these are not usually a clinical problem until hydronephrosis and renal failure). Percutaneous removal has been reported in people. Using fluoroscopy or ultrasonography, a needle is placed through the flank into the kidney. A small guidewire is placed through the needle. The tract is progressively dilated to 24Fr to accommodate a nephroscope. Smaller calculi are removed using forceps or a basket. Larger calculi are fragmented using lithotripsy. The nephrostomy tube is left in place for 3 days.

Ureteral calculi

Ureteral calculi are rare and can cause intensive pain. They may be palpable per rectum just cranial to the brim of the pelvis. Most horses will have renal failure at the time of diagnosis. Pyelograpy, ultrasound, endoscopy (go up the ureter) or scintigraphy can be useful in the diagnosis. Surgical removal can be performed via a paralumbar incision. An alternative is to pass a Dormia basket stone dislodger retrograde from the ureteral orifice. The dislodger is guided by digital palpation into the ureteral orifice and then guided beyond the calculus by a second person palpating per rectum. The basket is opened and retracted to snare the stone. Slow gentle traction is used for removal.

Management for recurrence

Once a stone former, always a stone former"

- recommend biannual examinations to check for stones
- stones are much easier to remove if small and "immature" (not fully calcified)
- it is easiest to detect stones with an empty bladder (catheterize bladder if necessary)
- combine rectal palpation/ ultrasound

- should ultrasound kidneys if cystic calculi found (we may not treat nephroliths but can detect hydronephrosis)
- increase water consumption and urine output
- feed salt (cattle fed salt at 1-2% of ration decreases incidence of stones)
- decrease calcium in diet
- acidifying diets may help dissolve or prevent stones
    - it has been extremely difficult to acidify urine in herbivores
    - acidic urine may not affect formation of stones in horses (unknown)
    - ascorbic acid = oral Vit C; 4000 mg po q12h
    - potassium magnesium aspartate 2500 mg po q 12h
    - latest : DCAB diets may help – SoyChlor is a ruminant feed additive that does acidify urine in horses
        - *we don't know the effects of this diet on equine bone yet but the diet is used to stimulate osteoporosis in sheep*
        - a*ppears to increase excretion of calcium so probably NOT a good idea in horses*

How to - Perineal urethrotomy, equine

Indications

Urinary obstruction secondary to urolithiasis or other obstruction (eg tumor). Access to the bladder for diagnostic or therapeutic procedures.

Relevant anatomy

Preoperative management

Food restrictions:

NSAIDs/analgesics:

Antibiotics:

Tetanus prophylaxis is recommended.

Local blocks:

Position/preparation:

This procedure is usually done standing under epidural anesthesia. Pass a urinary catheter to better identify the urethra. Preop antibiotics and NSAIDs are routine. Clip and prep the area below the tail. Secure the tail away from the surgery field.

Surgery Supplies:

-

Surgical procedure

Starting a few cm below the anus, make a midline incision 6-8 cm in length. Continue on midline between the paired retractor penis muscles using sharp and blunt dissection. You should be able to palpate the catheter (have someone move it if you aren't sure). Dissect down to the catheter. Eventually you should incise the urethra longitudinally (we don't want to transect it). The lining of the urethra is a shiny white and you should be able to see the catheter and pass an instrument up and down the urethra. Your patient can now urinate and get to a hospital for further treatment as indicated!

Postoperative care

-

Complications

Videos

Resources

Ruminant urolithiasis

Urolithiasis podcast

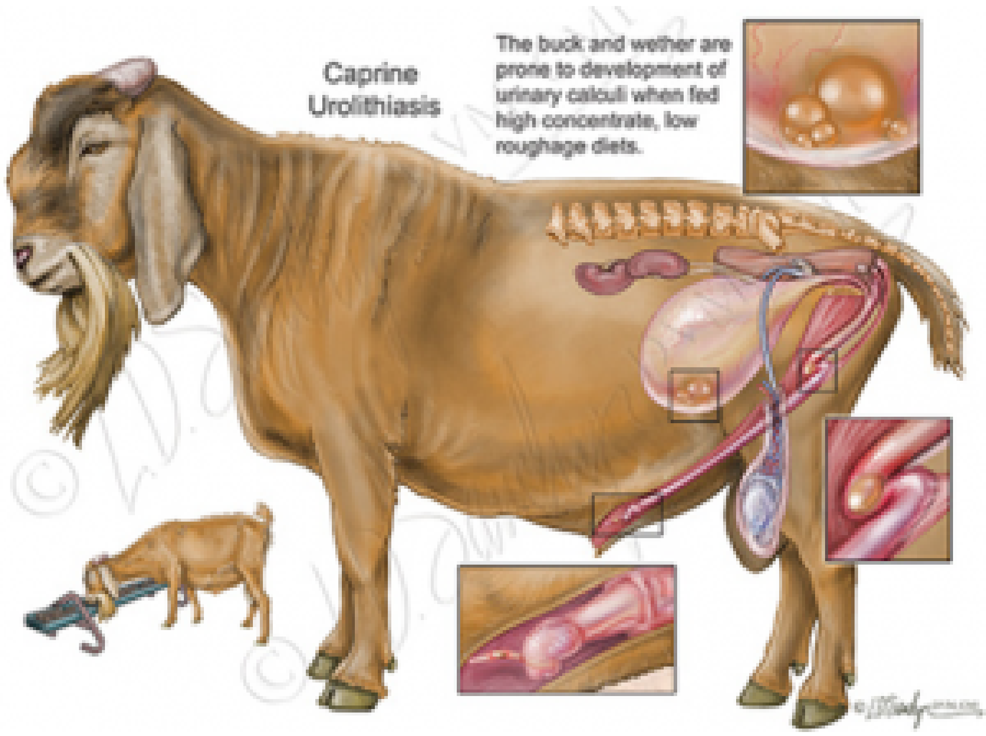
Urolithiasis is a common problem in goats and feedlot cattle. It is not uncommon in pigs, camelids and horses. The type, number and location of stones varies by species. Pigs and camelids can also develop urethral polyps which present in very similar manner to stones but are much harder to treat (since we can't readily remove them). Camelids tend to die due to related metabolic complications.

Horses present for hematuria. All the other species present for partial or complete urinary obstruction. Stones will often lodge in the vermiform appendage of goats and in the sigmoid flexure of all ruminants (and generally in both). Animals may be seen straining to urinate or defecate. Feedlot steers may be found dead (often with calculi on the preputial hairs). A vocalizing buck or wether should be assumed blocked by a urolith until proven otherwise.

Diagnostics

Passing a urinary catheter is generally not possible in ruminants or camelids due to the urethral diverticulum. Just because you can't pass a urinary catheter does not mean the animal has stones. The most effective diagnostic test is a rectal exam (digital rectal exam in small ruminants). In an obstructed animal, the urethra is often pulsing.

Imaging can be used to confirm or assess the number and location of stones. Most (but not all) stones are radio-opaque. Ultrasound can be used to identify full bladders, urine leakage and occasionally urethral stones. The stifle is often right on top of the sigmoid flexure on radiographs so look carefully in that area.



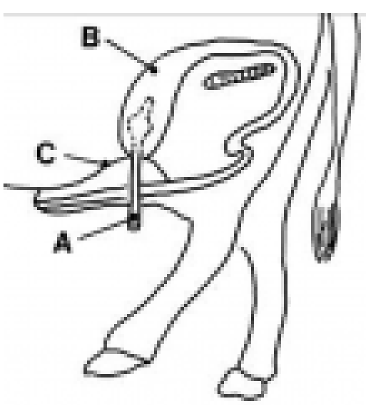
. Caprine urolithiasis

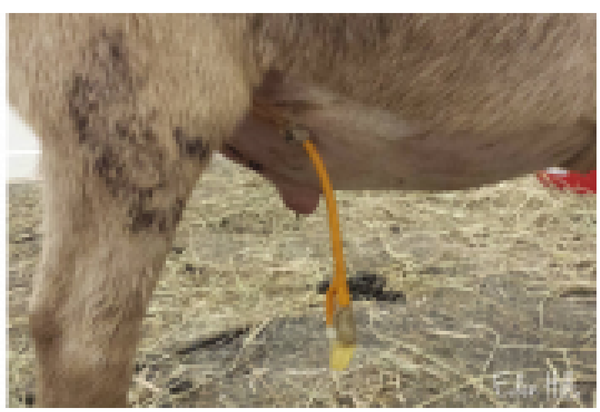
Treatment

- Enable urination (amputation of the vermiform appendage, tube cystotomy or other procedure) or relieve the bladder via cystocentesis
    - amputation of the vermiform appendage can help temporarily. The offending stone is removed but more come down the urethra later.
    - perineal urethrostomy is not a great choice in ruminants due to their propensity to stricture; it works fine in feedlot steers as their lifespan is limited
    - penile amputation is performed in feedlot steers (instead of perineal urethrostomy) as it is easier
    - most pet goats will do best with a tube cystotomy
- Remove, dissolve and/or encourage passage of the stones
    - once the pressure to urinate is relieved (tube placed into bladder), the stones may pass on their own as the urethral relaxes
    - retrograde or anterograde (at surgery) flushing of the urethra tends to cause urethral rupture
- Minimize the risk of recurrence

  - once a stone former, always a stone former
  - dietary adjustments are needed
  - soychlor or pasturechlor is the most effective dietary adjustment we have currently
  - many people incorrectly believe ammonium chloride in the feed is effective
    - it works but goats don't like it. For effective use, it needs to be given orally as a medication.
    - it should also be given in a pulsatile fashion – it stops working if given continuously
- Manage any related complications (uremia, urinary tract infections, ruptured bladder, ruptured urethra)
- Analgesics are needed, especially for goats
  - consider phenazopyridine (relieves bladder irritation), narcotics and NSAIDs
  - goats are pretty sensitive to pain and will tend to be in rough shape for a day or two post-operatively
- Remove the tube once the goat can urinate on his own through the penis
  - this happens when the stone is passed, even with the tube still in place
  - antibiotic coverage is maintained while the tube is in place due to the risk of ascending infection
  - generally we leave the tube in for at least 8 days to create an adhesion to the body wall (this number is pulled out of thin air as far as I can tell)

Uremic animals are not edible. All uremia needs to resolve before an animal is shipped for meat. This can take several weeks.





Tube cystotomy in a goat

Other options

Bladder marsupialization was developed to manage recurrent urolithiasis in goats. The bladder is tacked to the body wall and cystostomy performed, similar to a rumenostomy. However, many goats die of ascending pyelonephritis within two years so it is not an ideal fix. Additionally, goats dribble urine constantly and urine scald can be severe. Bladder prolapse can occur.

Laser lithotripsy has been used to remove stubborn stones. The procedure requires specialized equipment and experienced operators. Postoperative swelling can also cause urinary obstruction.

Key Takeaways

- If you have an animal with renal compromise, be very cautious with NSAIDs, steroids, tetracyclines and aminoglycosides. Penicillins are generally pretty safe. Consider drugs excreted by liver if no other restrictions apply (eg fluorquinolones).
- Goats get stones because of diet issues. Urethral pulsation = obstruction. Tube cystotomies rule. Do not flush the urethra – goat urethras easily rupture.
- Feedlot steers get stones due to diet issues. Penile amputation is recommended and the site will still stricture. Slaughter when no longer uremic. Uremic animals are not edible.
- Camelids die
- Pigs can have stones (removable) or polyps (not removable)
- DCAD (cation-anion) diets are most effective. Do not give soychlor to the breeding does as it also pulls calcium from the goat and leads to jelly babies (no calcium).
  If clients use ammonium chloride (most goats won't eat enough to help), they need to stop it intermittently or it stops working

Primary Resources

urolithiasis anes and tube cystotomy _ Sheep and Goat Medicine- works through all the diagnostics and options for treatment in more detail

Prevention of urolithiasis in livestock– CSU Van Metre- great practical hints for preventing stone formation

Secondary Resources

General anesthesia for patients with liver or renal disease, DVM 360 2011 – SA perspective but nice review of what drugs are good or bad when your patient has other issues

1990 antibiotic associated complications with renal disease 1990 Reviews of Infectious Diseases- also for your files. hard to find this info.

Obstructive urolithiasis in ruminants – a review – 2013 VetWorld – starts at square 1 and covers physiology, lab changes etc

urolithiasis in small ruminants, ACVS – succinct general overview describing options; doesn't give relative pros/cons

Urolithiasis in small ruminants, AASRP- more details than you ever wanted to know; good reference for future as he goes through more complex situations; please don't do the hydropulsion though.

Surgery of obstructive urolithiasis in ruminants, VCNA 2008 -good overview with nice references; good for your files

Summer 2005 newsletter case of the month (page 3-4)- I use this for soychlor dosing; for your files. Also totally agree with filling the foley balloon with saline vs air. They last longer

Effects of castration on penile and urethral development in Awassi lambs, 2007 Bulgarian J of Vet Med -finally some EBM on this topic

penile amputation -for those of you struggling to visualize or just wanting more: youtube video

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=853#oembed-1

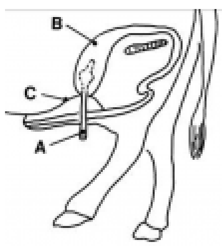
How to - Tube cystotomy

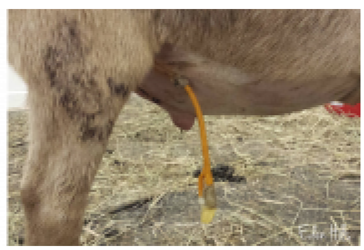
Indications

Tube cystotomy is typically performed in small ruminants for treatment of obstructive urolithiasis. Tube cystotomy can be performed in other species. It is generally temporary but can be a permanent option if the obstruction does not resolve or is due to polyps or tumors.

Relevant anatomy

A tube is placed in the bladder and exited from the body wall in a location that allows the bladder to sit in a normal position and in direct apposition to the body wall.





Preoperative management

Fluid deficits and severe electrolyte abnormalities should be corrected preoperatively. Hyperkalemia is rare in goats and dehydration is not often severe so therapy does not often need to be completed prior to anesthesia.

Food restrictions: NA

NSAIDs/analgesics: Preoperative NSAIDs and analgesics are recommended as goats are very sensitive to pain. Flunixin meglumine is often combined with a narcotic.

Antibiotics: Preoperative antibiotics are indicated. Common choices are ceftiofur, amoxicillin or ampicillin.

Tetanus prophylaxis is recommended.

Local blocks: The skin incision can be blocked using a U shaped line block

Position/preparation: Dorsal recumbency

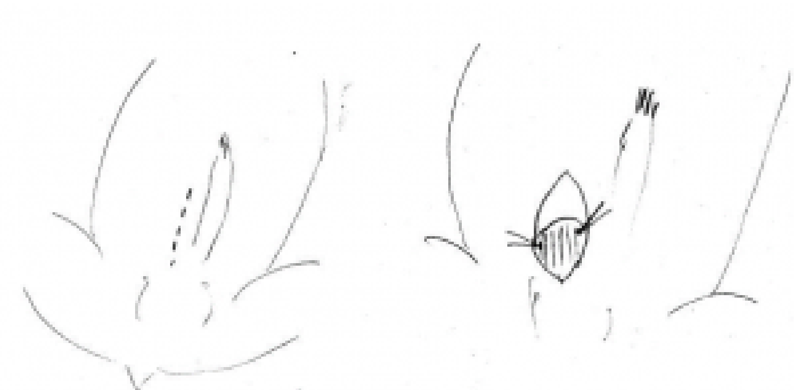
Surgery Supplies:

- Standard surgery pack
- 3-0 absorbable suture (bladder)
- 0-1 absorbable suture (PDS) or nonabsorbable suture (body wall)
- 2-0 absorbable suture (musculature, SQ tissue)
- 2-0 to 0 nonabsorbable suture (skin)
- 2-0 to 0 suture for fingertrap knot (braided works well to hold it but is often absorbable so can be a problem in long term cases)
- Pezzar (foley if pezzar is not available) sized to match the patient (no more than 1/8 size of bladder when not distended). Pezzars are preferred as the foley balloon can rupture. If used, the balloon should be distended with saline rather than air. 

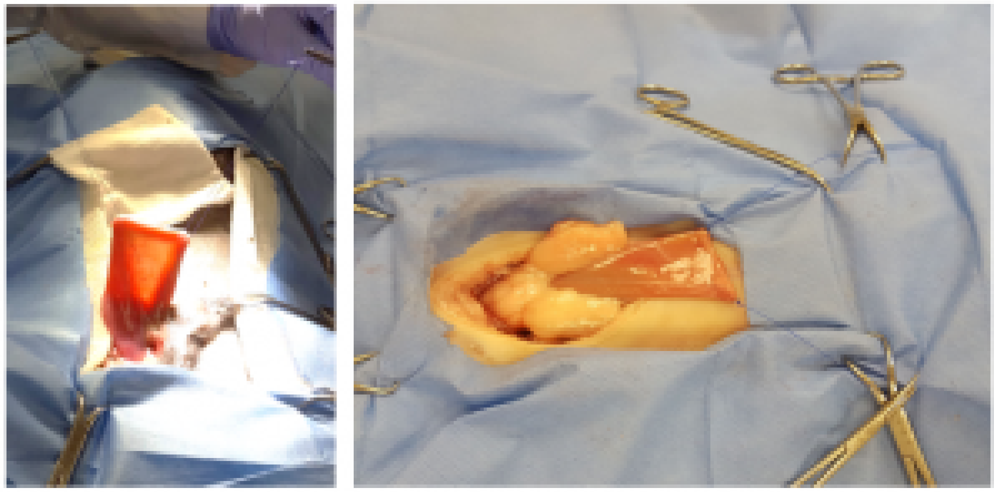
Surgical procedure

The patient is placed in dorsal recumbency under general anesthesia, prepped and draped.

A paramedian skin incision is made in the caudal abdomen, adjacent to the prepuce. The incision should extend ~10 cm and finish between the nipples. The skin and prepuce are shoved to the side and the abdomen opened through the linea alba.

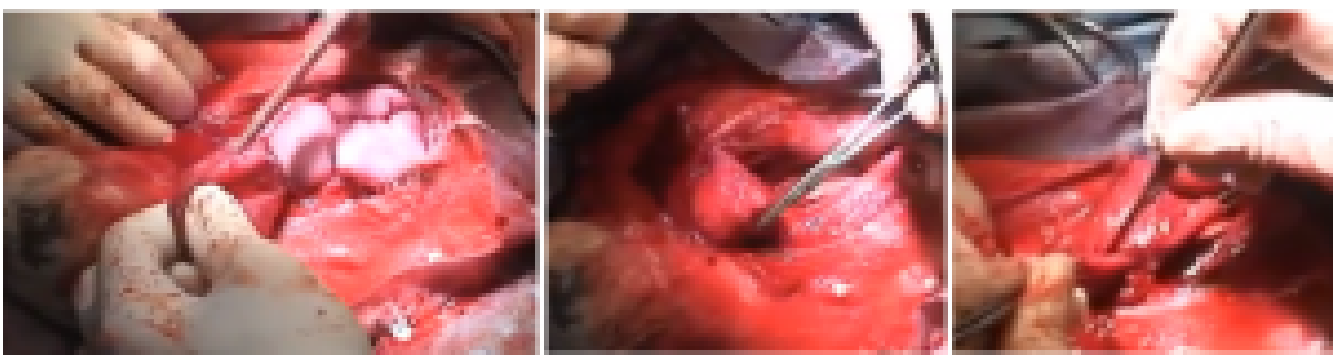


The bladder is identified. Two 3-0 stay sutures are placed in the bladder at the dorsal aspects on either side.



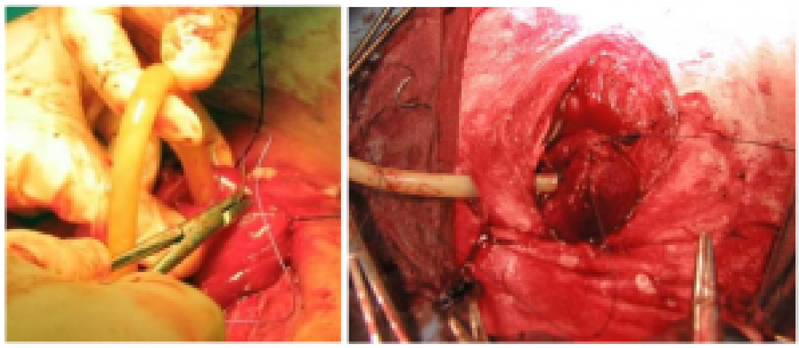
Stay sutures with and without an assistant

The bladder is incised close to the trigone and the bladder flushed to remove as many stones as possible. A red rubber catheter can placed into the urethra and the urethra flushed (low pressure only) to remove additional stones. Forceful flushing can easily rupture the urethra and should be avoided.



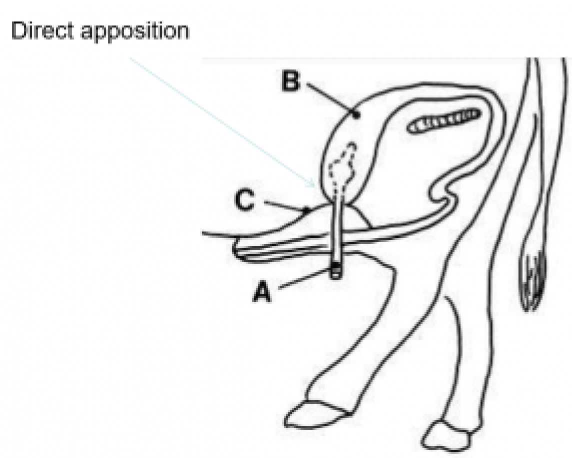
A second incision is made on the same side of the bladder as the tube will exit the body wall. A small nick is made and the tube passed through the nick. This can be done by pushing the pezzar end into the bladder or the tube end out of the bladder. A **purse string** suture is placed around the tube.

The bladder is closed in 2 layers using 3-0 absorbable suture in **inverting** patterns. The stay sutures can be tied in place in trimmed short to prevent leaks. The bladder should be checked for leaks by adding fluid through the pezzar.

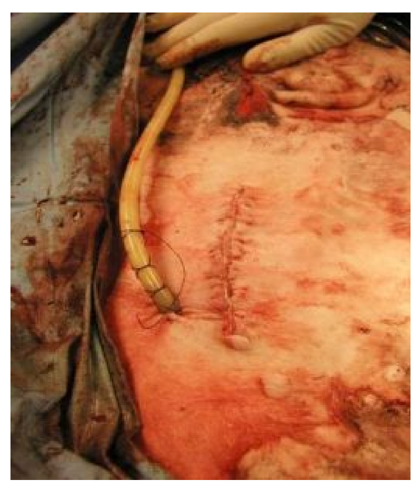


Purse string   Bladder closed

The tube is exited through all layers of the body wall, generally at a slight angle so that there isn't a direct path from body wall to outside but that each opening is a little off from the others. Be careful to make sure the tube goes through the wall, not through the incision (or you can't close the incision). **The bladder needs to reach the body wall- the incision through the skin cannot be too far forward.**



The pezzar is pulled up so the bladder is snug against the body wall. The pezzar is secured in place using a fingertrap knot of 2-0 suture material.



The body wall is closed routinely. The linea is closed using a simple continuous pattern with slowly absorbing 0 suture material. If the incision was off midline, the ventral sheath of the rectus abdominis is closed similarly. Subcutaneous tissues are closed in a simple continuous pattern using 2-0 absorbable suture. The skin is closed using nonabsorbable suture in a Ford interlocking or simple continuous pattern.

The pezzar is tacked to the body wall in 2-3 spots so that the opening of the pezzar is lined up with the preputial opening.

Postoperative care

- A glove fingerip is placed over the end of the tube; a nick is made in the end of the glove finger to allow urine drainage. This is to minimize the risk of ascending infection.
- Postoperative analgesics are usually required in the first 24 hours. Buprenorphine is commonly used; morphine is also an option.
- The patient is left on antibiotics until after the tube is removed.
- NSAIDs are maintained for at least 3 days, typically until normal urine flow is resumed.
- The tube is checked frequently to ensure the tip is dripping. If dripping stops, the tube may be blocked by a stone or blood clot. The obstruction should be flushed free using sterile technique.

Most patients will start urinating out of the prepuce within a few days. Once the obstruction is relieved with the tube placement, the urethra relaxes and the stone(s) pass.

The tube should be left in place for at least 8 days. The goal of this time frame is to permit an adhesion to form between the bladder and the body wall so urine does not leak into the peritoneal cavity with tube removal.

Once the patient is urinating and it has been at least 8 days, the tube can be removed. The fingertrap knot is removed, the body wall is held in place with one hand while the tube is pulled forcefully with the other. The owner should monitor for uroabdomen (distension, off feed) but this is rare.

Complications

Lack of urination

Occasionally the stones do not pass. Lidocaine can be infused up the catheter using sterile technique. A lidocaine epidural may be administered. Muscle relaxants and alpha blockers (acepromazine, bethanechol, phenoxybenzamine) can be tried. The tube should be kept in place. Occasionally other therapy (laser lithotripsy etc) may be necessary.

Urethral rupture

If flushing is too vigorous, the urethra may rupture. The skin ventral to the area should be lanced and the tissues flushed. The tube will help with healing.

Infection

As with any surgery, incisional infections and peritonitis are a risk. Animals will be off feed, tender on palpation of the incision (incisonal infections), and may be febrile.

Videos

Goat cystotomy: Youtube video

pulling pezzar through body wall: youtube video

Resources

Urolithiasis in small ruminants, AASRP- more details than you ever wanted to know; good reference for future as he goes through more complex situations; please don't do the hydropulsion though.

Surgery of obstructive urolithiasis in ruminants, VCNA 2008 -good overview with nice references; good for your files

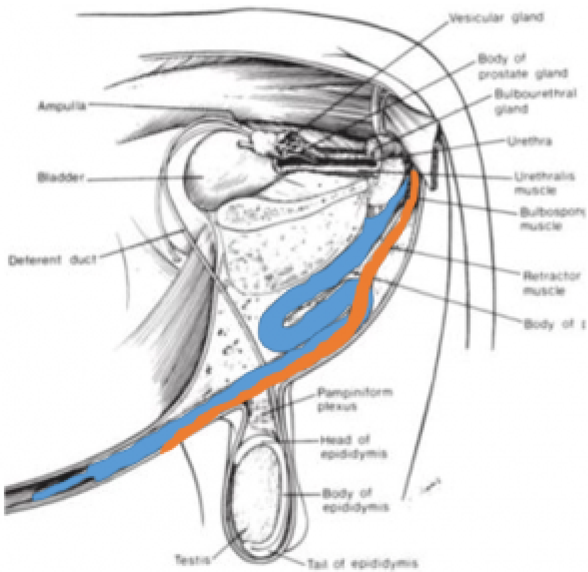
Bladder stone removal (dog): youtube video

Indications

Penile amputation is performed for obstructive urolithiasis. It is considered a salvage procedure and is most commonly performed in feedlot steers.

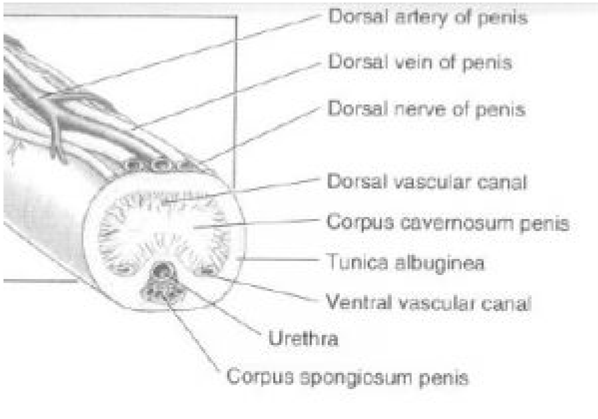
Relevant anatomy

The amputation needs to be performed proximal to the obstruction (typically the sigmoid flexure). The closest aspect of the penis to the skin is actually at the common obstruction site. The retractor penis muscles will be encountered first and are sometimes mistaken for the penis. They are paired, more superficial and less muscular than the penis.



blue = penis; orange = retractor penis muscles

The dorsal artery will need to be ligated. This will be on the opposite side of the penis since the approach is from the ventral aspect.



Preoperative management

Food restrictions: NA; Procedure is performed standing.

NSAIDs/analgesics: Preoperative NSAIDs is needed.

Antibiotics:Preoperative antibiotics are recommended.

Local blocks: Epidural anesthesia

Position/preparation: The animal is kept standing. Chute restraint is recommended. The surgeon gloves.

Surgery Supplies:

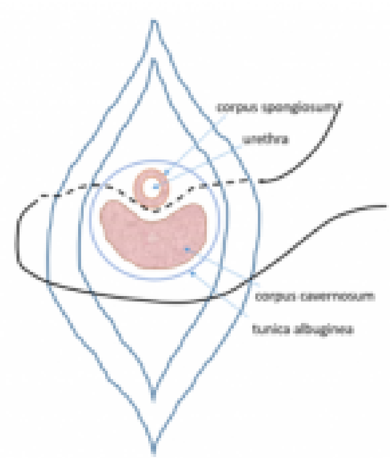
- Standard surgery pack
- 2-0 absorbable suture – dorsal artery and corpus cavernosum
- 0 non-absorbable suture cutting needle – pexy penis to skin and skin closure

Surgical procedure

Make a 12 cm vertical skin incision, starting just where the perineum starts to curve forward. Dissect down to the penis, primarily using blunt dissection. Separate the penis from the surrounding tissues and pull it caudally and dorsally. A large carmalt can be inserted between the penis and pelvis to help retract the penis.

At least 6 cm of penis should be exposed without tension to prevent subcutaneous retraction postoperatively. The entire penis can be pulled free but this is not usually necessary. The dorsal artery and vein are ligated near the 6 cm point and the penis transected just distally.

The penis is secured to the surrounding skin using horizontal mattress or other tacking suture of 0 nylon or similar material. The horizontal mattress can be passed through the corpus cavernosum; this will also serve to control hemorrhage from the penis.



The surrounding incision is closed using short continuous runs proximally and distally to the horizontal mattress.

The distal segment of the penis can be removed if ruptured or necrotic. Steady traction will usually permit removal if necrosis is present. Otherwise dissection can be continued forward (distally) until the preputial attachment is cut.

Postoperative care

- NSAIDs are continued for 3 days; antibiotics may be continued if urethral rupture or necrosis.
- If urethral rupture occurred, incisions are made to allow urine drainage from subcutaneous tissues.
- Animals should be shipped to slaughter after uremia has resolved and within 4 weeks.

Complications

- Urine scald
- Hemorrhage from the penis
- Trauma to the stump or urethra
- Retraction of the stump subcutaneously
- Re-obstruction (blood clot, stricture)

Videos

Penile amputation – youtube video

Better length amputation and ligation: youtube video

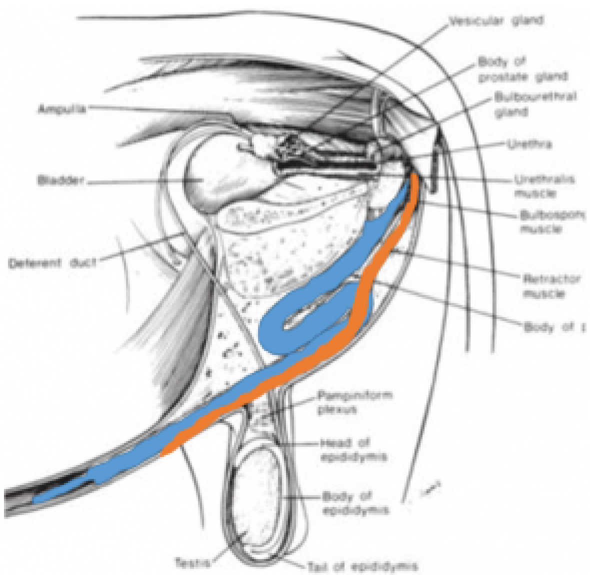
Resources

Indications

Perineal urethrostomy can be used for obstructive urolithiasis. Perineal urethrotomy (not sutured to skin) can be performed as a temporary measure, maintaining fertility in males. PU is a short term fix in most ruminants due to rapid stricturing and reobstruction. It is considered a salvage procedure and is no longer commonly performed as penile amputation is easier.

Relevant anatomy

The surgery needs to be performed proximal to the obstruction (typically the sigmoid flexure). The incision should stay on the vertical aspect of the perineum to avoid urine scald. The retractor penis muscles will be encountered first and are sometimes mistaken for the penis. They are paired, more superficial and less muscular than the penis.



blue = penis; orange = retractor penis muscles

Preoperative management

Food restrictions: NA. Surgery is performed standing and usually on an emergency basis.

NSAIDs/analgesics: Perioperative analgesics are necessary.

Antibiotics: Ascending infection is more likely postoperatively; however, the goal is salvage for slaughter.

Local blocks: Epidural anesthesia combined with local anesthesia if required.

Position/preparation: Standing

Surgery Supplies:

- Scalpel blade and handle
- Large hemostats (carmalts)
- Needle holders
- Thumb forceps
- Mayo scissors
- Suture scissors
- 2-0 and 0 absorbable suture, cutting needle
- Foley catheter, 20-28Fr with stylet (optional)

Surgical procedure

- Create a 10 cm vertical incision on midline, starting about 5 cm below the anus.
- Incise the dense fascia to expose the paired retractor penis muscles. These can be transected.

Incision on midline and exposure of retractor penis muscles

- Bluntly dissect between the muscles to the bulbospongiosus muscle with the palpable urethral groove immediately deep to the muscle
- Force a carmalt underneath the penis to stabilize it in the incision (optional).

Elevated penis and palpation of urethra

- Incise on midline to open the urethra. The urethra has a smooth mucosal surface and a catheter can be passed in either direction.

Incised urethra

- The mucosa of the urethra is sutured to the skin using simple interrupted sutures, cruciates or short continuous runs.
- A catheter may be placed into the bladder to maintain urine flow for bladder or ruptured urethras.

Postoperative care

- Continue NSAIDs for 3 days
- Slaughter when uremia has resolved

Complications

- Urethral stricture and reobstruction

Videos

Perineal urethrostomy youtube video

Resources

Hooper and Taylor, Urinary Surgery. VCNA 1995, Vol.11(1), pp.95-121 – see page 111.

Uroabdomen

Risk factors

Uroabdomen is typically seen with parturition or urolithiasis. For horses, the most common population is 1-2 day old colts that have their bladder squeezed too much during parturition. Occasionally the dam suffers a ruptured bladder due to compression of the bladder between the foal and the pelvis. For ruminants, the most common cause is urolithiasis – goats, steers, and pigs in particular.

Diagnostics

Foals are normal at birth, with no signs of illness for 24-48 hours. They then become lethargic with a decreased interest in suckling. Some foals will become colicky (show signs of abdominal pain).
Many can urinate normally. Occasionally a foal will be anuric or void only small volumes of urine.

Abdominal distension develops over time. Abdominal distension can occur due to many reasons. A common mnemonic is 7(or more) F words:

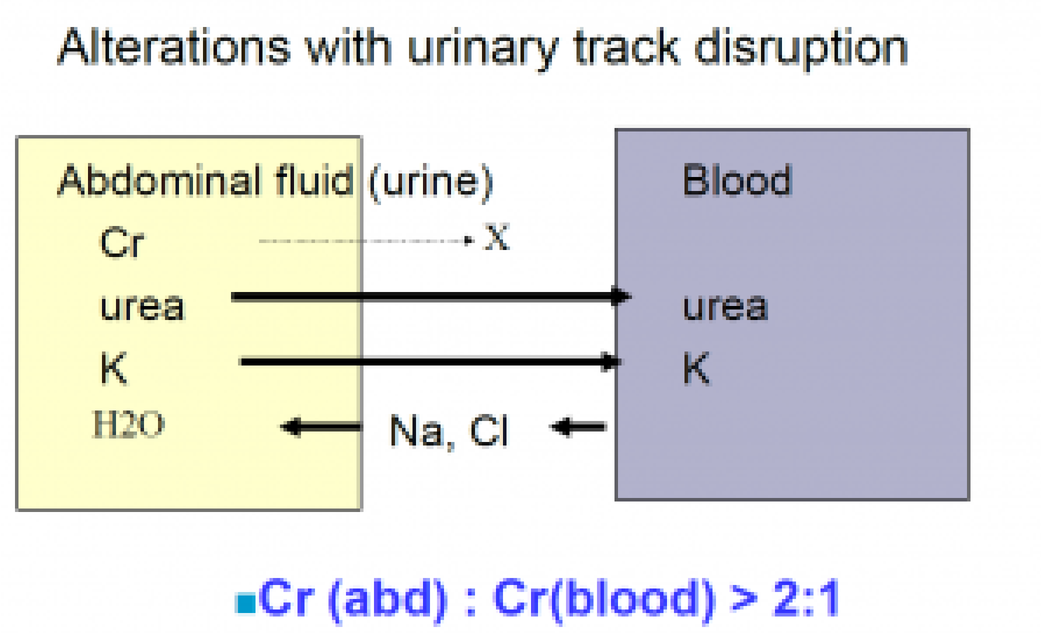
Flatulence	Fetus	Fat
Fluid (urine, ascites, peritonitis)	Freaked out cells (neoplasia)	Free gas (ruptured bowel)
Frank hemorrhage	Feces (impaction)	

In a neonate, impactions, gas and urine would be the most common. A fluid wave may be detectable.

Foals will be tachycardic. Some foals will develop pleural effusion and tachypnea.

Ultrasound is a key diagnostic test. With a ruptured bladder, a large amount of free abdominal fluid is visible. While a 5 MHz linear transducer is okay; 7.5-10 MHz best. Occasionally you may see collapsed bladder ± tear with fluid exiting it. Another trick is to inject “agitated” saline solution (regular saline that has been shaken up) into bladder. This makes it easier to identify the site of the tear as you watch air bubbles exiting bladder The ultrasound can also help determine a safe site for abdominocentesis and drain placement. The thorax should also be scanned; pleural fluid isn’t common but does occur. Obviously thoracic fluid would add to the anesthetic risk unless removed (via thoracic drains).

Peritoneal fluid analysis can also be used to confirm uroabdomen. Due to the size of the molecule, we use creatinine to determine if the fluid in the belly is urine or not. Creatinine doesn’t equilibrate so we can compare the abdominal fluid creatinine to the serum creatinine. If the concentration in the abdominal fluid is at least 2x the concentration in the blood, it is urine. Heating the fluid is often a quick and dirty way to tell, too.



When urine is released into the peritoneal cavity, it is full of water, urea and potassium. The urea and potassium equilibrate with the blood, leading to abnormally higher levels of urea and potassium in the blood. The free water pulls sodium and chloride after it, leading to low levels of sodium and chloride in the blood. Creatinine cannot equilibrate so is useful to measure.

Serum chemistry will typically show increased creatinine, BUN and potassium along with decreased pH (acidosis), sodium and chloride. PCV/TPP and white blood cells are elevated. In foals, IgG should be evaluated to ensure colostral absorption.

ECG monitoring is recommended due to the hyperkalemia (watch for tall peaked T waves due to rapid repolarization).

Treatment

Stabilization prior to surgery is required. Electrolyte and fluid shifts should be corrected. Uncontrolled hyperkalemia can lead to death due to arrhythmias. Sodium chloride and sodium bicarbonate are given iv (avoid LRS due to the potassium in the fluid). Dextrose and insulin are administered to drive potassium into the cells where it is safely sequestered (0.5 g dextrose/kg bwt; 0.1 unit insulin/kg bwt iv). Urine should be drained from the abdomen/thorax to enable better ventilation and to remove the toxins. The foal should have a normal temperature, glucose and hydration prior to surgery.

Bladder repair in foals, goats and pigs is performed under general anesthesia. Once the potassium is <5.5 mEq/L, anesthesia can be performed. Bladder repair in mares is possible in the standing patient, assuming the patient is amenable to standing surgery.

Differentials

Uroabdomen can also occur with ureteral tears, urachal leakage/ urachal necrosis in10-14d old foals), meconium impaction in neonatal foals and neonatal maladjustment/ septicemia.

Ureteral tear

Fillies with uroabdomen should be checked for ruptured ureters since ruptured bladders are less common. With a ruptured ureter, urine accumulates retroperitoneally, as well as intraperitoneally. While ultrasound can help in certain cases, antegrade pyelography (inject contrast into the renal pelvis and watch its exit path fluoroscopically) can be very useful in identifying any leaks in smaller patients. Scintigraphy can be used in larger animals.

Treatment involves ureteral catheterization (from the bladder) with retrograde dye infusion to identify the defect. The catheter is then advanced to the renal pelvis and the defect repaired with absorbable suture. The catheter may be left in place as a stent with distal end exited out either the urethra or via a perineal urethrotomy. In the older gelding, conservative treatment with antibiotics, NSAIDs and fluids was adequate without stenting as the ureter remained patent.

Resources

Uroperitoneum in foals, Merck online- nice overview of how these babies look

Ruptured bladders

Ruptured bladders podcast

Ruptured bladders are most common in neonatal colts and in ruminants with urolithiasis. Ruptured bladders are unusual in camelids and swine. In adult horses, ruptured bladders are generally associated with parturition and are not common.

It is suspected that compression of full fetal bladder in the pelvic canal during parturition leads to an outflow obstruction; a rupture may also occur secondarily to necrosis of the bladder wall. Colts are more likely than fillies to develop ruptured bladders during parturition. The longer narrow urethra means the squeeze of parturition is more likely to rupture the bladder than to express the bladder. The bladder generally ruptures on the dorsal surface. Foals are often normal for the first day but then develop signs of uroabdomen.

Ruminants with obstructed urethras may rupture either the bladder or the urethra. When the bladder ruptures, the fluid leaks into the peritoneal cavity. When the urethra ruptures, the fluid leaks subcutaneously along the ventral abdomen.

Treatment

1. drain the urine out of the peritoneal cavity
2. repair the bladder surgically or keep the bladder decompressed so it can heal via second intention (this may require a PU)
3. manage the inflammation, uremia and electrolyte disturbances

Because these are neonatal and/or sick animals, anesthesia can be tricky. If the animal has high potassium when it is anesthetized, it can lead to fatal arrhythmias. Oxygenation can be impaired if the thoracic or abdominal cavities contain fluid that restricts diaphragmatic function. Dehydration needs to be managed without causing more fluid accumulation and with careful attention to the electrolyte imbalances. Remember, many fluids contain potassium and/or lactate. Note: hyperkalemia is less marked and less common in ruminants.

For neonate sedation concerns, go back to the earlier drug chapters for more resources.

Preoperative care should include tetanus toxoid, perioperative antibiotics and analgesics and bladder catheterization.

With the patient in dorsal recumbency, a ventral midline approach to the bladder is performed. The penis and prepuce are reflected off midline. Umbilical structures are removed in the approach. The tear is usually found on the dorsal surface of the bladder at the trigone as this is a weak spot. Debridement of the tear margins are not usually required; bladders heal well and quickly.

In large animal species, we recommend a two layer closure of the bladder. Both layers are typically inverting patterns to minimize suture in the lumen (a nidus for stone formation) and suture exposed to the peritoneal cavity (a risk factor for adhesions). The most common is a Cushings pattern with 2-0 absorbable suture that dissolves fairly rapidly. Dexon dissolves in urine and should not be used.

The abdomen is flushed and the abdominal wall closed routinely (typically #1 absorbable suture, simple continuous pattern).

In beef cattle with ruptured bladder secondary to urolithiasis, the bladder is left to heal by second intention (urinary catheter placed via urethrotomy to keep urine drained out).

Postoperative care

- Antibiotics are administered for 3-5 days unless the patient is sick.
- Low level antiinflammatories are given (watch for gastric ulcers and treat with omeprazole).
- Monitor for complications of celiotomy: peritonitis, adhesions, incisional infections
    - The most common complication is recurrence of the uroabdomen. This may be due to leakage through the bladder wall or incision. Many can be managed with bladder catheterization rather than repeat laparotomy.

Prognosis

Prognosis is surprisingly good. Anesthesia is the risky part. Foals recover well and seem to have no related problems. Goats need to have the cause of the obstruction fixed as well as the ruptured bladder. Large ruminants are generally managed conservatively until slaughter is possible. Steers with a serum phosphate >2.9 mmol/L are associated with longer duration ruptures and have poorer prognosis.

Key Takeaways

- Ruptured bladders occur most commonly in male foals (~ 2 days of age) and in ruminants with urolithiasis.
- Peritoneal creatinine 2x serum creatinine = urine. A quick test is to heat the sample and sniff.

- Foals should be referred to a hospital equipped to manage the hyperkalemia and anesthetic risk. These animals must be stabilized – eg get K < 5.5 prior to anesthesia. Medical emergency, not surgical emergency.
- Prognosis is good for foals. Prognosis is not as good for animals with urolithiasis.
- Keep suture out of bladder (use cushing or lembert); otherwise it becomes a nidus for stone formation

PRIMARY RESOURCES

Ebook Anesthesia chapter _- see Foal resources section at bottom of page

Common fluid types in vet med -note: we carry saline, LRS and sterile water/dextrose.

SECONDARY RESOURCES

Bladder ruptures, AAEP- client friendly version

Conservative management of a ruptured bladder in a gelding, 2019 EVE – good review of principles that can apply across species

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Study break- be proud!

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Ruptured urethras

The most common cause of ruptured urethra in a ruminant is urolithiasis. In horses, the most common cause is trauma. Ruptured urethras are rare in camelids and swine.

Ruminants

As the stones lodge in the urethra, they can cause local damage (pressure necrosis). The force of urination can lead to rupture at the damaged site. The early signs of urethral obstruction can easily be missed in feedlot cattle; often the animals present with urethral rupture. Urethral flushing or forceful bladder compression can also rupture the urethra. This is much easier to do in small ruminants than in small animals. It may be a combination of weaker urethral wall due to the sigmoid flexure and chronicity of the stones. AVOID flushing the urethra in goats!

Subcutaneous urine is very irritating. Animals often develop a fever and skin necrosis from the urine. As urine gravitates ventrally, a plaque of edema will develop around the prepuce. This eventually leads to cold, leathery skin in the area.

Treatment

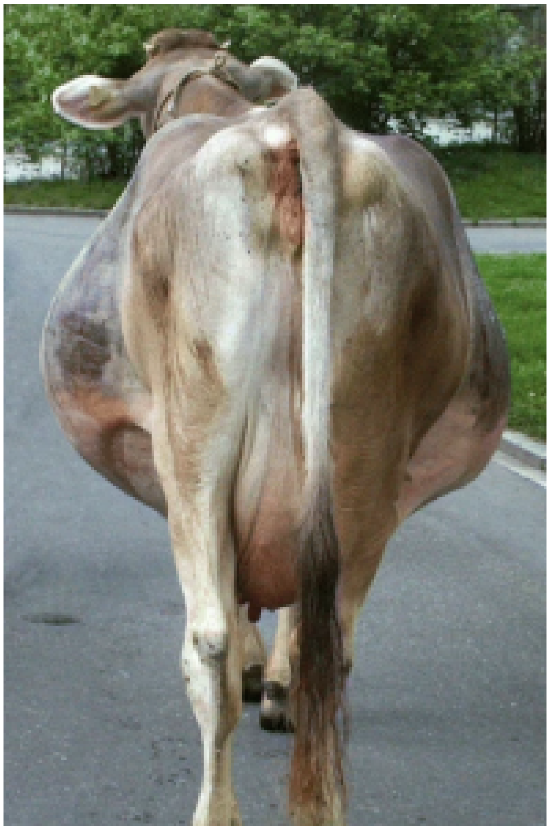
1. avoid more urine leakage – divert urine via a tube cystotomy or perineal urethrotomy
2. release the urine that is collecting subcutaneously – incise the skin to allow drainage
3. reduce the inflammation – NSAID therapy

Animals cannot be shipped for meat until the uremia resolves. Pet animals can recover with proper treatment. The urethral rupture will usually heal via second intention closure.

Horses

Urethral rupture is rare in horses and is usually related to a kick in the perineal region or to accidental trauma during castration. Treatment goals are the same as for cattle. Diagnosis can be more challenging as the kick injury may not have been witnessed and signs are often not evident for several days. See equine hematuria

Ruptured bladder (left) vs ruptured urethra (right)



https://actavetscand.biomedcentral.com/articles/10.1186/s13028-015-0126-y

https://veteriankey.com/bovine-urolithiasis/

Practice - Level A

Exercise

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Try a kahoot quiz! (level B)

Male urogenital surgery

Teaser animals

Scrotal, testicular preputial and penile abnormalities

Also see Preputial injuries and Penile injuries

Teaser animals

Teaser animals are useful to improve herd reproduction (see the ram effect). Having males with testosterone around improves cycling, fertility and heat detection. Teaser animals should be amenable to handling, not so large that they injure the females, and must be interested in their jobs.

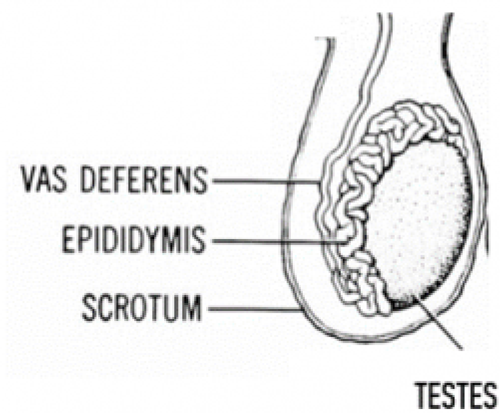
Malone ppt review- youtube

In bulls, we typically recommend two procedures.

- Prevent pregnancy
    - Teaser animals are not destined to sire offspring
    - If offspring are needed, no need to create a teaser animal
- Prevent intromission
    - This is to minimize disease transmission

Pregnancy prevention

We have two main options. For both, the goal is removal of a portion of the sperm pathway. Both affect the same path, just different parts.



Vasectomy

- Vasectomy can be more challenging. Depending upon the age of the animal, the vas can be very thin, hard to find and can resemble the nerve. Transecting the nerve does not prevent pregnancy. However, vasectomy may be easier than epididymectomy if the procedure is performed laparoscopically (camelids) or in adult sheep (due to the restraint position of cradling them on their hindquarters). A centimeter or longer chunk of the vas deferens should be removed to minimize the risk of recanalization.

Epididymectomy

- Epididymectomy is typically easier once the surgeon has performed the first one. The epididymis is hard to miss. The only challenge to the surgery is figuring out where to ligate since there isn't a discrete structure. However, due to the larger tissue volume being removed, hemorrhage is more likely. If uncontrolled, hemorrhage can lead to healing complications. Most of the tail of the epididymis should be removed. Recanalization is possible but not common.

Prevent intromission

Particularly in open herds (new animals coming in), teaser animals should not actually breed the females as this can increase the risk of venereal disease transmission. In order to prevent this, several options exist with varying success rates and healing times.

Penile translocation – aka Sidewinders

- The preputial opening is moved to the flank of the bull. The penis is left untouched. When the bull gets an erection, the penis is extruded out his flank and he usually misses the target. Since there is no pain involved, most of these bulls maintain their libido.
- This procedure requires general anesthesia. It is typically performed in hospitals rather than in the field.
- Healing time is 2 months (plan ahead).

Preputial pouch

- The preputial opening is sutured closed and another opening created ventrally for urine flow. The penis is left untouched. As long as the urine hole is small enough, the penis cannot be extruded. Since there is no pain involved, most of these bulls maintain their libido.
- This procedure requires general anesthesia; however, it is simpler to perform than the penile translocation.
- Urine collects in the sheath requiring periodic flushing (higher maintenance).
- Healing time is 2 months (plan ahead)

Penectomy

- The penis is shortened to prevent intromission.
- Hemorrhage is a risk with this procedure. Careful closure of the corpus cavernosum is required.
- Bulls do not maintain their libido due to apparent discomfort.
- Healing time is 2 months.

Artificial thrombus model

- Methylmethacrylate (mixture of power and liquid cures into a solid form) is injected into the corpus cavernosum to prevent erection due to blockage of blood flow.
- The procedure can be performed in the standing animal and is relatively straight forward
- If the urethra is injected instead, the resultant urinary obstruction can be fatal.
- Healing time is 2 weeks.

Penis tie-down

- Adhesions are created between the penis and the internal sheath, preventing exteriorization of the penis.
- The procedures is relatively quick and straight forward
- Adhesions may break down if the bull gets an erection prior to strong scar tissue formation
- Healing time is 2 months.

Iatrogenic preputial stenosis

- The internal prepuce is wrapped with a K wire (Kirschner wire) to prevent exteriorization of the penis while still permitting urine flow
- Creating the appropriate diameter is a bit of an art
- The procedure is quick and straight forward
- Healing time is 2 weeks

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Primary Resources

Surgical techniques for the preparation of teaser bulls, 1995 VCNA – older but one of my favs for images and descriptions

Secondary Resources

Teaser preparations in small ruminants, OSU- explains options for goats and sheep

Development of Teaser Bulls Under Field Conditions, 2008 VCNA- useful images and explanations

Preparation of teaser bulls 2014 Bovine Reproduction- I have not read yet

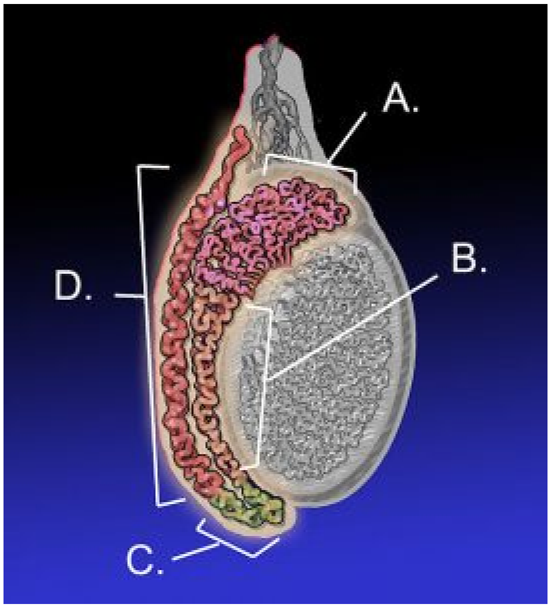
Occlusion of the corpus cavernosum penis in bulls intended for estrus detection: 18 cases (2002–2016), 2019 JAVMA- latest and greatest on this technique; includes challenges and success rates

Indications

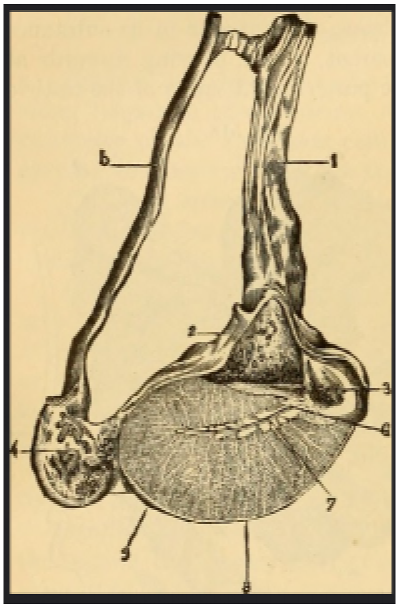
Bilateral epididymectomy is performed to create a non-fertile male that can still identify animals in heat and/or retain male secondary sex characteristics (lion mane, etc). Unilateral castration is performed for unilateral disorders of the epididymis that require removal.

Animals selected as teasers should be manageable, of a size to not cause injury during mounting behavior and have good libido.

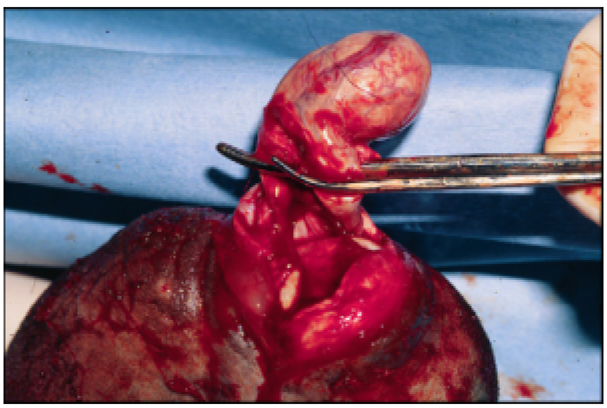
Relevant anatomy



C – tail of epididymis. D- ductus deferens



epididymis (4) and ductus (b) separated from testicle to show anatomy



Preoperative management

Food restrictions: In bulls, the procedure can be done standing in a chute with no sedation. In most other cases, the animal is only lightly sedated for the procedure and no food withholding is required. If needed for exotic ruminants or other cases, food should be withheld for 48 hours to minimize bloat.

NSAIDs/analgesics: Preoperative NSAID administration is recommended to minimize pain and inflammation. Postoperative NSAID administration is not usually required unless inflammation or pain is evident.

Antibiotics: Preoperative antibiotics are not indicated for routine cases.

Tetanus prophylaxis is recommended.

Local blocks: Lidocaine is used to block the cord and/or the surgical site. A cord block avoids distortion of the surgical site. A ring block around the cord can help with analgesia.Injection along the proposed incision line and into the epididymis is quick and effective but does alter the anatomy.

Position/preparation: Bulls can be restrained a chute with a butt bar in place. Sheep are held in a sitting position. Other animals are cast or sedated until in lateral recumbency. The upper leg should be pulled forward to expose the scrotum. The scrotum is clipped (if needed) and scrubbed prior to and after the local block. Surgeons should glove. A headlamp is recommended.

Surgery Supplies:

- Scalpel blade + handle
- Allis tissue forceps or towel clamps
- Needle holders
- Suture scissors
- 3-0 to 0 absorbable suture depending upon patient size

Surgical procedure

A clean towel or sterile drape can be placed under the scrotum and/or over the animal's abdomen for suture management. Stabilize the testicles in the scrotum with your nondominant hand or with a penrose drain wrapped around the scrotum to hold the testicles in place. The tail of the epididymis should be clearly visible and the testicle should not be able to move in the scrotum.

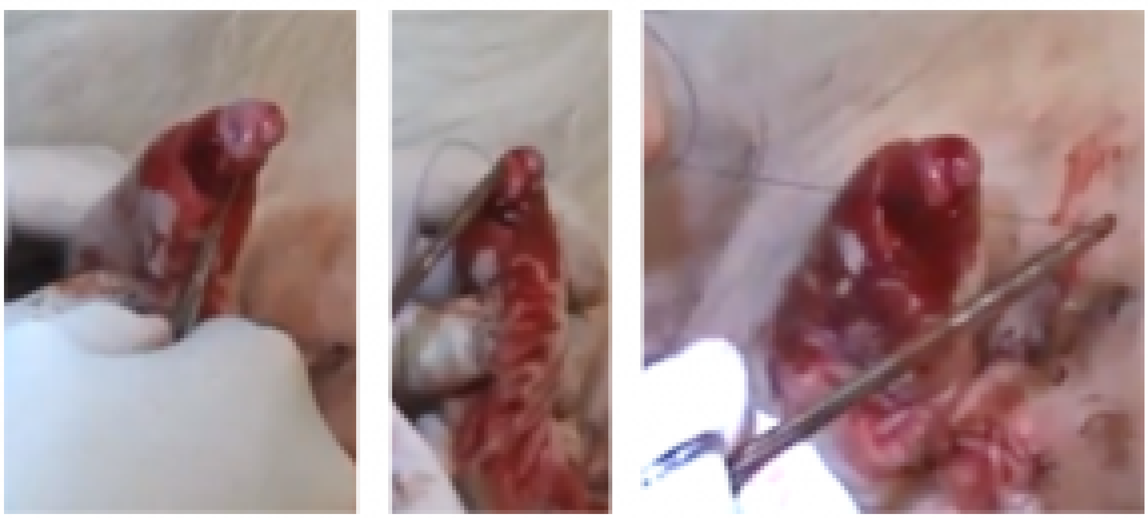
This bull is also getting a penile translocation. Dorsal recumbency makes both procedures possible.

Incise over the tail of the epididymis, exposing both the site at which it is connected to the testicle and the connection to the narrower ductus deferens. Dissect through the skin until you can see the epididymal bulge. Expand the incision so you can see where the epididymis ends and the testicle is visible.

Incision over epididymis. Epididymal bulge. Area of attachment to testicle (blue arrow)

Option 1. Ligate and then dissect

Continue your incision through the vaginal tunic, exposing the epididymis. One side will connect to the ductus and has a relatively narrow area to ligate. The other side connects to the testicle and is going to be harder to define where best to place your suture. It doesn't matter. The discontinuity you are creating is the important part. Find one side and ligate it. Repeat on the other side. Dissect the epididymis free from the testicle and remove it. Close either the tunic or the skin using 3-0 or smaller absorbable suture in a continuous pattern.



Ligating the ductus side. Sliding the needle in hub first is easy and minimizes accidental trauma

Dissecting off the other side means much thicker tissue in the ligature and dissection

Option 2. Dissect and then ligate

Grasp the epididymis (still covered by the vaginal tunic) with the Allis tissue forceps. Dissect the epididymis off at the junction with the testicle. Continue until you have the epididymis only connected to the other structures by the ductus deferens. Ligate the ductus with 3-0 absorbable suture. Cut the epididymis off. Close the tunic is a simple continuous pattern using the 3-0 absorbable suture. Leave the skin open.

"Closed approach". Dissecting the epididymis off of the testicle.

Postoperative care

- Monitor for signs of infection. Open for drainage if necessary.
- Avoid breeding or access to females for 8 weeks.
- Communicate meat withholding restrictions

Complications

There is a risk of hemorrhage and damage to the testicle; resulting testicular atrophy could alter secondary sex characteristics. There is a risk of continued fertility, primarily due to recanalization of the ductus. Sperm granulomas likely occur but have minimal impact on health of the teaser animal.

Videos

Testicular block

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2812#oembed-2

Cord block

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2812#oembed-3

Scrotal ring block

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2812#oembed-4

Dissect first approach -video

Closed approach– video

Dr. Knauers demo of dissection

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2812#oembed-1

Resources

Preparation of teaser bulls – Veteriankey

Teaser preparation in small ruminants, Niehaus, OSU

Epididymectomy on a cadaver (starts at 5:50)- good view of anatomy

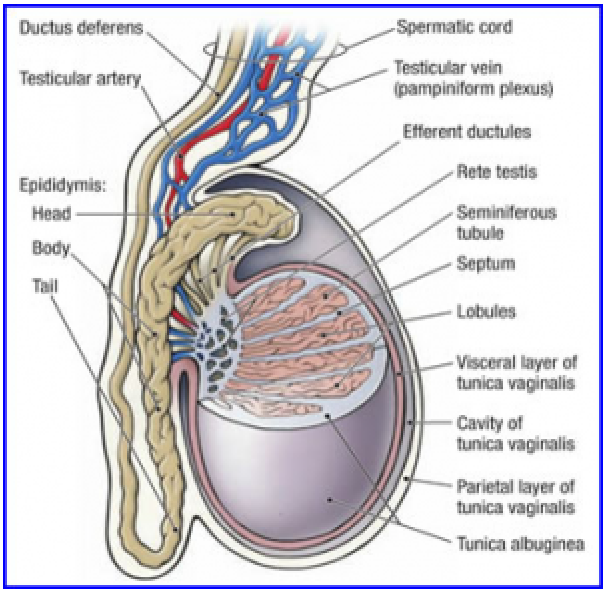
One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2812#oembed-5

Indications

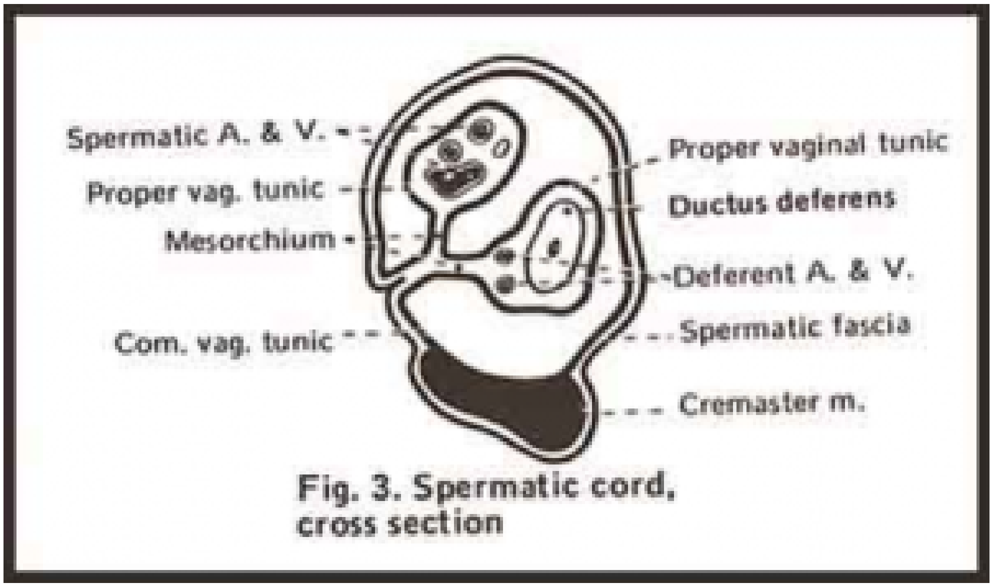
Bilateral vasectomy is performed to create a non-fertile male that can still identify animals in heat and/or retain male secondary sex characteristics (lion mane, etc).

Animals selected as teasers should be manageable, of a size to not cause injury during mounting behavior and have good libido.

Relevant anatomy



Note relationship of vessels and ductus in cord



Note how ductus deferens is in a separate tunic within the vaginal tunic

Preoperative management

Food restrictions: n bulls, the procedure can be done standing in a chute with no sedation. In most other cases, the animal is only lightly sedated for the procedure and no food withholding is required. If needed for exotic ruminants or other cases, food should be withheld for 48 hours to minimize bloat.

NSAIDs/analgesics:Preoperative NSAID administration is recommended to minimize pain and inflammation. Postoperative NSAID administration is not usually required unless inflammation or pain is evident.

Antibiotics: Preoperative antibiotics are not indicated for routine cases.

Tetanus prophylaxis is recommended.

Local blocks: Lidocaine is used to block the cord and/or the surgical site. A ring block around the cord can help with analgesia.Injection along the proposed incision line and into the cord is quick and effective but does alter the anatomy.

Position/preparation: Bulls can be restrained a chute with a butt bar in place. Sheep are held in a sitting position. Other animals are cast or sedated until in lateral recumbency. The upper leg should be pulled forward to expose the scrotum. The scrotum is clipped (if needed) and scrubbed prior to and after the local block. Surgeons should glove. A headlamp is recommended.

Surgery Supplies:

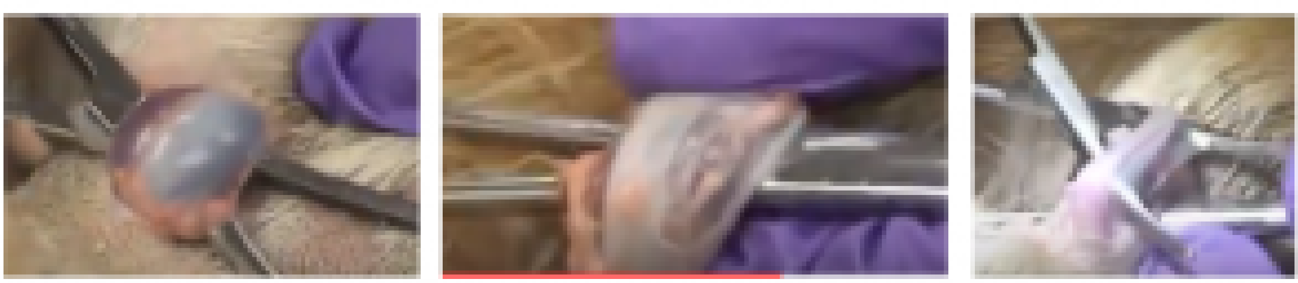
- Scalpel blade + handle

- Allis tissue forceps or towel clamps
- Mosquito hemostat x 2-3
- Kelly hemostat, curved
- Needle holders
- Suture scissors
- 3-0 to 2-0 absorbable suture

Surgical procedure

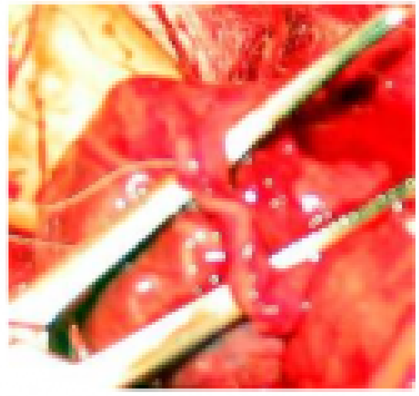
A clean towel or sterile drape can be placed under the scrotum and/or over the animal's abdomen for suture management. Identify the spermatic cord in the neck of the scrotum. The vas deferens is located on the axial side. Make a longitudinal incision over the axial side of the cord through the skin and subcutaneous tissues. Identify the cord. The vas deferens can be palpated on the axial aspect in some cases, separate from the pampiniform plexus.

Elevate the cord onto the kelly forceps to keep it stable. You may be able to see the white vas deferens on the side, through the wall of the tunic. Incise the tunic that covers the structures within. *This step is commonly missed. If the pampiniform plexus is not readily visible, you haven't gone through the tunic.* Once the tunic is open, find the firmer structure that is somewhat isolated. Elevate this on the mosquito hemostat. When relaxed, the vas deferens has a slightly coiled appearance to it.



elevating the cord and then separating the vas deferens

Clamp the ends of the section of vas deferens to be removed. In older animals, ligate each end to prevent sperm granuloma formation and remove at least 1 cm section. In a mature animal, the contents can be squeezed onto a slide and checked for sperm to verify it is the vas deferens. In younger animals, the section can be removed without ligation (piglets). The skin is closed routinely.



Postoperative care

- Monitor for signs of infection. Open for drainage if necessary.
- Avoid breeding or access to females for 8 weeks.
- Communicate meat withholding restrictions

Complications

There is a risk of removing the wrong structure, particularly in younger animals. Accidental damage to the pampiniform plexus could cause significant hemorrhage. There is a risk of continued fertility, primarily due to recanalization of the ductus. Sperm granulomas may occur.

Videos

Testicular block

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2808#oembed-1

Cord block

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2808#oembed-2

Scrotal ring block

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2808#oembed-3

Cadaver demo

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2808#oembed-4

Vasectomy (on a calf but doing it the piglet way)

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2808#oembed-5

midscrotal approach in a sheep

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2808#oembed-6

Resources

Preparation of teaser bulls – Veteriankey

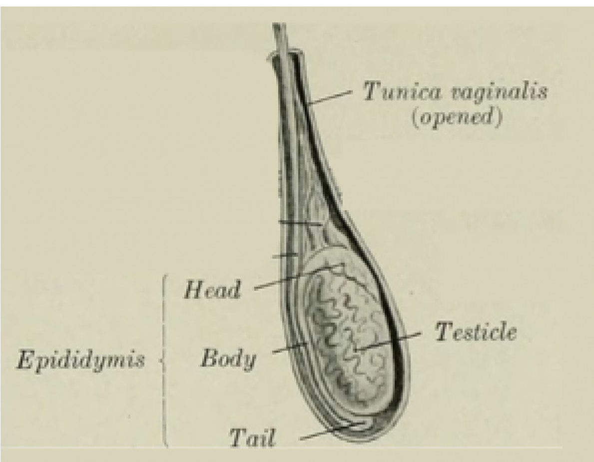
Teaser preparation in small ruminants, Niehaus, OSU

How to - Unilateral castration

Indications

Unilateral castration is most commonly performed to maintain fertility in a male animal despite trauma, tumors or temperature changes in the single testicle. Inguinal hernias are treated most effectively by unilateral (if not bilateral) castration. Removing the testicle means being able to fully close the inguinal ring. Leaving space for the testicular artery means leaving space for the guts to come through, as well.

Relevant anatomy



Preoperative management

Food restrictions: In bulls, the procedure can be done standing in a chute with no sedation. In most other cases, the animal is only lightly sedated for the procedure and no food withholding is required. If needed for exotic ruminants or other cases, food should be withheld for 48 hours to minimize bloat.

NSAIDs/analgesics: Preoperative NSAID administration is recommended to minimize pain and inflammation. Postoperative NSAID administration is indicated. Excessive inflammation can lead to fibrous tissue formation and inability to thermoregulate.

Antibiotics: Antibiotics are not usually indicated unless the reason for castration involves infection. Results of culture and sensitivity can guide antibiotic selection if available. If not, the most common organism in cattle will be *Trueperella pyogenes*. Antibiotics tend not to work well in pus despite sensitivity *in vitro*. Drainage is important.

Tetanus prophylaxis is recommended.

Local blocks: Lidocaine is used to block the cord and/or the surgical site. A cord block avoids distortion of the surgical site. A ring block around the cord can help with analgesia.Injection along the proposed incision line and into the testicle is quick and effective but does alter the anatomy.

Position/preparation: Bulls can be restrained a chute with a butt bar in place. Sheep are held in a sitting position. Other animals are cast or sedated until in lateral recumbency. The upper leg should be pulled forward to expose the scrotum. The scrotum is clipped (if needed) and scrubbed prior to and after the local block. Surgeons should glove.

Surgery Supplies:

- Scalpel blade + handle
- Needle holders
- Suture scissors
- 0-1 absorbable suture depending upon patient size
- Emasculators

Surgical procedure

An incision is made vertically in the scrotum, following the length of the affected testicle along its abaxial border (minimizing trauma to the unaffected testicle). The testicle is exteriorized. The cord is ligated with 0 absorbable suture (avoid chromic gut). The testicle is emasculated distal to the ligature or another ligature placed.

The scrotum can be left open for second intention healing if infection is a concern. Betadine soaked gauze can be inserted into the space to keep the wound open until the space is closed by granulation tissue. Animal comfort is increased if the scrotum can be closed. Extra skin can be removed to minimize deadspace but will cause bleeding. The scrotal skin is closed with simple continuous, cruciates or a Ford-Interlocking pattern. Two -three interrupteds placed ventrally will make drainage easier if infection develops. Absorbable suture may be used if removal will be difficult.

Postoperative care

- Continue NSAID therapy for 3 -5 days
- Cold hydrotherapy can be used if the skin was closed and if swelling is present.
- If packing was used, pull out and trim off a small amount each day until fully removed.
- Keep the area clean and dry for 10 days postoperatively
- Minimize exercise for the first day to minimize the risk of bleeding

- Monitor for signs of infection, herniation or dehiscence.
- Evaluate semen quality in 60 days (allow recovery).
- Communicate meat withholding restrictions

Complications

Inflammation can cause scarring. Scarring can lead to inability to thermoregulate and subsequent infertility.

Videos

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2872#oembed-1

Resources

Surgery of the scrotum, Vet Clin Food Anim 24 (2008) 253–266

How to - Penile translocation

Indications

Penile translocation is performed as part of a teaser bull procedure. The goal is to minimize intromission and minimize disease transmission.

Relevant anatomy

The prepuce is moved above the flank fold so that the erection misses the vagina. The penis is not usually observed in this procedure.

The prepuce is minimally attached to the body wall. It can be readily dissected free.

Preoperative management

Food restrictions: Withhold food 48 hours. Water should be withheld if the animal is drinking excessively.

NSAIDs/analgesics: Preoperative NSAIDs are recommended.

Antibiotics: The procedure tends to be contaminated. Give preoperative antibiotics.

Local blocks: An inverted U line block around the prepuce and a ring block around the new exit site.

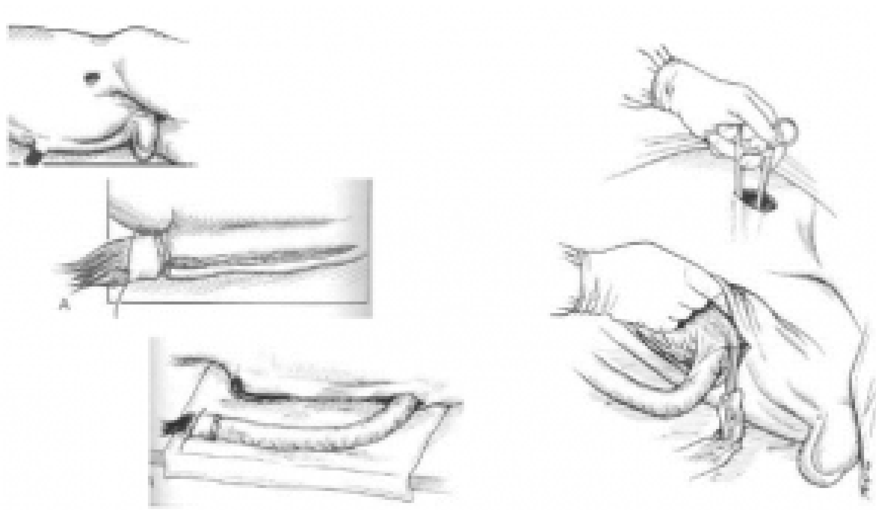
Position/preparation: The animal is positioned in dorsal recumbency. Inserting a long probe into the prepuce can help identify structures and minimize trauma to the sheath.

Surgery Supplies:

- Standard surgery instruments
- Probe (optional)
- Sterile rectal sleeve
- Lap sponge forceps

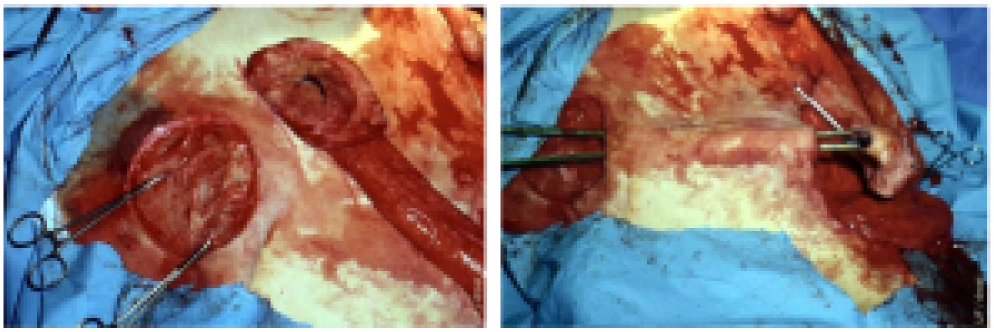
Surgical procedure

- If used, the probe is inserted into the sheath and the sheath clamped shut.
- A circular incision is made through the skin around the prepuce.
- The incision is continued through the skin the length of the prepuce.
- A circle of skin is removed at the new exit site (careful with size- it will expand as soon as cut free)
- Dissection is continued to the body wall on the cranial aspect of the prepuce. The incisions over the prepuce are extended subcutaneously around the prepuce. Try not to enter the prepuce. This should result in a prepuce that is freed from the skin and the body wall for sufficient length to move to the new site.



Turner & McIlwraith. Techniques in Large Animal Surgery

- Create a subcutaneous path from the new site to the prepuce through blunt and sharp dissection.
- Pass a sterile rectal sleeve through the new site and insert the prepuce (with preputial opening) into the sleeve. Pull/push the prepuce through to the new exit site.



- Remove the rectal sleeve and secure the prepuce to the new site using a continuous pattern of 0 absorbable suture. Stop halfway around the opening to prevent a **purse string** effect

Postoperative care

- Suture removal in 10-14 days
- Sexual rest 60 days

Complications

- **Dehiscence**, stricture

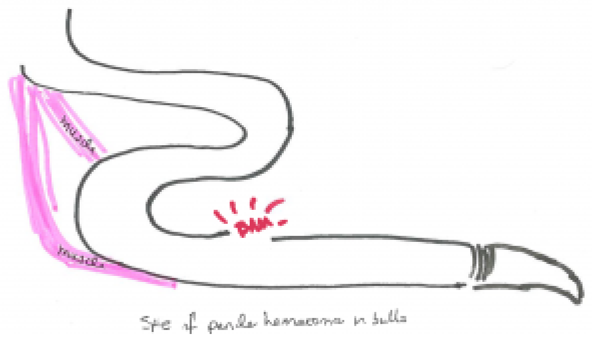
Videos

youtube video

Resources

Penile injury

The most common penile injury in breeding bulls is penile hematoma (broken penis). Rather than just a small vessel rupture, these are generally tunica albuginea ruptures. The amount of pressure in the bull's erect penis is very high. If the bull bumps the cows flank, something has to give. The penis almost always ruptures at the base of the sigmoid flexure at the level of the retractor penis muscle attachments. It ruptures on the dorsal surface. This area is weaker due to the bending required. This results in a bleed on the dorsum of the penis with the size of the hematoma related to the amount of breeding attempted by the bull after the injury.



Multiple complications can occur :

The dorsal nerve can be damaged either during the rupture or be entrapped by scar tissue during the healing. Some of these bulls will develop nerve damage with further breeding attempts as the tissue tears rather than stretches.

The tunic can fail to heal, leading to loss of pressure in the corpus cavernosum and the inability to gain an erection.

The hematoma can become infected, turning into an abscess.

Adhesions can develop between the penis and sheath, creating phimosis or inability to extrude the penis.

The prepuce is often prolapsed due to limited space in the sheath and can get damaged.

Resources

Penile and preputial problems in the bull, MS Gill

Penile amputation after trauma, case report

Penile and preputial neoplasia

Squamous cell carcinoma

SCC is a common tumor of the penis and prepuce. The clitoris can also be affected. SCC is common in older geldings, particularly those with unpigmented preputial/penile skin (Appaloosas and Paints). SCC has been associated with chronic irritation due to smegma. Horses with ocular SCC should be checked for urogenital SCC as well and vice versa.

SCC can appear as several small lesions (papillomas), ulcers, plaques or granulomatous cauliflower-like lesions. The glans and urethral opening are often affected. Tumors tend to be locally invasive and, while slow to metastasize, can spread to regional lymph nodes. A rectal examination can be useful to detect spread to sublumbar lymph nodes. Deep palpation of the inguinal area can detect enlargement of those nodes (easiest when the horse is anesthetized).

Lymph node aspiration is recommended; enlarged nodes may be due to metastasis or inflammation.

Differential diagnoses should include papillomas and habronemiasis. Benign papillomas may progress into malignant SCC.

Treatment options are the same as for SCC at other sites. The most commonly used treatments include cryotherapy, CO2 laser resection, topical 5-fluorouracil, and resection.

Cryotherapy: Cryotherapy can be performed in the standing horse using sedation +/- local anesthesia. After the initial freeze, the area is relatively numb and local anesthesia is not commonly used. A double to triple freeze-thaw cycle is used at a minimum, with a quick freeze and a slow thaw preferred for the most cellular damage. When you have frozen it enough, the area stays “frozen” and doesn’t thaw rapidly anymore.

Because this is a mucous membrane, the probe can “stick”. Have water ready to apply if the probe is difficult to remove.

Do not freeze where scars may squeeze. Avoid freezing the urethral opening and be careful around the glans.

Cryotherapy is most useful for small lesions or following **debulking**. It is often used to control recurrence and may be combined with other treatments (eg 5 FU).

5-Fluorouracil: 5-FU is a topical chemotherapeutic agent that interferes with the cell’s ability to synthesize DNA. Repeated application can lead to tumor remission. The drug is much less toxic when applied topically as opposed to systemic administration.

5-FU is applied after surgical debridement or to small lesions. In mares, daily application is necessary. Recheck mares every 2 weeks until remission and then every 6 months. In geldings/ stallions, the sheath maintains a higher drug concentration and 5FU is applied every 2 weeks. An inflammatory response is expected beginning at 5-7 days and continues through 2-4 weeks. The tumor sloughs at 6-12 weeks in many cases. Therapy often involves 3-6 treatments but should be continued until the tumor is under control.

5-FU can be obtained from most human pharmacies and comes in small tubes that aren't cheap. If a tumor is debulked, you may want to wait until bleeding stops before applying 5FU to ensure that it isn't washed away.

Many horses need continued treatment at least 1-2x a year. 5-FU can be used indefinitely but does eventually affect normal skin cells (since they are rapidly dividing). The irritation can lead to epithelial changes (and tumor formation?).

Cisplatin beads : new treatment and relatively inexpensive. One bead implanted per cm.2

CO2 Laser: The CO2 laser is useful for removing skin tumors, including urogenital lesions. The shallow cutting action and limited lateral damage of this laser make it easy to "shave" tumors off until normal tissue is apparent with minimal inflammatory response. Laser treatment can be performed in the standing animal using local anesthetic and sedation. The laser also decreases nerve sensation and seems to have less postoperative pain associated than does cryotherapy. Tumor recurrence can be more difficult to detect as it may be covered by normal skin.

Tumor resection: Besides the option of removing a local lesion (can be done standing with local anesthesia and primary closure of the defect; get wide margins), tumor resection may involve removal of the prepuce or part/all of the penis or clitoris. With clitoral SCC, extensive dissection and wide margins are required.

i. Posthioplasty or Reefing

In this procedure, the superficial mucosal layer of the prepuce is removed (and hopefully the tumor along with it) and the remaining ends reanastomosed. The procedure is most commonly done under general anesthesia but is short enough to be done under injectable anesthesia.

Circumferential incisions are made in the prepuce on either side of the lesion and connected by a longitudinal incision. Marking sutures may be placed on the outside edges of the circumferential incisions to make sure the tissues aren't twisted. A penrose drain placed proximally works well as a tourniquet. The mucosa between the circumferential incisions is peeled off underlying tissues with sharp and blunt dissection. The remaining mucosal edges of the prepuce are re-anastomosed with short continuous suture patterns, usually with absorbable 2-0 suture.

Postoperative care involves NSAIDs to minimize swelling +/- oral antibiotics (not the cleanest area).

ii. Phallectomy (penile amputation)

Phallectomy can be used to remove tumors of the distal penis that have not spread to local lymph nodes (inguinal or sublumbar). Ultrasound can be useful to determine if the tumor has penetrated through the tunica albuginea (and likely entered the vascular system).

There is a limit to how much penis can be physically removed.

This procedure should not be done in intact stallions as erection can result in wound dehiscence and hemorrhage. Stallions should be castrated at least 2 weeks prior to phallectomy.

Complications include urethral swelling and obstruction (maximum at 3-4 days); dehiscence (partial usually heals okay), and tumor recurrence or incomplete removal (25.6% recurrence rate; biopsy margins at surgery; apply 5FU, etc).

Budget cases: can amputate standing using a Callicrate bander; need to perform a PU so they can urinate. Penis undergoes ischemic necrosis. Might be difficult for some owners to handle.

iii. En bloc resection and penile retroversion

Rarely done anymore due to extensive complications and aftercare required.

iv. Amputation and sheath ablation

This is a newer procedure to retain more normal orientation of the penis. A new skin opening is made in the ventral abdomen and a urethrostomy performed at the new site. Pain occurs if too much traction is present (assess likely sx site when horse is standing), hemorrhage and dehiscence are possible. Urine scald is reportedly not as severe. Lymph nodes can be removed through separate incisions. Better owner acceptability? (most commonly recommended right now)

With all of these treatments, reevaluation and sheath cleaning is recommended at least every 6 months for cases of SCC.

Sarcoids

Sarcoids can occur on the preputial skin. Treatment is the same as for treatment of sarcoids in other sites. Aldara, cryotherapy, cisplatin beads and/or laser removal are the most common recommendations at this time.

Others

Melanomas are common in the sheath of gray horses. Treatment is not usually required.

Very rarely are these tumors malignant, however, malignancy and metastasis has been reported. Lymphosarcoma can also develop in the sheath. Systemic steroids can help control the disease. Hemangiosarcoma has been reported. Papillomatosis is usually self limiting but persistent cases have been reported. May be a precursor to SCC.

Habronemiasis

Habronemiasis or "summer sore" is a result of Habronema larvae encystment. These lesions are more common in warm, humid climates. External genitalia is a frequent site due to moisture that attracts flies. Exuberant granulation tissue is present and small, yellow, hard, caseous granules can be squeezed out of the lesions.

Eosinophils are usually present in the blood and in samples from the lesion. Treatment includes ivermectin and steroids. If affected, the urethral process can be amputated in the standing horse after local anesthesia. A catheter is preplaced to minimize the risk of trauma to the urethra. The urethral mucosa is apposed to the remaining stump of the process with interrupted sutures of 2-0 absorbable suture.

References

Diagnosis of equine penile and preputial masses: A clinical and pathological perspective– clinical commentary, Equine vet. Educ. (2017) 29 (1) 10-14

Fortier LA and MacHarg MA. Topical use of 5-fluorouracil for treatment of squamous cell carcinoma of the external genitalia of horses: 11 cases (1988-1992). JAVMA 1994. 205:1183-1185.

Van den Top JGB et al. Penile and preputial tumours in the horse: Literature review and proposal of a standardized approach. EVJ 2010. 42:746-757.

Preputial wounds

Preputial wounds are relatively common in breeding bulls. Due to their location, these wounds do have more associated complications, particularly swelling, infection and adhesions.

Most preputial wounds should be treated by second intention healing or delayed primary closure due to contamination. The exception is preputial avulsions. These wounds are 360º avulsions of the prepuce from the free portion of the penis at the preputial ring. Generally these are seen in bulls being collected for AI. These wounds heal poorly if left unsutured; however, since the bull was generally cleaned prior to collection, the area is only minimally contaminated and the wounds can be closed primarily.

With second intention or delayed closure, the wound must be managed to minimize swelling, contamination and adhesions.

Contamination

It is very difficult to clean the sheath to minimize contamination. Wound identification may also be delayed, letting bacteria adhere and form a protective glycocalyx. Assume the wound needs sharp debridement. Soaking in an antiseptic solution may also help remove surface bacteria.

Swelling

Trauma leads to swelling and this is particularly significant in ventral tissues. If the prepuce can be returned to the sheath, the swelling is minimized. A **purse string** may be necessary to retain the tissues in the sheath.

However, if the prepuce is not reducible, the area needs to be elevated as much as possible. The prepuce can be slung or held next to the ventral abdomen with old sheets or with sticky tape applied over a soft wrap.

Swelling and bandaging can lead to urethral obstruction; a penrose drain or silicon tube can be used to wick urine out of the sheath.

Adhesions

A lanolin based ointment can be coated on the damaged tissue to minimize adhesions within the sheath that would prevent intromission or semen collection. As healing progresses, sight stimulation of a cow in heat will also encourage movement of the prepuce.

Preputial issues

Pot bellied pigs can develop penile prolapse as can bulls, especially Bos indicus breeds. Bulls are treated by preputial resection (reefing) or amputation.

Pigs are treated by phallopexy (but might be amenable to preputial resection as well).

Resources

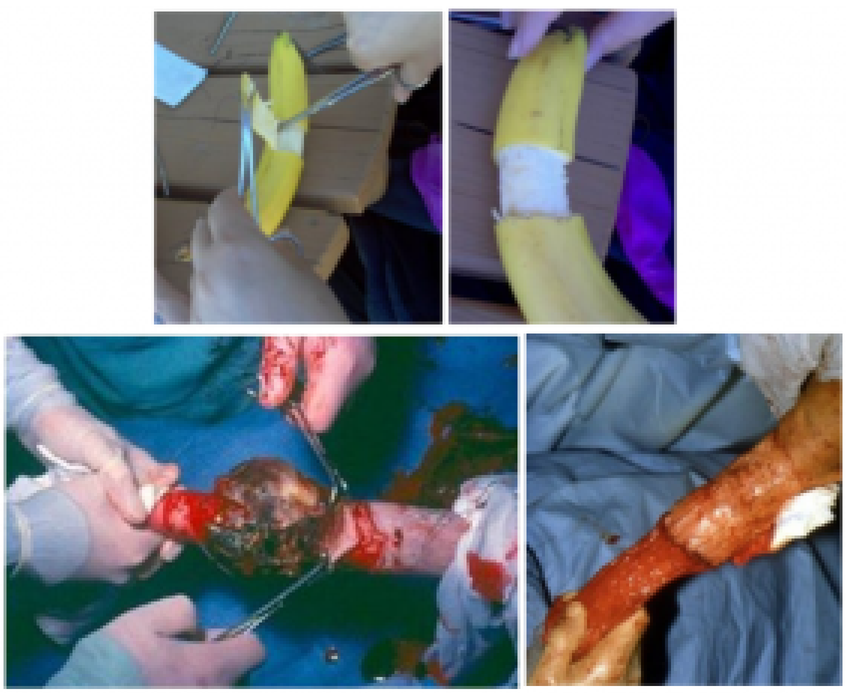
L Reig et al. Surgical treatment of chronic penile prolapse in Vietnamese pot-bellied pigs: 5 cases (2016–2017). 2019 Vet Surg 48:890-896.

Preputial surgery

Many preputial wounds will need eventual surgery. This may be sharp debridement and primary closure but more often this is reconstructive surgery. There are two main options for preputial reconstruction : reefing (circumcision) and amputation. These surgeries are essentially the same as rectal prolapse surgery; reefing is essentially submucosal resection while amputation is similar in both. Vaginoplasty would also equate to reefing.

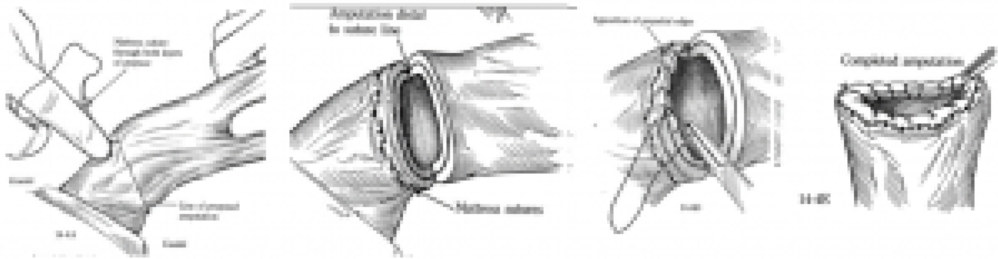
Preputial resection

Preputial resection is preferred over preputial amputation when possible. It is only possible when the penis can be extended and exteriorized. With the penis extended, the damaged area of prepuce is removed by making a circumferential incision around each side of the damage. These are connected by a longitudinal incision and then peeled off the underlying layers. The two circumferential incisions are then reanastomosed, taking care to not twist the penis and prepuce while doing so.



Preputial amputation

Preputial amputation is performed when the penis cannot be exteriorized. After placement of overlapping sutures 360º around the healthy prepuce to control bleeding, the distal prepuce is transected and the cut edges anastomosed. It may be helpful to cut a “v” incision in to the circle to avoid cicatrix formation. These do tend to stricture, regardless. For breeding purposes, a prepuce length of at least 1.5-2x as long as the free portion of the penis.



From McIlwraith & Turner, Large Animal Surgery

Resources (google at your own risk)

Penile and preputial problems in the bull, MS Gill

Surgical procedures in the bovine, start at page 13

How to - Preputial resection

Indications

Relevant anatomy

Preoperative management

Food restrictions:

NSAIDs/analgesics:

Antibiotics:

Tetanus prophylaxis is recommended.

Local blocks:

Position/preparation:

Surgery Supplies:

-

Surgical procedure

- With the penis extended, determine the amount of prepuce (generally damaged) that needs to be removed. If you don't have an assistant, it can help to use a towel clamp or piece of gauze to keep the penis extended. A penrose drain makes a good tourniquet.
  Keeping dorsal aspects aligned, create a circumferential incision at each end of the area to be removed. The incision should extend into the loose connective tissue. Connect the two circumferential incisions with a linear incision to the same depth. Remove the damaged area using scissors.
  Reconnect the two ends using simple continuous runs of suture (at least two to avoid a **purse string** effect). Absorbable suture is probably wise.

Postoperative care

-

Complications

Videos

Resources

Practice- Level A

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=2622#h5p-102

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=2622#h5p-180

Cranium - Male Urogenital Surgery

This game is designed to let you show off your knowledge and skills

The instructor will divide you into teams of 2-3 so that there is an even number of teams. You will compete against one other team (one board per two teams). Team A vs Team B.

Go to your page of the ebook to get the questions (and answers) that the other team will have to answer. Your instructor will give you the password for your team page.

Team A page

Team B page

Your goal is to get around the board and into bed (your Moon) for a well deserved break.

Each team has to successfully meet a challenge before they can roll and move.

Team A will pull up the first challenge and pose it to Team B. Each team has 60 seconds to answer knowledge questions (open book) and 5 minutes to draw, sculpt or act out the secret word/phrase questions. Challenges can be adjusted by the team posing the challenge as needed. Secret word/phrases should be passed to only ONE member of Team B and done privately

Teams decide how easy/hard they will grade answers.

If a team successfully meets the challenge, they roll the die and move clockwise toward their Moon,

Team B repeats the process for Team A.

First team to reach their Moon wins.

Practice - Cranium Team A

Cranium – Male Urogenital Surgery -One person in the group makes a copy of the gameboard and share it with everyone on both teams (editing rights). See rules on the first tab

Team A questions (to ask Team B)

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=5862#h5p-191

Practice - Cranium Team B

Team B questions (to ask Team A)

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=5865#h5p-192

Female urogenital surgery

Vaginal prolapses, rectovaginal trauma and repair of injured structures

Perineal analgesia

Your choices for regional anesthesia in the perineal area are local infiltration, epidurals, perineal nerve block, and/or splash blocks. General anesthesia would also work but is often more challenging as the anatomy is changed by the change in animal position.

Local infiltration

Line blocks can be quick and easy. We routinely use lidocaine (without epinephrine) and a small gauge needle. Small ruminants are sensitive to lidocaine so monitoring the total dose is important.

Line blocks are very useful for caslicks, lacerations, and other superficial procedures.

Epidurals

Epidurals are relatively easy in dairy cattle and harder but generally doable in the other food animal species and in horses. Lidocaine is used routinely. The main side effect of lidocaine is ataxia and that is typically not as problematic in food animals. Lidocaine works quickly so you can tell if it worked. Assume it will wear off in about an hour. If you need longer duration effects, other options include a combination of xylazine + lidocaine or the use of mepivicaine. Xylazine takes longer to kick in than lidocaine but lasts longer. Combinations of xylazine + lidocaine are also used in horses as the xylazine provides analgesia (receptors in the spinal cord) with less related ataxia. Horse surgery is usually performed in stocks, away from the stall, so the horse needs to be able to walk back to its stall after surgery. Ataxia can be dangerous at that stage. Cattle surgeries are often performed in the stanchion so they may not need to walk very far but the same principles apply.

Local anesthesia chapter

Pudendal nerve block

This is a really cool block. It is great for bull penis surgery and for some cow urogenital procedures.

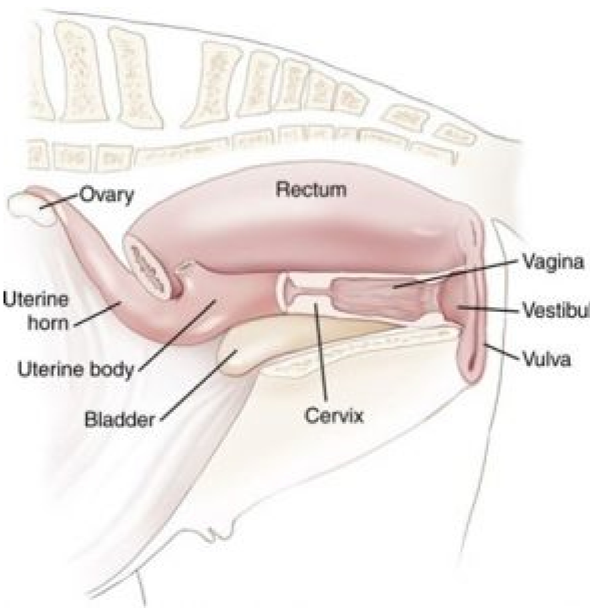
An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://open.lib.umn.edu/largeanimalsurgery/?p=2442#h5p-136

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=2442#oembed-1

Splash blocks

Lidocaine is absorbed through mucous membranes. Spraying or splashing the lidocaine into the vulva will help a little. This is often an added analgesic; rarely is it enough on its own (or your dentist would not actually inject your gums for dental work).

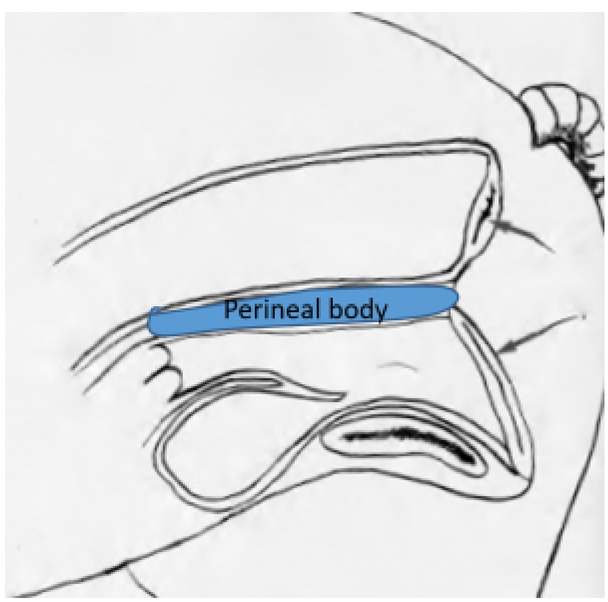
Anatomy

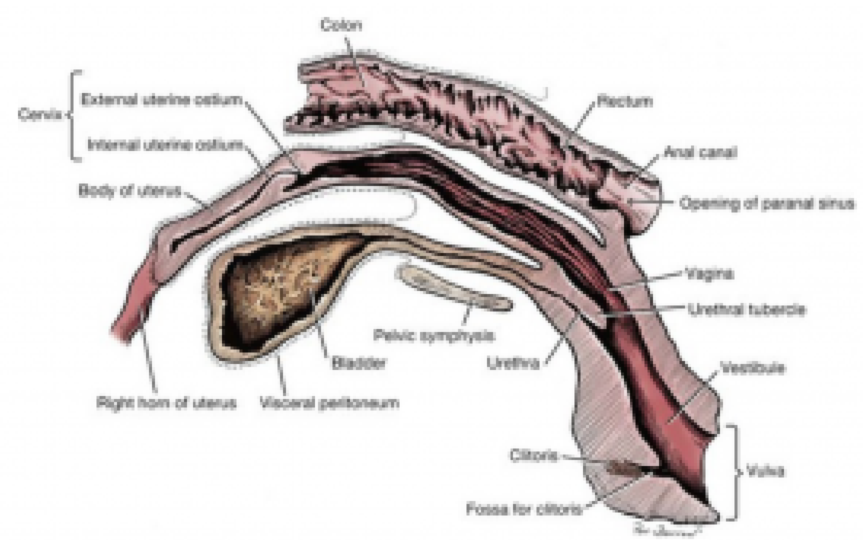


There are 3 main barriers to the uterus:

- vulvar seal created by good anatomic closure of the vulvar lips
- vestibular sphincter (vestibulovaginal ring) created by the perineal body and vaginal tone
- cervix- cervical seal created by good cervical muscle tone

The perineal body is a muscular structure surrounding the vagina. It is composed of the constrictor muscles of the vestibule and vulva. It helps maintain normal tone to the vulvar area and vestibulovaginal seal by counteracting the pull of the rectum and viscera.





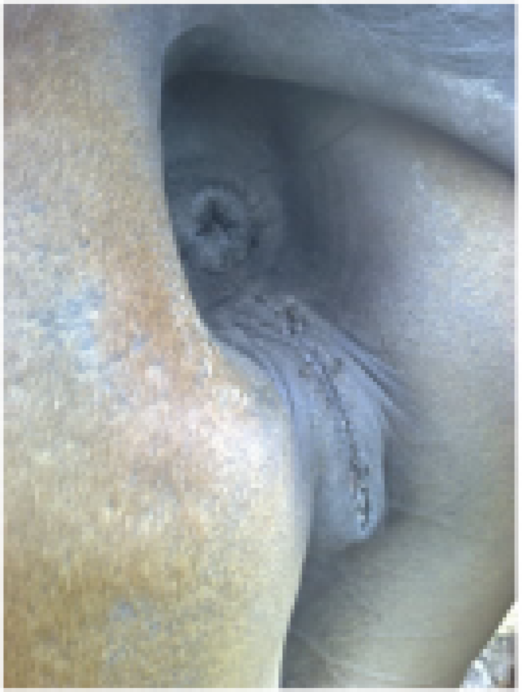
https://veteriankey.com/vagina-vestibule-and-vulva/ Note muscular tissue surrounding the vulva and vestibule

With trauma and/or normal aging, the three structures can be disrupted.

Vulvar seal

The vulvar seal can be disrupted by direct trauma (including foaling) or with aging changes. The normal vulva should be vertical with 75% of the vulva below the pelvic bone.

Mares can develop “splanchnoptosis”, a tilt to the vulva due to forward traction by the viscera (the weight of the guts drags it toward the peritoneal cavity). This is typically due to multiple deliveries or weight changes. The perineal body helps to counteract the pull of the viscera in a young mare.



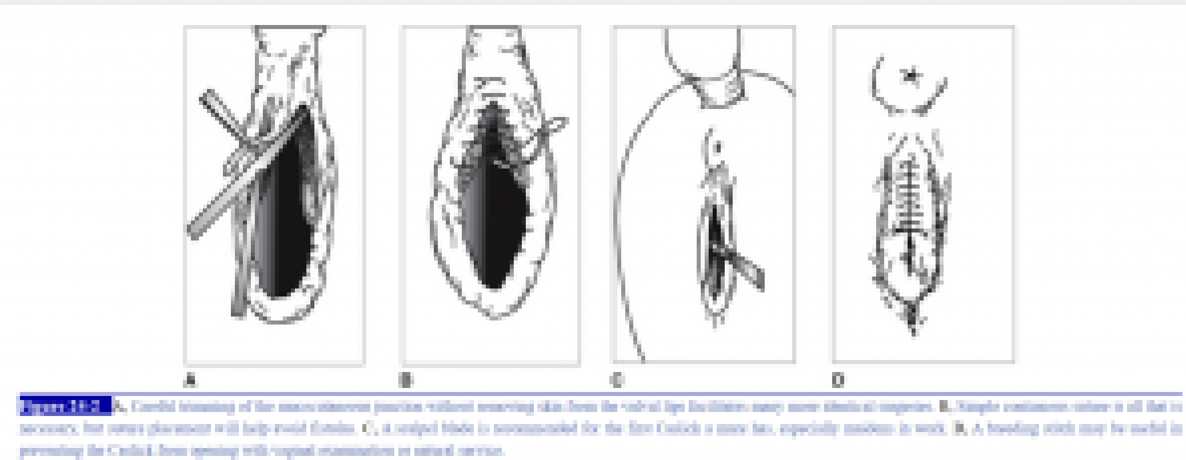
Splanchnoptosis

Good conformation

When the vulvar seal is disrupted, mares develop pneumovagina (windsucking) and vaginitis.

Treatment is performance of a Caslicks suture to artificially create vulvar closure. If the mare is bred, the Caslicks does need to be transected prior to foaling!

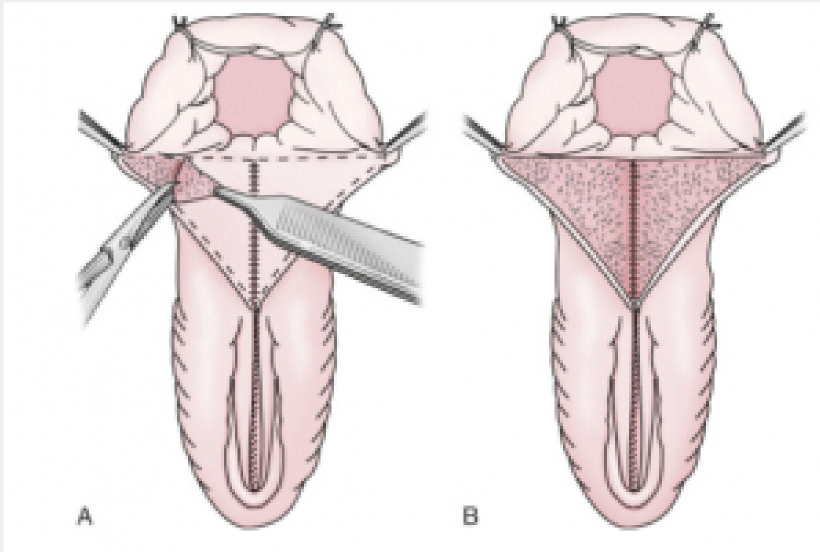
[**Selected Reproductive Surgery of the Broodmare**]



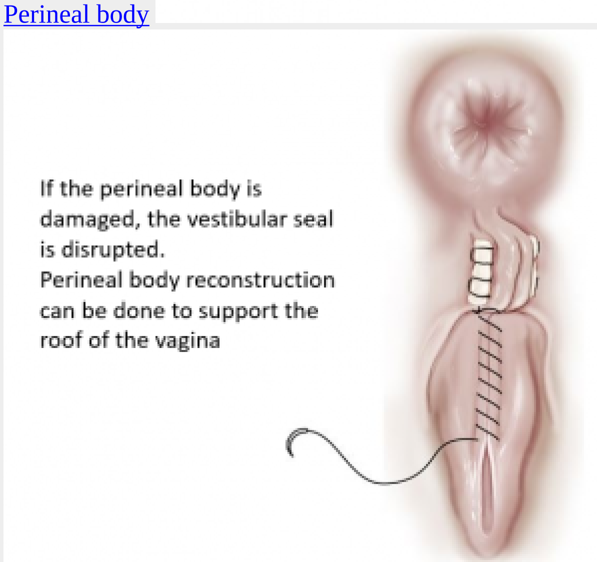
Local anesthesia is generally via a line block on each side of the vulva. This does create temporary swelling. Place sutures more closely together than normal to avoid gaps when the swelling resolves. 2-0 absorbable or non-absorbable suture on a cutting needle works well.

Vestibular seal

Over time or with deliveries, the sphincter muscles can be damaged, resulting in a thinned or ineffective perineal body. The perineal body can be reconstructed using a similar approach as for a Caslicks. This procedure may be useful if a Caslicks does not resolve the windsucking (pneumovagina) or vaginitis.



Perineal body



Cervical seal

Generally damage to the cervix is iatrogenic and caused by veterinary manipulation during dystocias. Cervical trauma is identified as a thinned area of the cervix rather than a distinct gap. The cervix is pinched between the thumb and first finger (one of which is in the lumen of the cervix) to identify a thinned area. This is easiest to detect in diestrus. Fixing cervical tears is challenging, requires special instruments and is considered a referral procedure.

Key Takeaways

Caslicks -Recreates the vulvar seal. Useful for pneumovagina and vaginitis occurring due to lack of a vulvar seal. Contraindicated if severe slope (splanchnoptosis) and if doing one would make urine hit the Caslicks and bound back into the vagina. Needs to be removed for natural service (breeding) or parturition

Perineal body transection-. Separates the pull of the viscera from the vagina. Useful for urine pooling due to severe slope and for realigning vulva so a Caslicks can be done without creating more issues. Left to heal by second intention.

Perineal body reconstruction – Creates more support to the vestibule to help reinforce the vestibular sphincter. Useful for pneumovagina and vaginitis that is related to aging changes and/or trauma during parturition. It provides extra strength to a Caslicks at the dorsal aspect.

Cervical reconstruction – Fixes thinned areas of the cervix. Performed for defects in the cervical seal. Referral recommended

Resources

Vulvar conformation, vulvar injuries and the Caslick, equine reproduction.com-

- Note: good for caslicks and first degree tears. Not good advice for repair timing on third degree tears!

This video shows a good Caslicks but with poor instrument handling- youtube video

Perineal body reconstruction video –youtube

How to - Caslick's suture

Indications

A Caslick's suture is used in mares to treat vulvar trauma, pneumovagina, vaginitis and infertility. It should not be used if splanchnoptosis is severe and the Caslicks would impair urine flow.

A deep (thick) Caslick's may be used as a permanent means of preventing vaginal prolapse.

Relevant anatomy

The vulvar lips comprise the first barrier to the uterus. If the vulvar lips do not seal totally, a Caslick's suture is placed to create the seal.

Preoperative management

Food restrictions: NA

NSAIDs/analgesics: NSAIDs are recommended preoperatively.

Antibiotics:NA

Tetanus prophylaxis is recommended.

Local blocks: Typically a line block on each side of the vulva is performed.

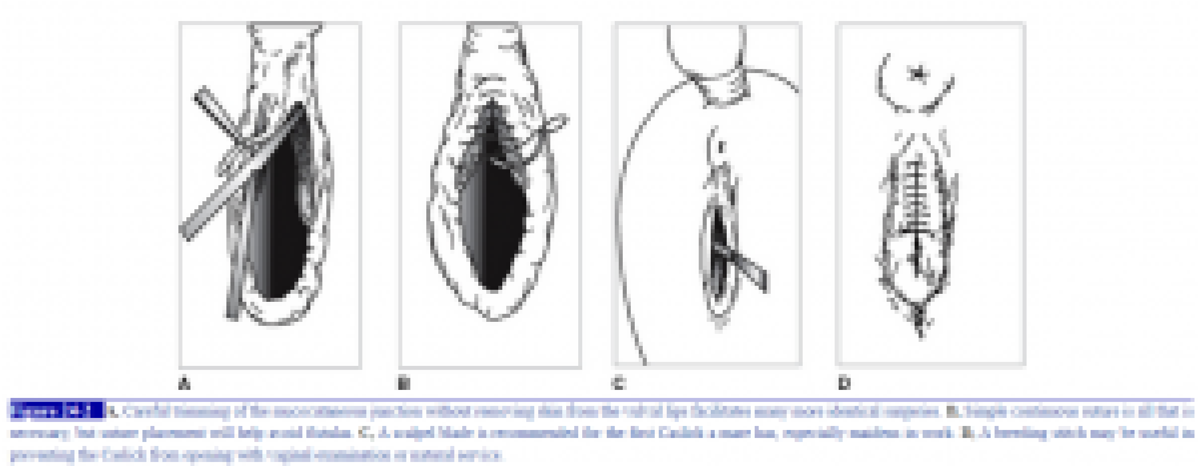
Position/preparation: The patient is sedated as needed and restrained in stocks (mares) or headgates (cattle). Sterile gloves are recommended.

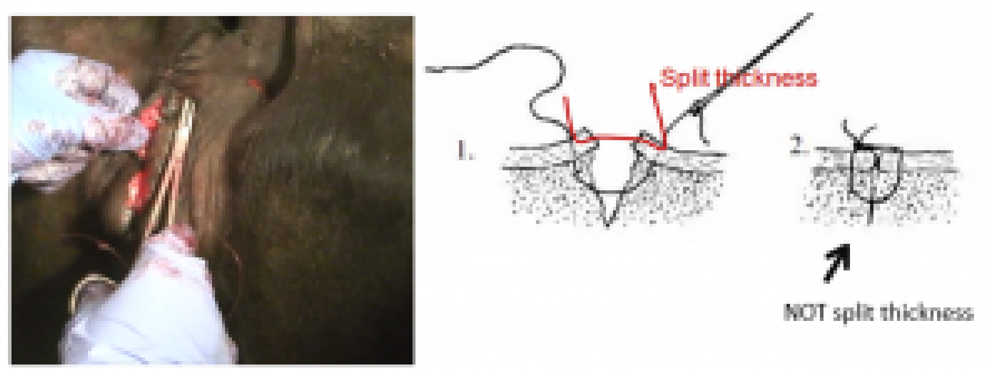
Surgery Supplies:

- Scalpel blade and handle
- Metzenbaums
- Suture scissors
- 2-0 suture on a cutting needle

Surgical procedure

A thin strip of tissue is removed from each side of the vulva at the mucocutaneous junction, extending from the dorsal junction to the pelvic brim (approximately 2/3 of the length). The cut edges are sutured together using a split thickness Ford Interlocking or continuous pattern of 2-0 absorbable or nonabsorbable suture material. Due to the local block, bites should be taken closely together (1/2 cm) and pulled snugly to prevent gaps.





Split thickness suturing

Postoperative care

- Sutures are removed in 10-14 days.
- Episiotomy (cut the Caslick's) is performed to open the Caslick's prior to parturition

Complications

- Gaps may develop between the vulvar lips if the suture pattern is too loose.
- Natural breeding with the vulvar lips closed can lead to trauma to the mare and/or stallion

- Foaling through the closed vulva can lead to trauma to mare and/or foal
- Each time the Caslick's is replaced, it becomes thicker and harder to create a seal.

Videos

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=3295#oembed-1

Resources

Manual of Clinical Procedures in the Horse

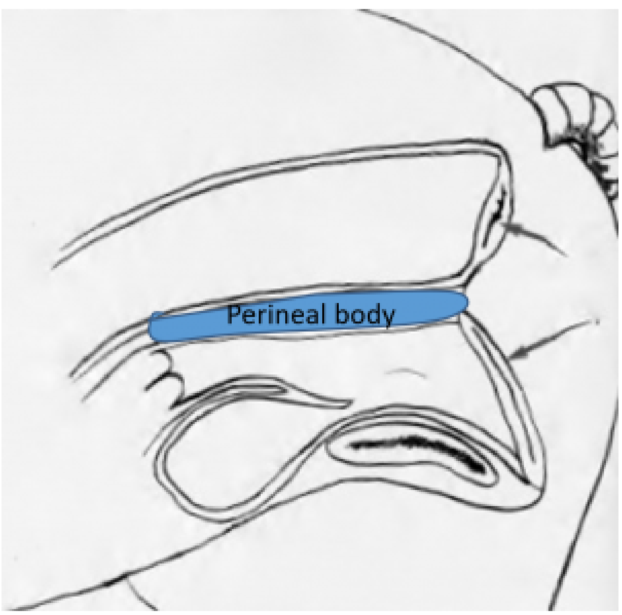
How to - Perineal body reconstruction

Indications

The perineal body is reconstructed when it is weakened by trauma or torn with parturition. A Caslick’s is often sufficient for reconstructing the region; however, if pneumovagina continues, perineal body reconstruction may be required.

Relevant anatomy

The perineal body is a muscular structure dorsal to the vagina and ventral to the rectum. It provides support to the vestibular seal, the second barrier to the uterus as well as to the vulvar lips.



Due to its location, it is easily traumatized during parturition.

At the time of injury, tissues are very friable and undergoing more necrosis. Surgery should be postponed until the area is well healed.

Preoperative management

Food restrictions: NA

NSAIDs/analgesics: Preoperative NSAIDs are recommended

Antibiotics: Preoperative antibiotics are recommended.

Tetanus prophylaxis is recommended.

Local blocks: Local infiltration or epidural

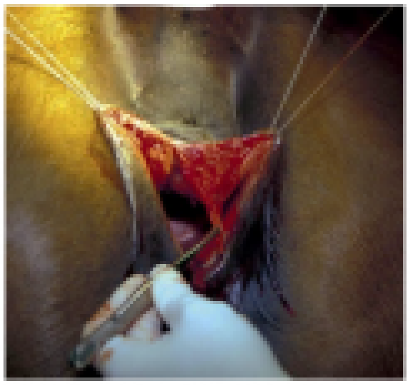
Position/preparation: Repair at the time of injury is unrewarding as most will dehisce. Repair should wait until the area has developed fibrous tissue, at least 3-4 weeks. The procedure is done standing with the patient sedated as needed. Surgeon should be gloved.

Surgery Supplies:

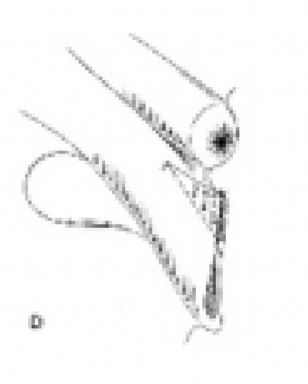
- Scalpel and handle
- Metzenbaum scissors
- Thumb forceps
- Needle holders
- Suture scissors
- 2-0 to 3-0 absorbable suture, taper needle
- 2-0 suture, cutting needle (Caslick's)

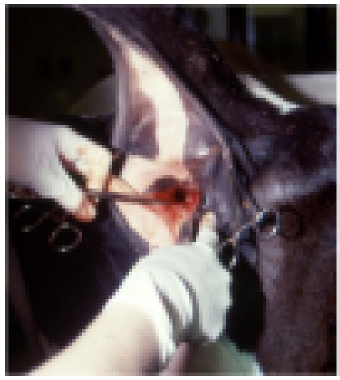
Surgical procedure

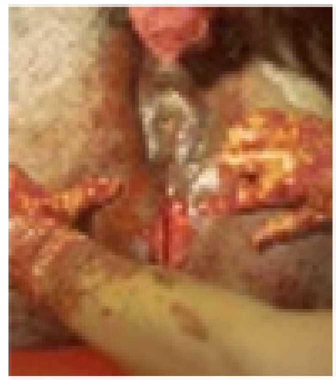
Stay sutures are held by an assistant or clamped to the perineum to provide exposure. The healed epithelial tissue is dissected off the surface, creating fresh edges in a roughly triangular pattern, extending the depth of the tear.



Once the edges are freshened, the two sides are apposed starting the in deeper tissues and using any pattern. Often cruciates are most useful







The most superficial layer is closed as for a Caslicks (continuous split thickness pattern) or with an interdermal pattern.

Postoperative care

- Keep the area clean and dry.
- Suture removal if needed in 10-14 days

Complications

The perineal body will not be as strong or as flexible as it was originally; this may lead to tears with parturition.

Videos

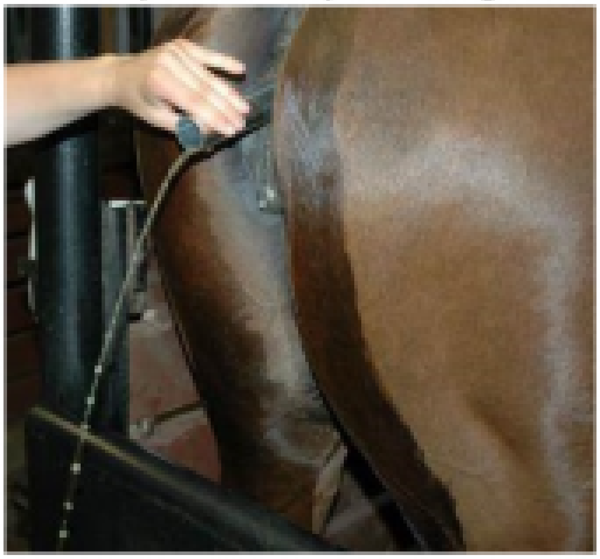
Resources

Vulva, vestibule, vagina and cervix, Equine Surgery

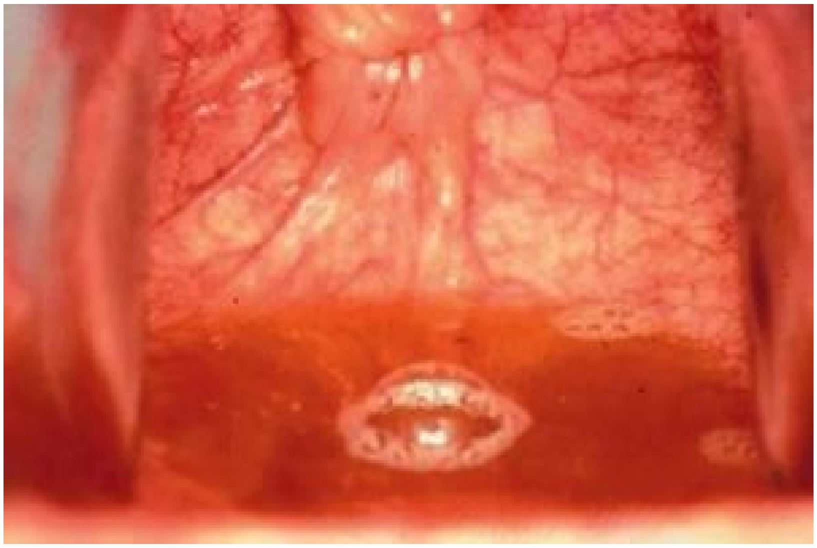
Surgery of the Bovine Reproductive System and Urinary Tract, Farm Animal Surgery 2nd edition

Urine pooling, perineal body transection and urethral extension

Mares (or cows) with poor conformation, particularly splanchnoptosis, can develop urine pooling due to a tilt in the vaginal vault



Vulvar tilt and evidence of urine pooling



view of urine inside the vagina (cervix at 12:00)

Urine is highly irritating and can create further vaginitis and/or enter the uterus. Urine in the uterus causes fibrosis and leads to infertility.

Treatment

Since vaginitis can lead to urine pooling, the first treatment is typically a Caslicks. *This is a bad idea if the vulva is severely tilted and mostly above the pelvic brim.*

If problems persist, the **perineal body can be transected** (Pouret's procedure), removing the traction from the viscera. This is a simple procedure performed with an epidural or line block. The tissue is transected until the vulva is again vertical. This is reflected internally as a flatter vaginal vault. While the article below describes closure, these usually do well when left to heal by second intention.

[Equine Perineal and Vulvar Conformation Correction Using a Modification of Pouret's Technique]

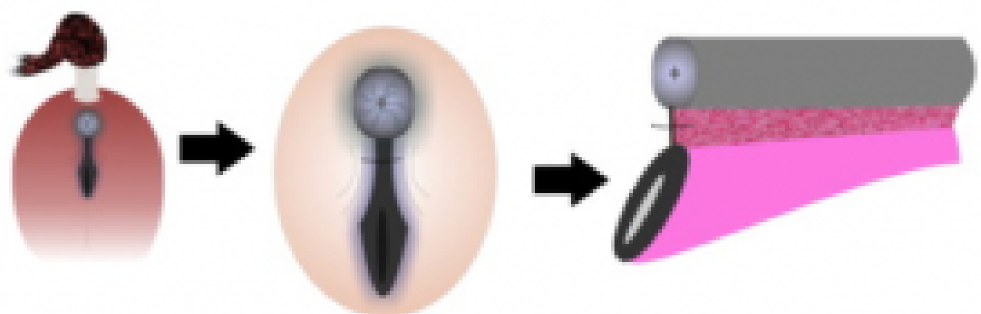


Fig. 1. Note the abnormal vulvar conformation before surgery, with the vulvar labia partially opened and the horizontal skin incision of 3-4 cm, which was made half way between the anus and the upper commissure of the vulva.

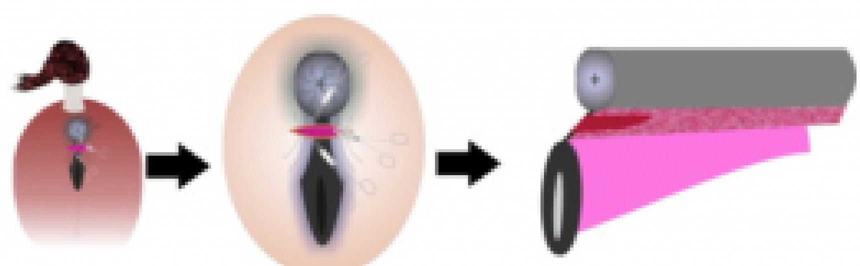
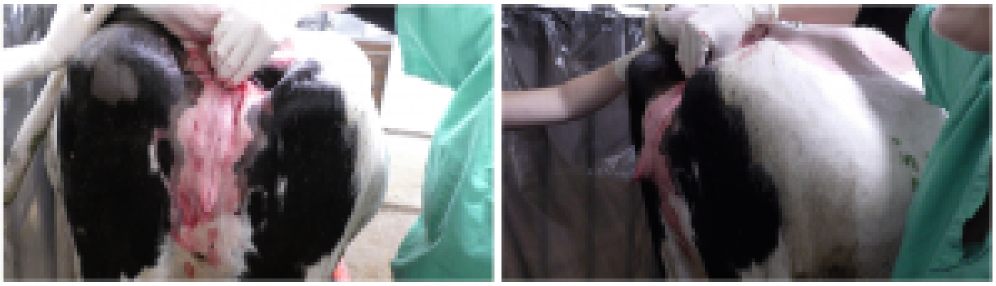


Fig. 2. Horizontal skin incision of 3-4 cm between the anus and the upper commissure of the vulva and the 10-cm-deep internal perineum divulsion with ligaments and internal muscle dissection, with just the vaginal mucosa and submucosa remaining. After divulsion, the vulva turns back to its normal anatomic position.

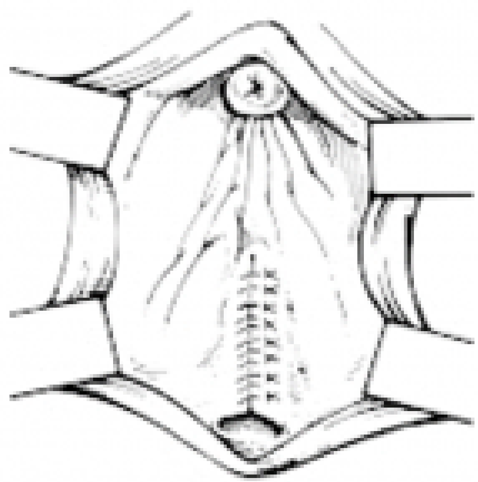


Prior to perineal body transection

After perineal body transection

If perineal body transection is not sufficient, the urethra tunnel can be extended so that urine is released close to the vulvar lips, giving minimal opportunity to flow back toward the cervix. Both procedures can also be done at the same time.

Perineal body transection



Urethral extension

Key Takeaways

To fix urine pooling:

- Perform Caslicks if slope isn't too severe
- Perform perineal body transection if splanchnoptosis

- Perform urethral extension if still not fixed

Resources

Perineal body transection video- youtube

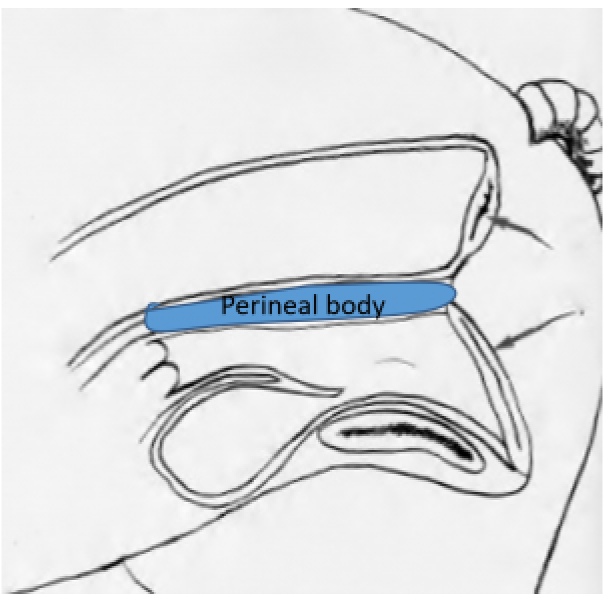
How to - Perineal body transection

Indications

Perineal body transection is performed for severe splanchnoptosis and for mild cases of urine pooling.

Relevant anatomy

The perineal body is located between the dorsal vagina and the rectal floor. It is comprised of sphincter muscles that create tone for the vestibule, help maintain the vestibular sphincter, and also connects the vaginal vault to the rectum and viscera (this isn't always helpful).



Preoperative management

Food restrictions: NA

NSAIDs/analgesics: Preoperative NSAID recommended

Antibiotics: NA

Tetanus prophylaxis is recommended.

Local blocks: Line block or epidural

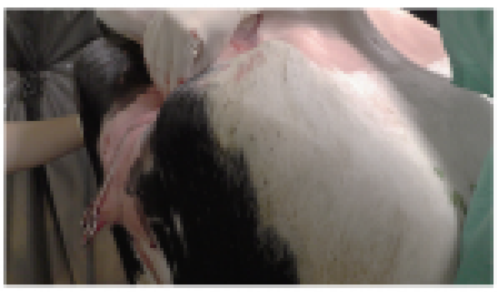
Position/preparation: Standing procedure. The rectum should be emptied prior to surgery. The area is cleaned and blocked. Surgeon should be gloved.

Surgery Supplies:

- Scalpel blade and handle
- Towel clamps

Surgical procedure

A towel clamp is hung on the dorsal aspect of the vulva. A 4-6 cm inverted U incision is made between the rectum and vagina. Sharp scalpel dissection is carried forward until the vulva is vertical. Slight additional dissection may be helpful to minimize the effect of scar tissue formation during healing.

The towel clamp is removed and the area left open for second intention healing.

Postoperative care

- Clean the wound daily until epithelialized.

Complications

- Very extensive dissection could enter the peritoneal cavity but this would be difficult as the peritoneal reflection is approximately 12″ deep

Videos

Perineal body transection

Resources

How to - Urethral extension

Indications

Urethral extension is indicated for urine pooling that does not respond to Caslicks and/or perineal body transection. There are multiple techniques.

Relevant anatomy

The urethra opens on the floor of the vaginal, approximately 6″ from the vulvar lips. The floor of the vagina is used to create a new tunnel.

Preoperative management

Food restrictions:NA

NSAIDs/analgesics:NSAIDs are recommended preoperatively.

Antibiotics: Antibiotics are generally considered optional. If used, trimethoprim sulfa is fine in horses. Ceftiofur or penicillin could be used in cattle.

Tetanus prophylaxis is recommended in horses

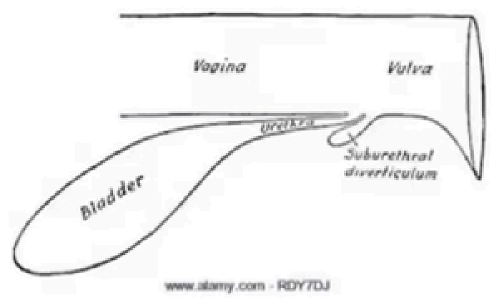
Local blocks: Epidural +/- splash block

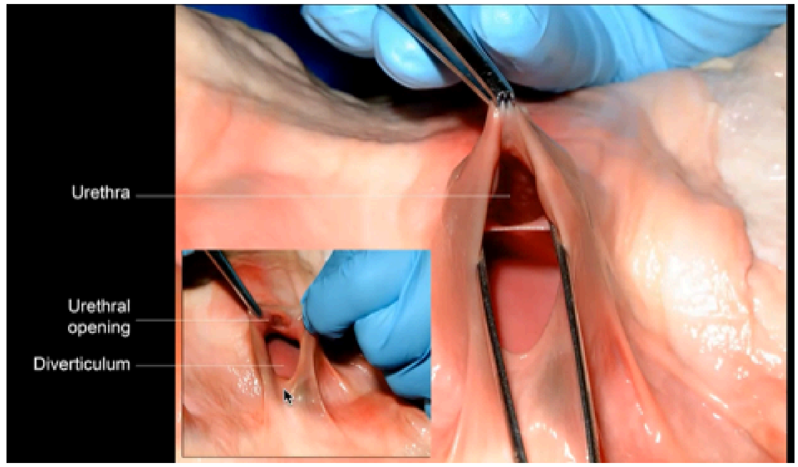
Position/preparation:

The patient is restrained in a standing position and sedated as needed. The surgeon wears sterile gloves and uses sterile gel lubrication to ease manipulation within the vagina.

The tail is tied to the side, the rectum is emptied and the perineal area cleaned.

Pass a urinary catheter or foley into the urethra. The bovine urethral opening is tightly closed unless the cow has just urinated. The opening is approximately wrist deep, just past the blind urethral diverticulum. The tissue just beyond the diverticulum is actually two layers and is the opening of the urethra. Sometimes a urethra papilla can be palpated on the floor. Push forward and down over the papilla.





www.alarmy.com and unknown but very useful source. The bladder opening is not this evident in the live animal

One suggestion – pass your finger and the catheter into the fold. Lift up and keep pushing the catheter forward. Can also try flipping so the catheter is on top. Alternate- pass your finger into the diverticulum to block it.

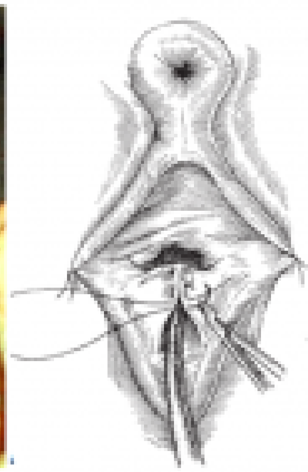
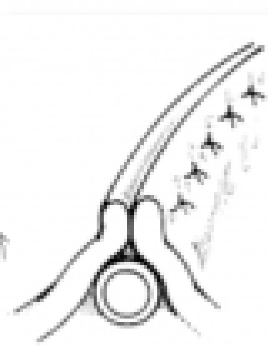
Surgery Supplies:

- Urinary catheter
- Scalpel and scalpel handle
- 0 suture, taper needle
- 2-0 suture, taper needle
- Needle holders

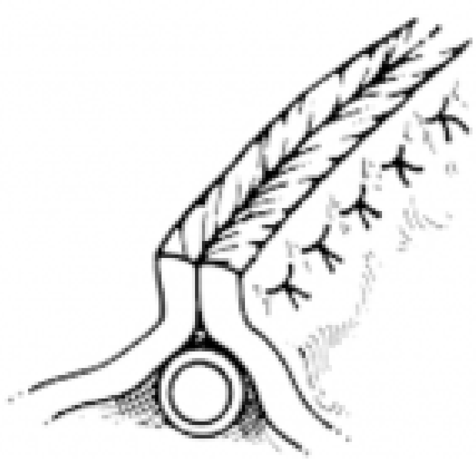
- Metzenbaum scissors
- Suture scissors
- Speculum or stay sutures
- Headlamp
- Allis tissue forceps – optional
- New methylene blue -optional

Surgical procedure – Shires & Kaneps

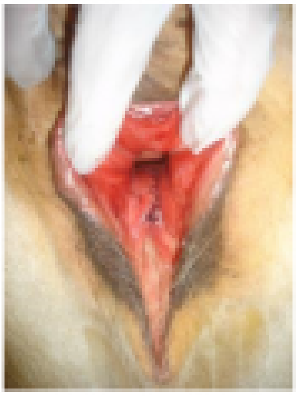
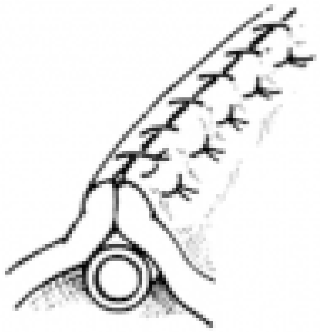
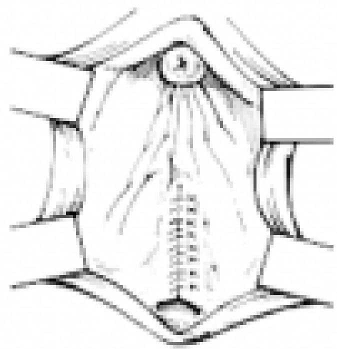
The vaginal vault is held open by stay sutures on the vulvar lips or use of a speculum. The floor of the vagina is loosely tacked up over the catheter using 2-3 horizontal mattress sutures of 0 suture material. The goal of this step is to hold the tissue in place; a water tight seal is not needed. Leave the suture ends long in case removal is needed.

The top edges of the tented tissue is transected using Metzenbaum scissors. This creates a fresh edge.

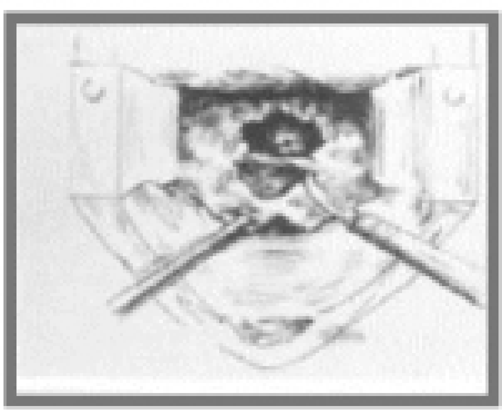
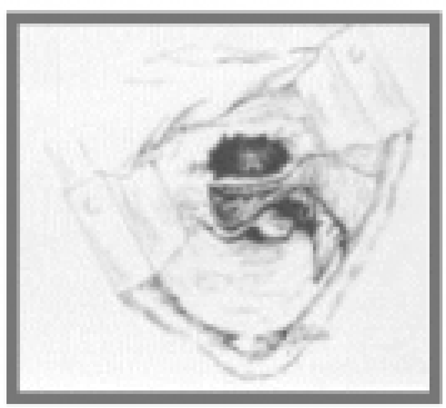
The fresh edges are apposed using a simple continuous pattern with 2-0 absorbable suture material.

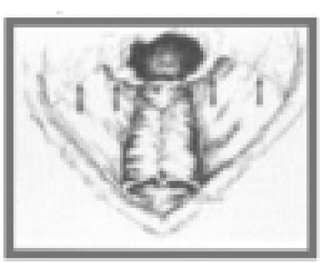
The catheter is removed. If the tunnel is tight, the horizontal mattress sutures can be cut free.

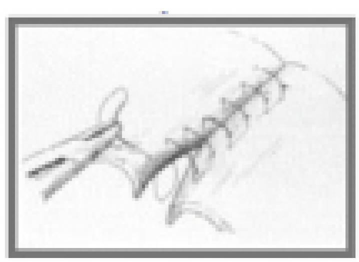
Surgical procedure – McKinnon & Vasey

After gaining exposure of the vaginal vault, the transverse fold is grasped with Allis tissue forceps, retracted caudally and split into dorsal and ventral shelves using scalpel dissection horizontally across the fold. The dissection is continued on the vaginal walls, creating a flap of tissue on either side. Each flap should extend to the vulvar labia. The dissection is continued until both flaps can reach past the midline without tension. It can be challenging to determine where the dissection is complete due to the bleeding involved. Sterile new methylene blue dye can be used to aid in visualization of what is already dissected as the dye sticks only to the submucosal tissues.

The three flaps are opposed using a Connell pattern (full thickness Cushing).





Additional variations on this technique exist, including further dissection of the transverse fold so that the top layer can be pulled forward and cover the sutured Y part of the repair.

©2009 The University of Tennessee

Postoperative care

- NSAIDs should be continued for 3 days
- The patient should be monitored to ensure she can urinate without difficulty

Complications

- Fistula formation is relatively common. Depending on the size of the fistula, repair may not be necessary

Videos

Resources

Shires and Kaneps, A practical and simple surgical technique for repair of urine pooling in the mare, AAEP circa 1989

Hooper and Taylor, Urinary Surgery. VCNA 1995, Vol.11(1), pp.95-121 – alternative technique pg 117-118

Rectovaginal lacerations

Rectovaginal tears generally occur with parturition and cause different levels of injury

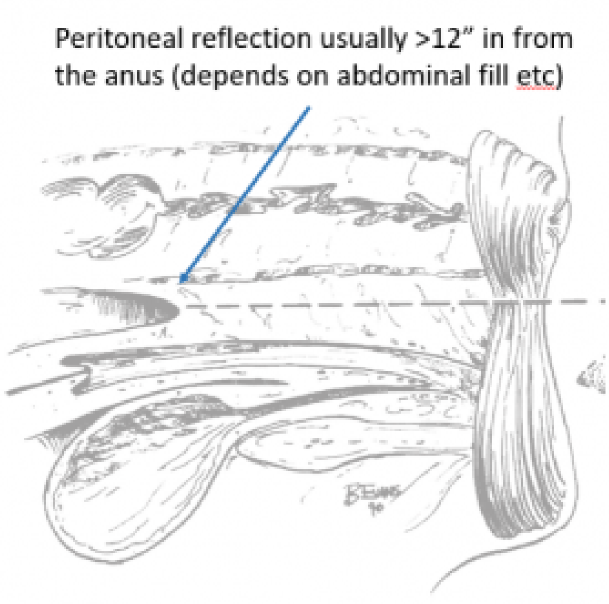
- injury to the vulva only (type I)
- injury to the vulva and perineal body (type II)
- injury to the roof of the vagina (perineal body included) and floor of the rectum (type III)

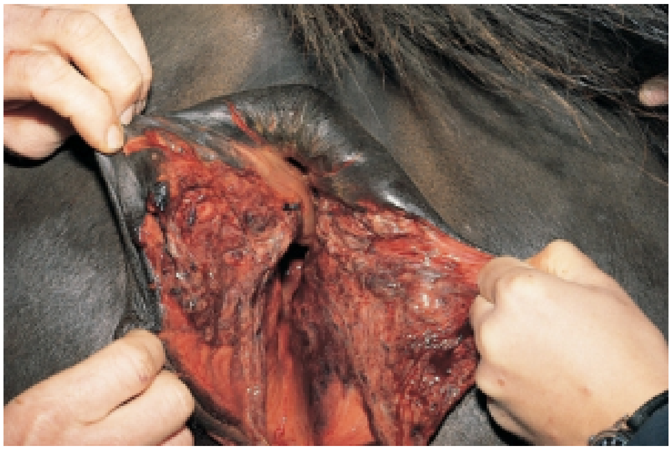
Therapy

Type I tears are treated by Caslick's procedure.

Type II tears are treated by perineal body reconstruction and Caslick's procedure.

Type III tears are treated by reconstruction of the two tubes (vagina and rectum) plus perineal body reconstruction and Caslicks. This is typically a referral procedure although it can be performed in the field by an experienced surgeon. The laceration does NOT extend into the peritoneal cavity in most situations.





acute injury

ready for repair

For initial care, animals generally require NSAIDs and often antibiotic therapy due to local tissue damage. For cattle, this is typically flunixin meglumine and ceftiofur or similar antibiotic. For horses, this is typically either flunixin meglumine or phenylbutazone and trimethoprim sulfa.

Due to the amount of tissue trauma, it is pointless to repair these at the time they occur. The high degree of blunt trauma results in continued tissue deterioration and any sutures placed will dehisce in 2-3 days. Granulation tissue develops in 5 days and is mostly vessels. Granulation tissue does not hold suture. While the vulva and perineal body can often be repaired at 2-4 weeks, type III tear repair requires fibrous tissue formation and should be delayed until 4-6 weeks after injury.

Type III tears are challenging to repair due to the high bacteria levels in the rectum and vagina, presence of collagenase producing bacteria in the feces, and, in horses, firm fecal balls. Mares should be on a laxative diet and have soft feces prior to repair. If the foal is alive and nursing, repair should be delayed until after the foal is weaned. It is unreasonable a mare to produce enough milk on the adjusted diet. Cattle usually have soft feces so dietary change is not needed.

Prognosis is actually very good with appropriate repair. While the vagina does get contaminated until the tear is fixed, it can rapidly clear the inflammation during the next heat cycle. The rectum and vagina typically heal quickly. The biggest issue is fistula formation due to tension on the repair. Second repair attempts are common.

Resources

Urogenital surgery with the mare standing, VCNA 2014 -details at the end of the article; just if interested

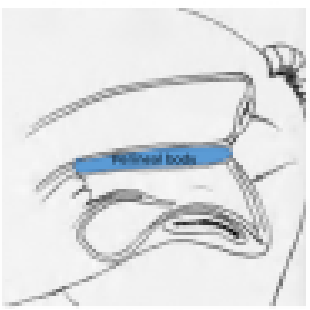
How to - 3rd degree rectovaginal tear repair

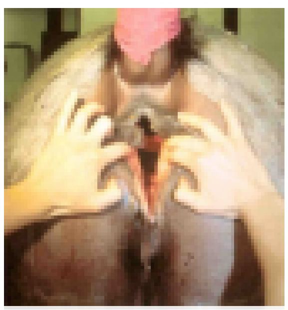
Indications

3rd degree tears are the result of dystocia. The baby splits the roof the vagina, the perineal body and the floor of the rectum. This creates two tubes that do not extend the normal distance.

Relevant anatomy

The trauma creates two tubes that do not extend the normal distance. Neither tube has a sphincter (no anal sphincter, no vulvar lips).






Preoperative management

Food restrictions: Mares should be on a low bulk diet – mostly grass and easily digestible feedstuffs. No hay. No dietary change is needed for most cattle due to the softer feces.

NSAIDs/analgesics: Perioperative NSAIDs are recommended.

Antibiotics: Perioperative antibiotics are needed.

Tetanus prophylaxis is recommended for horses

Local blocks: Epidural

Position/preparation: This is an advanced procedure; the surgeon should have advanced skills and a hospital environment is best. The procedure is done at least 3-4 weeks after the injury to allow fibrous tissue formation. The patient is standing and the surgeon is gloved.

Surgery Supplies:

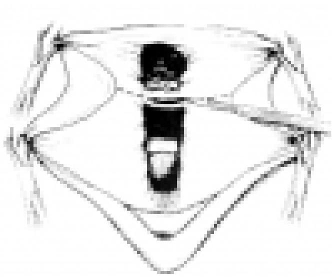
- Standard surgery pack
- Headlamp
- Retractor suture or speculum
- 3-0 absorbable suture, taper needle
- 2-0 absorbable suture, taper needle
- 2-0 suture, cutting needle (Caslicks)
- headlamp

Surgical procedure

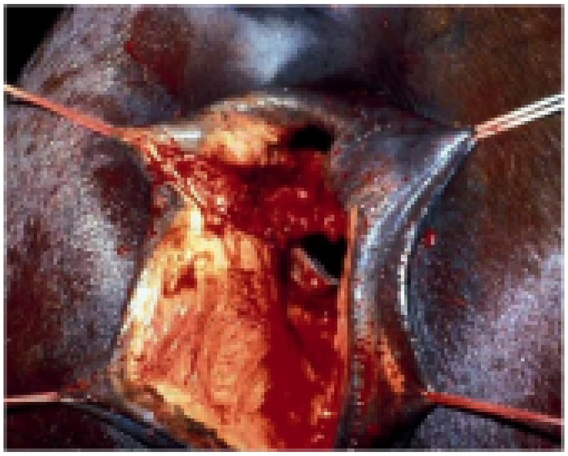
The goal of the surgery is to recreate the anal tube, the vaginal tube, the perineal body and some version of sphincter for each.

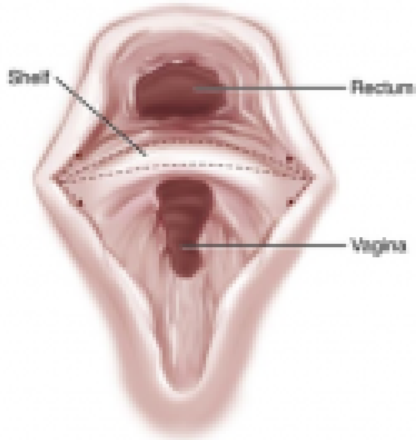
Create anal tube and vaginal tube

The shelf between the rectum and vagina is split horizontally, keeping the rectal side thicker than the vaginal side.

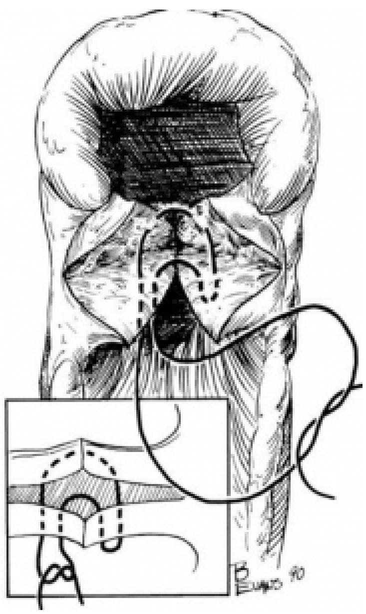




The incision is continued along both walls to the external mucocutanous junction. The wall dissections are undermined up the wall of the rectum and down the wall of the vagina to create two shelves that easily pass the midline.



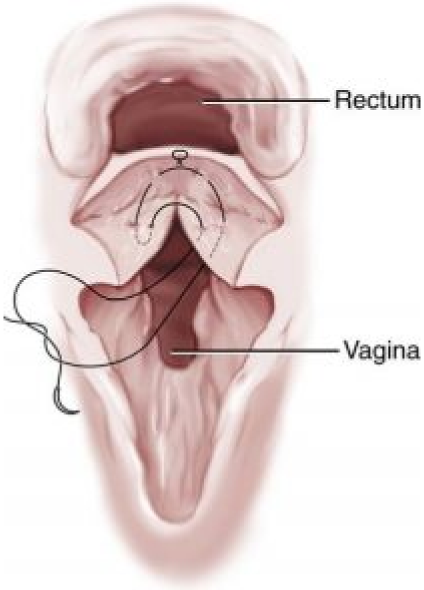


Once the shelves are created, they are apposed in three layers – the floor of the rectum, the perineal body, and the roof of the vagina. This can be done in a 6 bite technique all at once or in steps individually.



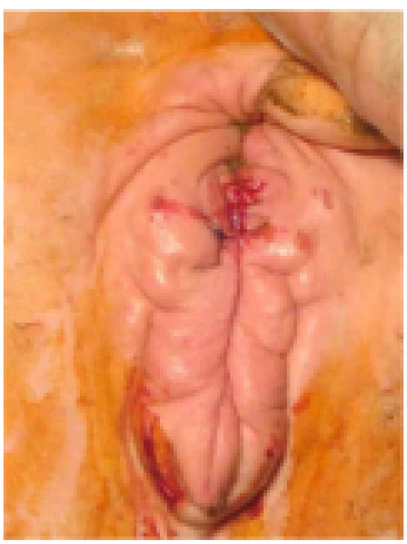
Auer, Equine Surgery

For the individual layers, 2 or 3 suture lines are run in tandem. One line closes the rectal floor using a simple continuous pattern. The perineal body and vaginal roof can be closed individually or in combination. A few bites are taken with one strand of suture, then a few bites with the other. The strands are alternated until the tube reach the level of the perineal body, approximately 1-2″ from the skin.



Auer, Equine Surgery

Once that level is reached, it is followed by perineal body reconstruction and a Caslicks.



Postoperative care

- Soft feces are maintained until recheck. The incision lines can be checked in 7-10 days for any fistulas needing further repair.

Complications

Fistula formation is common, particularly with insufficient undermining of shelves and firmer feces.

Videos

Resources

Vulva, vestibule, vagina and cervix, Equine Surgery

Vaginal prolapses

Vaginal prolapses are not uncommon in food and fiber species, being most predominant in late gestation cattle, sheep and pigs. Older animals are more commonly affected. Prolapses are occasionally seen in beef heifers and at other stages of gestation.

Besides pregnancy, other risk factors include coughing, obesity, hormonal changes (including estrogenic feeds), trauma, short tail docks (sheep) and previous vaginal prolapses. Poor quality roughage and severe cold weather have been implicated. Breed predispositions occur with Herefords, Shorthorn cattle and llamas. Bos indicus breeds are more prone to a variant involving cervical prolapse.

Differentials include rectal and uterine prolapses. Uterine prolapses are covered with caruncles ("bread loaf" appearance). Animals may develop secondary prolapses (eg rectal prolapse from straining due to a vaginal prolapse).

Recurrence of vaginal prolapses is common.

Vaginal prolapses do not lead to uterine prolapses.

Therapy

The 3 R's apply to fixing vaginal prolapses:

- Replace
- Retain
- [Prevent] recurrence

In the middle of that we try to deliver a live neonate.

Epidural anesthesia is indicated. Pudendal nerve block may help.

If prolapsed tissue isn't damaged, osmotic agents (hypertonic saline, hypertonic dextrose*) are used to reduce swelling and return the tissue to its normal position. The bladder is sometimes involved; emptying it can help with replacement (lift prolapse toward anus).

*we can create a sugar or sugar paste, as well, but there is some concern that sugar and salt granules can directly damage the mucosa.

If the tissue is damaged or the swelling just won't go back in, we can perform surgery to remove the damaged area, using either mucosal resection/anastomosis or a complete amputation and anastomosis.

Retention can be via:

- closing the vulva lips and preventing anything from extruding
- creating scar tissue to hold the vagina in position (pexy)
- removing the vaginal tissue to minimize the amount that can prolapse

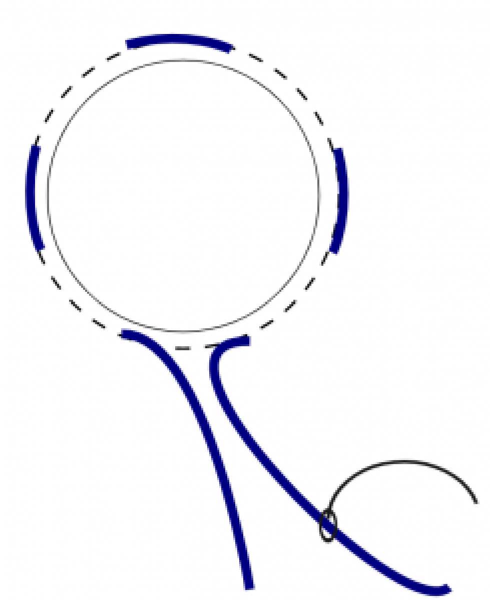
As the animals are often pregnant, it is necessary to choose a technique that will not cause delivery issues. This can vary depending upon accuracy of due dates and level of calving supervision (see notes in the techniques listed below).

Standing sedation (if needed) and local anesthetic blocks are effective for these procedures. A pudendal nerve block can help with relaxing the vagina as well as providing analgesia if pexy techniques are performed (see page 22 in the linked reference).

Sheep are often treated with a commercial retention device, rather than surgery.

Buhner stitch

The Buhner stitch is basically a "purse string suture" around the vulva, designed to hold everything in place.



A large Buhner needle is used to place umbilical tape deeply around the vulva. This is tightened until only 1-2 fingers can fit into the vulva. The umbilical tape must be removed prior to parturition or delivery will result in trauma to mom and baby. Cattle do develop signs of impending parturition that can be used as markers (milk in the udder, relaxed tail head, etc) to tell the manager when to remove the Buhner stitch. [This would not be a good option for a beef cow that calves unsupervised on pasture.]

Variations of the Buhner include horizontal mattress sutures (easier to put in but less physiological in the type of closure) and bootlace patterns (suture loops on each side of the vulva are placed for umbilical tape to be threaded through; this variant can be opened and reclosed without surgery but is not as strong).

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Minchev Pexy

The Minchev procedure creates an adhesion between the vagina and the sacrosciatic ligament (in the pelvis) to prevent prolapse. This technique keeps the vagina open and does not need to be removed for delivery. It is important to avoid the rectum when performing the pexy. Typically we place two sutures to distribute forces. The sutures should be on the same side to avoid squeezing the rectum between them. “Buttons” are used to distribute pressure; without such stents the suture tends to cut through the tissue. Sutures are left in place until after calving.

A Minchev can be challenging if the tissue is very swollen. If you can get the prolapse back where it belongs, the swelling goes down. It may help to place a Buhner stitch initially and then replace it with a Minchev pexy the following day.

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Cervicopexy

Since the prolapse typically originates from the floor of the vagina just in front of the cervix, that would be an ideal location for a pexy. However, there is a large artery in the area that makes doing a blind pexy too dangerous. The ideal cervicopexy procedure actually involves a flank approach as well as a vaginal approach. One surgeon inserts the needle vaginally, pushing it into the abdomen. The second surgeon, working through the flank incision, grabs the needle, passes it through the prepubic tendon and then back vaginally to the first surgeon.

The procedure is easier if the cow is off feed and if pneumovagina is created manually.

Note: it is common to get a rectal prolapse after vaginal prolapse and vice versa. Consider pursestringing both holes if straining is likely to continue

Primary Resources

Cervical and vaginal prolapses, Merck manual

Prolapse section, Veterinary Care of Sheep and Goats textbook

Goat vaginal and uterine prolapses, Vet Folio 2019

Secondary Resources

Management of uterine and vaginal prolapse in the bovine, VCNA 2008 – pp 214-end. Note : While this article says vaginal prolapses can be either pre or postpartum, the majority are prepartum unless the cow is on hormones for superovulation. The chapter is more useful for uterine prolapses.

The purse string suture, Aneskey

cervicopexy notes from ACVS, 2016

Bovine Prolapse surgeries

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How to - Buhner stitch

Indications

A Buhner stitch is used for vaginal prolapse retention. It can be used short term until a more permanent procedure can be performed in beef cattle and embryo flush cows or can be used as the primary control method in dairy cattle with monitored calving.

Relevant anatomy

The Buhner stitch is placed deeply around the vulva, exiting the perineal body dorsally and the subcutaneous tissues ventrally.

Preoperative management

Food restrictions: NA

NSAIDs/analgesics: NSAIDs are recommended.

Antibiotics:NA

Local blocks: Epidural or pudendal nerve block

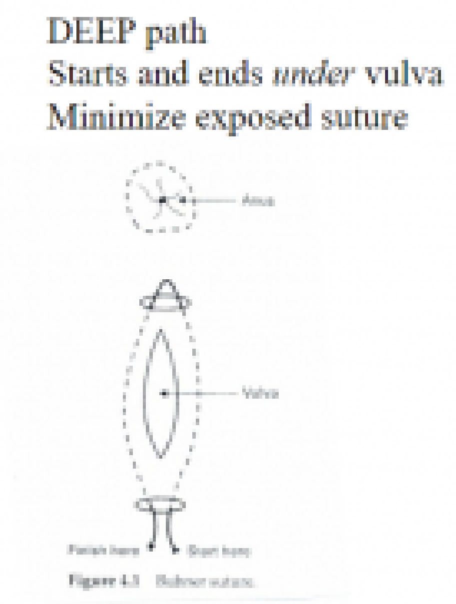
Position/preparation: The cow is restrained in a standing position. Sedation is not usually required

Surgery Supplies:

- Buhner needle
- Scalpel blade
- Umbilical tape

Surgical procedure

A 1cm full thickness skin incision is made just below the vulva at the 5:00 position. The Buhner needle is inserted in this incision and directed upwards. The vulvar skin is manipulated on the Buhner needle until the needle exits dorsally above the vulva and below the anus. A 1 cm skin incision can be made horizontally above the vulva to make it easier to exit the needle. Once the needle is exteriorized, umbilical tape is threaded through the opening in the needle. The needle and tape are pulled ventrally so that one end of the tape exits the original incision. A long strand is left exiting from the dorsal incision.



The procedure is repeated on the opposite site starting with a 1cm incision at 7:00 and exiting out the same dorsal incision. The dorsal free end of the umbilical tape is threaded through the needle and pulled down through the ventral incision.

The two strands of umbilical tape are tied in a bow, tightly enough to keep the prolapse inside the vagina but loosely enough to allow urination. Having separate ventral incisions makes it easier to remove the umbilical tape when needed (it stays superficial in this area).

NEW: tie at 3pm vs 6pm to make more visible and remind everyone it is there

Postoperative care

- The tape must be removed prior to parturition.

Complications

- Localized infection (and odor) will develop
- Trauma to dam and baby if the tape is in place during parturition

Videos

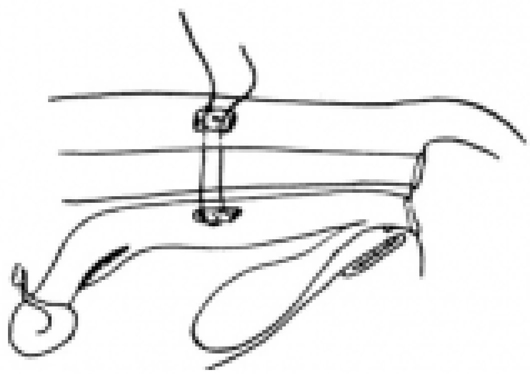
One or more interactive elements has been excluded from this version of the text. You can view them online here: https://open.lib.umn.edu/largeanimalsurgery/?p=3297#oembed-1

Resources

How to - Minchev pexy

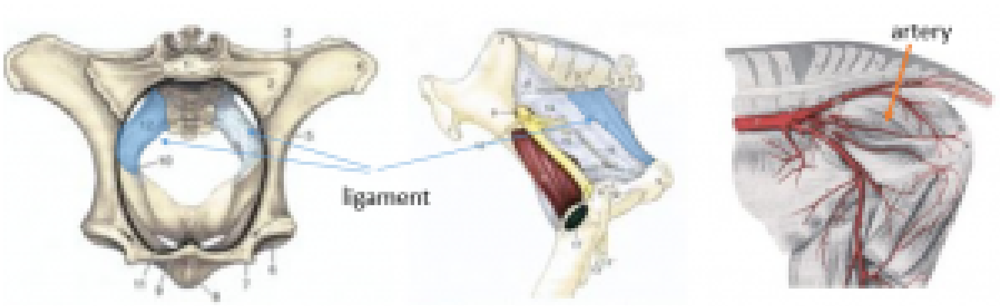
Indications

The Minchev technique is used for retention of vaginal prolapses particularly when animals will not be observed for parturition and when continued retention is likely (eg embryo flush cows).



Relevant anatomy

The suture is passed from the vaginal vault through the sacrosciatic ligament. The rectum and internal iliac artery should be avoided. The artery runs horizontally across the pelvis and the pulse is palpable.



Preoperative management

Food restrictions: NA

NSAIDs/analgesics: Perioperative NSAIDs are recommended.

Antibiotics: Preoperative antibiotics are recommended.

Local blocks: Epidural, pudendal and/or line block

Position/preparation: The patient is restrained standing. The surgeon is gloved. The vagina is cleaned as is the skin over the gluteal muscles. An assistant with a rectal sleeve can be used to move the rectum out of the line of fire.

Surgery Supplies:

- Straight needle (strong, at least 3″ long), Buhner needle or Minchev kit

- Umbilical tape or large nonabsorbable suture
- Buttons, inserts from ligapak, gauze rolls or stents
- Gauze (padding for glove) or thimble- optional

Surgical procedure

The surgeon palpates vaginally to find the internal iliac artery and determine placement of two buttons. These should be placed as close to the cervix as possible. The surgeon can push on the vaginal wall and see the exit site on the outside of the cow.

The prolapse device or Buhner needle are inserted vaginally and exited out the vaginal wall at 1-2:00, avoiding the artery. Manipulation is minimal due to the size of the instruments. The prolapse device has a locking pin and buttons. It is self-retaining after the stylet is removed and the pin inserted.

Buhner needle

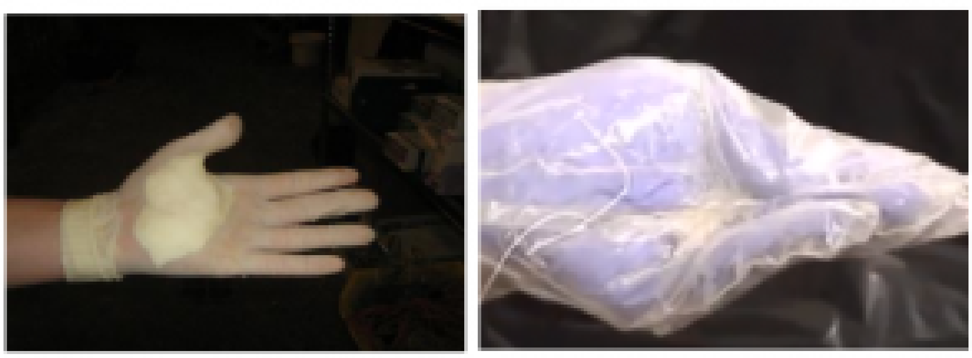
Once the Buhner needle is exited, umbilical tape is threaded through it and it pulled back into the vagina, bringing the tape through. The procedure is repeated to create a horizontal mattress. The tape is threaded through a stent, button or around gauze both externally and internally to prevent suture pull through.

A second pexy is repeated on the same side to strengthen the adhesion without constricting the rectum.

Straight needle

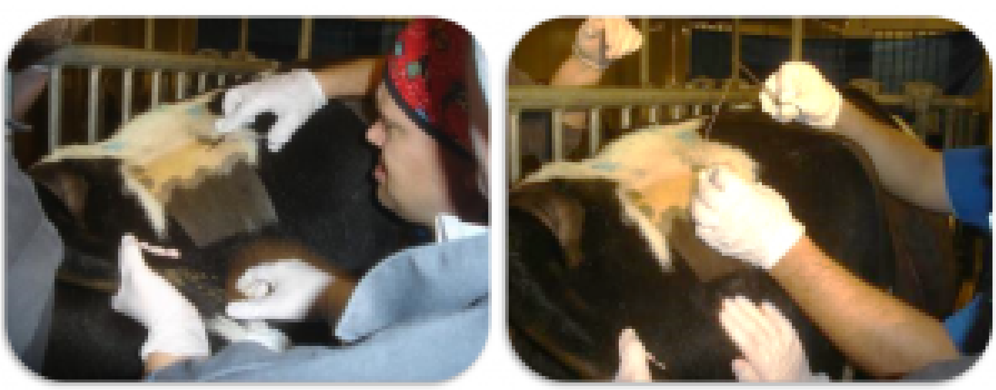
With the straight needle, a long piece of suture is threaded on the needle. The needle is inserted into the vaginal wall at the desired location.

Minchev exit points



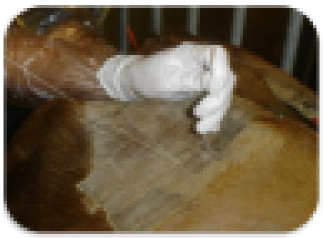
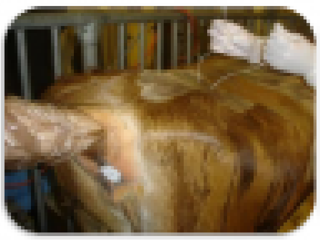
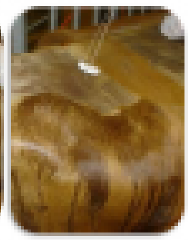
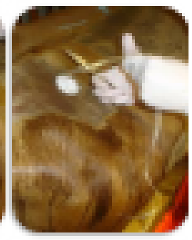
Padded glove and glove+ sterile sleeve+ lube holding needling

The surgeon pushes the needle through (a thimble inside the glove or a gauze padded palm make this less painful) and an assistant grabs it as it exits.



One strand of the suture is pulled to the outside and held. The internal strand is threaded through a button or stent and the needle replaced on that strand. The procedure is repeated close to the first puncture.


Both ends are tied over a second button externally.

A second pexy is repeated on the same side to strengthen the adhesion without constricting the rectum.

Rectal palpation should be used to verify no suture has entered the lumen.

Postoperative care

- Sutures should be left in place through parturition or at least for 3 weeks if the animal is not pregnant.

Complications

Infection is common but rarely leads to an abscess. Suture that enters the lumen of the rectum should be removed.

Prolapse is still possible, particularly if the pexy isn't far enough cranial, if the sutures tear out or if just bad luck.

Videos

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Resources

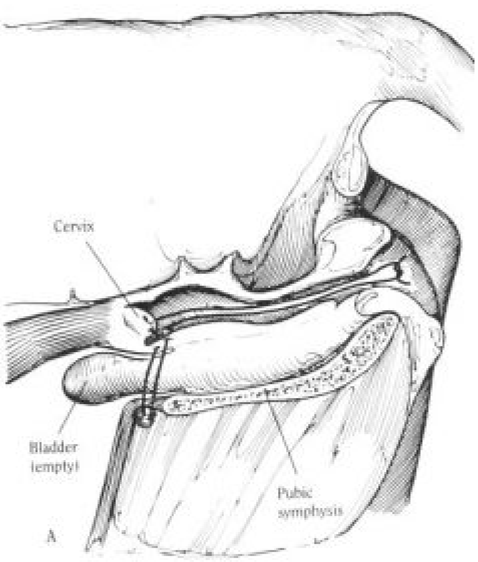
How to - Cervicopexy

Indications

Cervicopexy is indicated for valuable cattle with recurrent vaginal prolapses. It is fairly complex so is generally used for prolapses not responding to other therapies.

Relevant anatomy

The floor of the vagina is sutured to the prepubic tendon, avoiding the artery and the bladder.



Preoperative management

Food restrictions: Animals should be held off feed for at least 24 hours to decrease abdominal fill.

NSAIDs/analgesics: Perioperative NSAIDs are recommended

Antibiotics: Preoperative antibiotics are recommended.

Local blocks: Epidural and local blocks

Position/preparation: The animal is restrained in a standing position. The surgeon working vaginally is gloved. A second surgeon should be ready for abdominal surgery. Place a rigid catheter into the bladder.

Surgery Supplies:

- Standard surgery pack
- Bent needle – S needle bent into backwards C with the lower leg shorter than the upper bit

how to bend an S needle for easier cervicopexy

- 3 Vetafil approximately 12 feet long

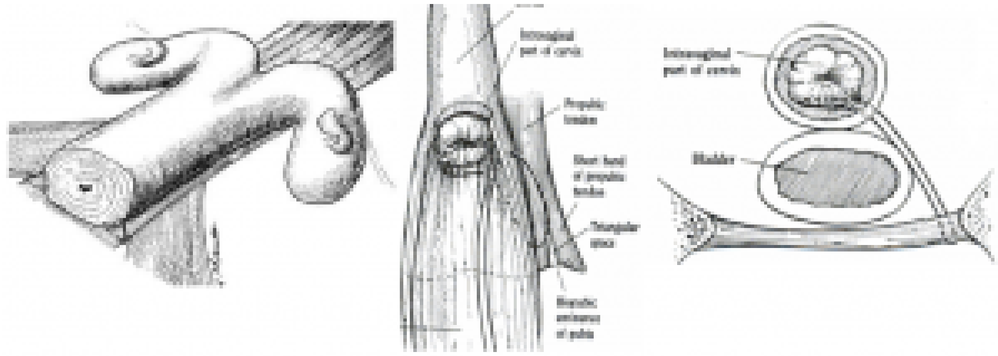
Surgical procedure

This procedure uses on surgeon in the vagina and one working through the right flank.

The surgeon in the vagina introduces the curved needle through the vaginal floor, just off midline in the fornix. The needle is pushed into the peritoneal cavity.

The surgeon in the peritoneal cavity takes the needle, passes it through the prepubic tendon and pushes it back into the vagina on the opposite of midline.

The first surgeon passes the needle through the ventral aspect of the cervix (not into the lumen) and ties the ends. The cervix is pulled down as tightly as possible.



The surgeon in the flank incision verifies nothing is caught on the abdominal side and then closes the incision.

Colpotomy version

The procedure can be performed by one surgeon if a colpotomy incision is made in the vagina to allow access to the peritoneal cavity. Risk of contamination is greater as is the risk of evisceration if the animal continues straining.

Postoperative care

- Antibiotics and NSAIDs are continued for 3 days.
- Monitor for vaginal discharge
- The suture should be considered permanent.

Complications

Contamination of the procedure may lead to persistent drainage and/or peritonitis and require suture removal.

The procedure can be challenging in obese cattle.

Videos

Resources

Ovariectomy

Ovariectomy is performed to remove abnormal ovaries, for uterus unicornus (stop ovulation on the side with the missing horn), to improve production in feedlots and to allow shipment of cattle from TB regions.

Ovariectomy can be done transvaginally through a colpotomy incision or via the flank.

Special instruments exist to assist heifer spaying. An ecraseur is effective in older animals but requires a flank incision or larger colpotomy.

How to - Colpotomy

Indications

Colpotomy is useful for access to the peritoneal cavity for ovariectomy, mummy removal and cervicopexy.

Relevant anatomy

The peritoneal cavity is entered at 2:00 or 10:00 from the vaginal fornix. This avoids the rectum (12:00), bladder (6:00) and iliac arteries (3:00 and 9:00). The upper incisions also decrease the risk of evisceration.

Preoperative management

Food restrictions: Hold patients off feed for 24 hours to minimize abdominal fill.

NSAIDs/analgesics: Perioperative NSAIDs are recommended.

Antibiotics: Perioperative antibiotics are recommended as it is a contaminated procedure.

Local blocks: Epidural and splash block

Position/preparation: The patient is restrained standing. Sedation is recommended.

Surgery Supplies:

- Colpotomy spear – scissors, ovariectomy device, ring blade or scalpel

Surgical procedure

After the vaginal is cleansed, the surgeon punctures the wall of the vagina and the peritoneum. This should be done quickly and relatively forcefully or the peritoneum will be pushed away rather than punctured. As the peritoneum is hard to block, this portion of the procedure can be painful.

The incision is made at 2:00 or 10:00, above the cervix.

The incision is left open in most cases. Closure would require laparoscopic type instruments.

Postoperative care

- Stall or pen rest for 3 days
- Horses may be restrained in a standing position to minimize the risk of evisceration.

Complications

- Peritonitis
- Intestinal evisceration
- Trauma to internal organs
- Inability to puncture the peritoneum

Videos

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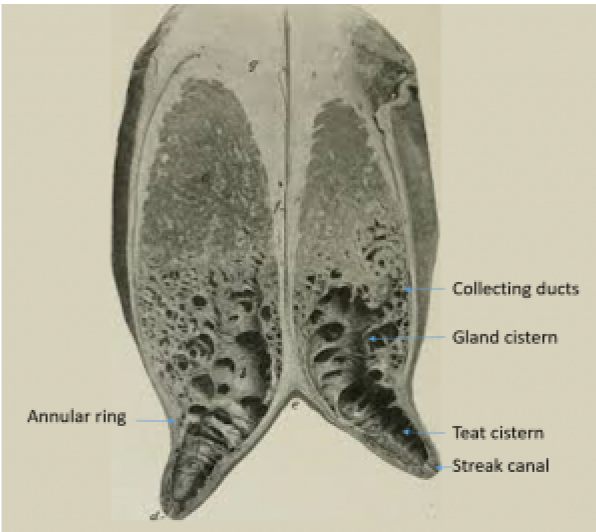
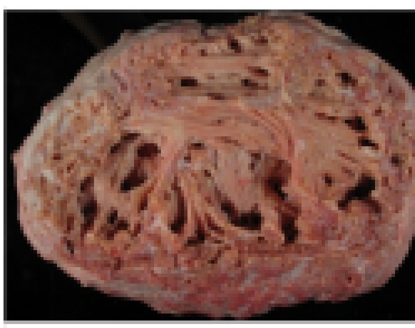
Resources

Udder anatomy and physiology

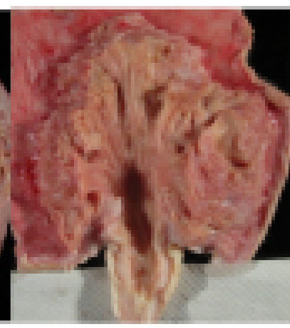


A functional udder needs both glandular tissue and a path for milk flow. Milk produced in the glands should flow into the collecting ducts and then into the gland cistern. The milk is held in the gland cistern until "let down" occurs with manipulation of the teats, calf bellowing and/or oxytocin.

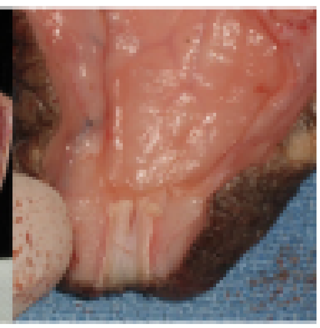
With let down, the milk flows past the vascular annular ring and into the teat cistern. The milk is kept in the teat cistern by the sphincter in the streak canal. If the sphincter is damaged, milk will leak out. Milk may also leak out due to a very full teat cistern.



Cross section of well developed active udder



Sagittal section of teat



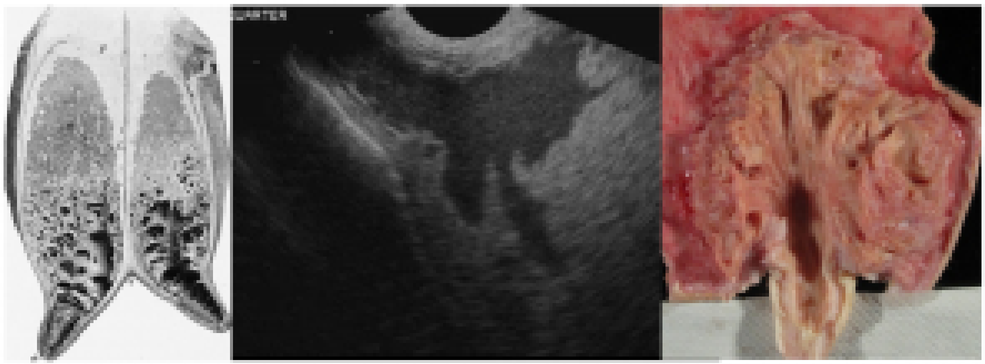
Close up of teat sphincter

Milk flow and teat abnormalities are common in food animal practice. Milk develops in the gland with impending parturition. The gland is also developing at the same time. A non-lactating heifer will not have fully developed collecting or gland cisterns until close to parturition.

Nonfunctional gland

Gland developing functional collecting ducts

Ultrasound can be used to assess normal structure and function of the gland and the teat. Milk will show as speckled black while the gland is white.



Ultrasonographic appearance of a well developed milk collecting system

Once milking stops, the pressure of milk buildup starts the process of "drying off" and the udder returns to a quiescent state. This can start within 5 days. If surgery is indicated to fix an obstruction, the gland should be ultrasounded to verify milk is still being produced.

Teat and udder diagnostics

Common teat issues include lacerations, congenital anomalies and blunt force trauma. Many are fixable but with a poor long term prognosis. Determining which are reasonable to fix is important.

Palpation and ultrasound are key.

Palpation

Palpation of the teat can identify if it is filled with milk, identify fibrosis and signs of inflammation. A sterile teat cannula can be inserted into the teat and used to palpate the lining. The cannula should be easy to insert and the lining should be smooth. Milk should flow from the cannula in a normal lactating animal.

Ultrasound

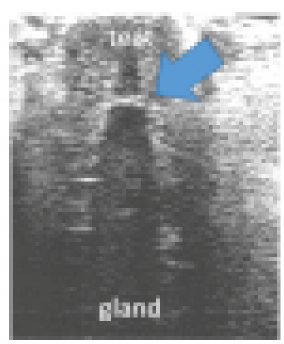
Ultrasound can be used to

1) determine the location of the obstruction

Milk can be identified in a normally functioning teat and gland. With stimulation, milk should enter the teat canal. A teat may be normal and be devoid of milk if the milk is not being produced or if milk cannot enter the teat. A common obstruction is a membrane at the junction of the teat and gland. With careful positioning, this membrane can be observed ultrasonographically in some cows.

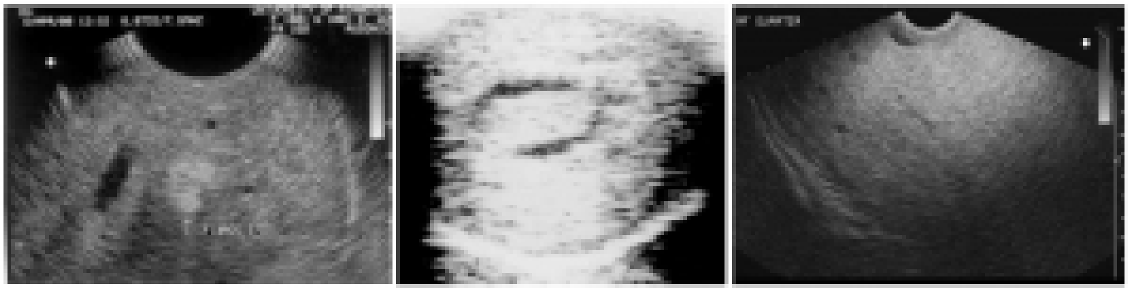
Normal teat with milk

Normal teat without milk



Membrane between teat and gland

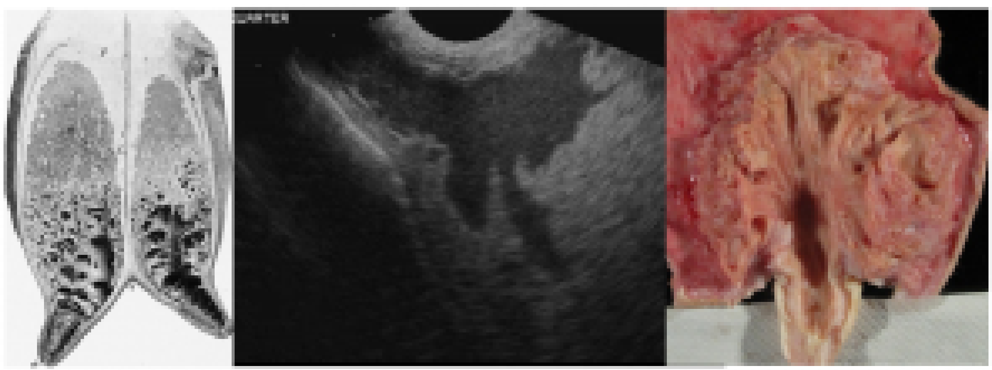
Ultrasound can often detect fibrosis and intraluminal obstructions. However, agenesis of the teat lumen (lack of formation) appears the same as a normal teat without milk flow.



Teat with scar tissue — Teat with luminal obstruction — Teat with agenesis of the teat canal

2) determine if the gland is normal and active

Two issues can arise with the gland. Congenital anomalies often come with other congenital anomalies. A malformed teat may coexist with malformed gland. And, if the teat has been obstructed for >5 days, the gland will start to dry off, even if normally structured. The quarter should be compared to the contralateral quarter to assess structure. A common abnormality is lack of gland cisterns (collection sites). This will significantly impact milk quantity.

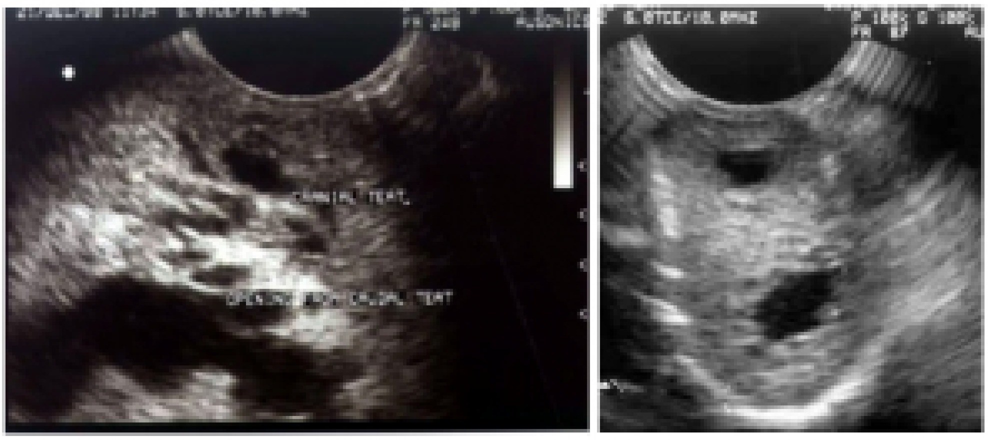


Normal gland anatomy and sonographic appearance

3) identify abnormal milk flow

Nonlactating (solid) gland and related sonographic appearance

Supernumerary teats come in many forms. Conjoined teats are one version. Ultrasound can show the two teat lumens.



Theloscopy

Evaluation of the internal structure of the teat can be performed by thelotomy (incision) or by scoping the teat with a needle scope. This is a referral procedure.

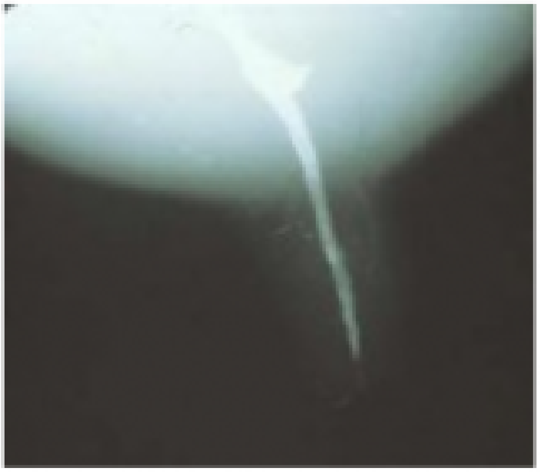
This teat has been stepped on and the teat sphincter damaged. The damaged portion has everted into the teat lumen. This causes intermittent obstruction of milk flow.

Theloscopic view of normal sphincter.

View of traumatized sphincter

Contrast Radiography

Occasionally, contrast studies are used to identify anomalies and structural changes.



Narrowed gland and teat cistern.

Conjoined teat

Teat trauma

Teats wounds are managed similarly to wounds in other species with the exception of milk flow.

As with other wounds, it is important to determine the level of healing potential.

- Is the wound acute or chronic?
- Is the wound clean or contaminated?
- Was the type of trauma blunt or sharp?
- How deep does the wound go? Any other structures involved?
- Does the wound have good blood supply?
- Is any skin missing?
- Are there any other factors that can interfere with healing?
- Has the wound been treated already? If so, with what? Response?
- Is the cost of treatment reasonable for the client?

Due to the good blood supply to the teat, superficial wounds heal well even with skin loss. Blood supply obviously comes from above so horizontal lacerations do disrupt the blood supply more than vertical lacerations. Blunt trauma can do internal damage that causes later issues; wounds created by a sharp object generally have a better prognosis.

Primary repair is ideal for full thickness wounds, so acute lacerations have a better prognosis than chronic wounds. However, partial thickness wounds do well regardless.

It is also important to consider the process of milking during the healing process. Machine milking is a vacuum process and is much less traumatic than hand milking. Machine milking can start as soon as fibrin seal forms across the suture line (approximately 6 hours in a healthy animal). Lactating dairy cattle have their teats cleaned 2-3x daily as part of the milking process; this also helps in wound healing.

Full thickness wounds

Wounds that extend into the teat lumen require special consideration.

Lactating animals

The repair of full thickness lacerations in lactating cows can be challenging. Adulteration of the milk with antibiotics and antiseptics must be avoided in lactating animals. Salves may help keep the wound moist and healthy but need to be food safe, as well.Teat bandaging is difficult and unnecessary.

Milk flow and milking will tend to keep the wound open. Fistula formation is more likely in lactating animals. With fistulas, the laceration heals but leaves an opening that permits milk to leak out the wound.

Wounds into the teat lumen significantly increase the risk of mastitis from environmental contaminants prior to repair so waiting to fix the laceration isn’t a better option. Lactating animals will also be losing milk as long as the wound remains open. This can be a significant financial loss. If it occurs, fistula formation also continues to increase the risk of bacterial contamination and mastitis.

Non-lactating animals

Full thickness wounds in non-lactating animals are a risk primarily due to the need for sedation and recumbency in these pregnant animals. Avoid dorsal recumbency and avoid xylazine sedation in the third trimester whenever possible.

Sphincter wounds

At this time, we do not have any way to recreate the teat sphincter. The sphincter can be damaged by lacerations or blunt trauma. Cows with a laceration involving the sphincter should be treated by teat amputation, udder amputation or culling. Cows with blunt trauma to the teat end (eg from a foot) may rupture the sphincter. Parts will prolapse into the teat and interfere with milk flow due to a ball-valve type action. The prolapsed tissue can be trimmed but granulation tissue will form and block milking. This occurs within a few weeks. Prognosis is poor.

Theloscopic view of normal sphincter.

View of traumatized sphincter

Teat laceration repair

Teat wounds are managed similarly to other wounds. Preoperative milk cultures are recommended to determine the best perioperative antibiotics. If not available, samples should be taken at the start of surgery.

Surgery should be performed in lateral recumbency with the cow sedated and limbs restrained. Local anesthesia can be performed by a ring block around the teat, supplemented with infusion of lidocaine into the teat. Suction is nice if available.

The wound should be gently cleaned and debrided if needed. Sharp debridement is preferred but minimize the amount of tissue removed to avoid constricting milk flow.

Full thickness teat wounds should be closed in 3 layers to minimize fistula formation. The smallest diameter suture material reasonable should be used; 3-0 is typical. Monocryl should not be used as it dissolves rapidly in normal milk. Dexon dissolves rapidly in mastitic milk. Teat tissue heals rapidly; a short duration suture material could be used. However, monofilaments are less traumatic in the delicate mucosa. The final layer can be closed in a subcuticular (intradermal) pattern, standard skin **appositional pattern** or with wound glue.

Note: it is not possible to recreate a functional teat sphincter at time time.

Typical teat laceration repair

Mucosa closure – 3-0 absorbable suture in a simple continuous pattern

options include polydioxanone, polyglactin 910

Submucosa closure – 3-0 absorbable suture in a simple continuous pattern

options include polydioxanone, polyglactin 910 and poliglecaprone 25

Skin closure – 3-0 absorbable or nonabsorbable suture in a subcuticular or appositional pattern

Teats should not be milked until a fibrin seal forms, typically in 6 hours. After that, frequent milking is useful to minimize swelling. Avoid hand stripping and hand milking for at least 24 hours.

Resources

Local blocks of the teat, slide #47

Cases

Repair of teat laceration in a cow, case report

Traumatic teat laceration in a Jersey cow, case report

Teat fistula in a Jamunapari goat, case report

Milk flow issues- no milk flow

First calf heifers are occasionally presented with no milk flow from a teat, despite heavy milking in the other quarters. This can occur due to trauma, obstruction from infection or lactoliths or due to congenital anomalies.

Congenital anomalies can be a persistent membrane between the teat and the gland or lack of development of the teat cistern.

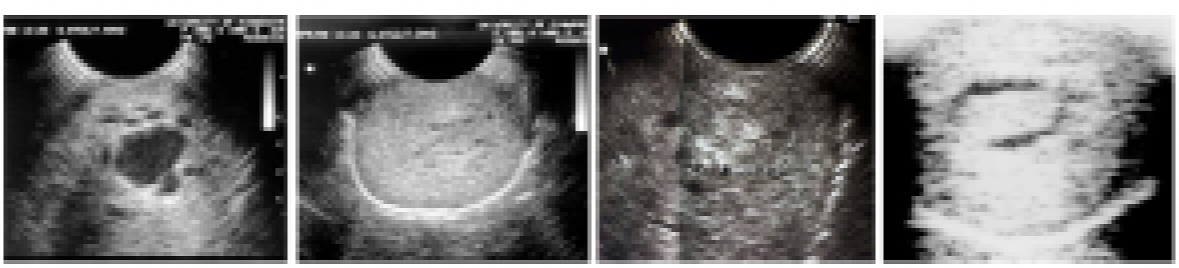
Diagnostics

Trauma, infection and milk stones are usually evident on physical examination.

A teat cannula can be passed up the teat and used as a gentle probe to evaluate the teat cistern.

A normal teat lining is smooth and does not obstruct passage of the teat cannula. If the teat cannula can be passed fully and easily, the most likely issue is a persistent membrane.

Ultrasound can be used to verify milk flow and occasionally can determine the cause of the obstruction. Fibrosis indicates prior damage and may be seen when calves suckle each other or when teats are stepped on .



Normal teat with milk   No milk flow   Scar tissue   Lumen obstruction

Theloscopy (scoping the teat) can be used to evaluate prolapsed sphincters and other damage. This requires a needle scope and is not always available.

Therapy

Milk stones are uncommon and can be removed by forceful milking or grasping instruments. Trauma may respond, at least temporarily, with NSAID administration.

The membrane can be cut open through a thelotomy (incision in the teat) or via the teat sphincter. It is essential to avoid damage to the sphincter. Teat knives can cut through the membrane without stretching the sphincter. The membrane will tend to close over; frequent (q2h) milking for 3 days may keep it open. Using a teat implant is not advisable as these cause severe damage to the teat when the animal lies down. Alternatively, the quarter can be allowed to dry off. Total lactation amounts will be only slightly lowered.

Milk flow issues - too slow or too fast

Normal teats -abnormal flow

Cows can also be “tight milkers” and have slow milk flow. Others tend to leak milk. Fixing these is more an art than a science.

Tight milkers – the sphincter can be partially transected in an attempt to improve flow. With the udder full, a teat knife is used to create 2 to 4 partial thickness incisions from the lumen side, spaced equally around the teat. The teat is cut until milk starts to leak. The incisions will fibrose over time, potentially leading to improved milk flow, excessive milk flow or even more limited milk flow.

Excessive milk flow – The same procedure can be used in a deliberate attempt to create scar tissue and tighten the teat. The cuts are made to a minimal depth. Alternately, iodine is injected around the teat spincter to create scar tissue.

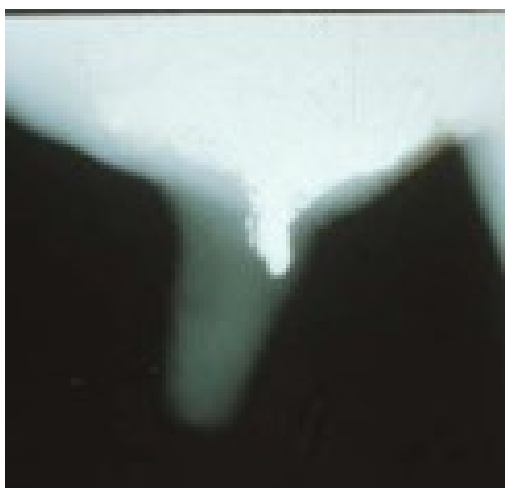
Supernumerary teats

Supernumerary teats may look like regular teats and be fully functional with normal anatomy. Others will be fused to the normal glands or teats and leak milk due to abnormal position and lack of normal sphincters.

supernumerary teat ultrasounds

Supernumerary teats are typically removed in calfhood so that the gland does not develop. The teats are removed with scissors, cutting along the long axis of the gland to follow the lines of tension.

If discovered later in life, the entire teat is removed and the lesion closed in 3 layers to minimize leakage. If the only visible issue is a fistula, that is also resected and closed. This will result in milk production changes related to size of the supernumerary gland.



contrast study showing size of supernumerary gland

If conjoined teats, the wall between can be opened up to allow milk to flow from both glands.

Udder disorders and surgery

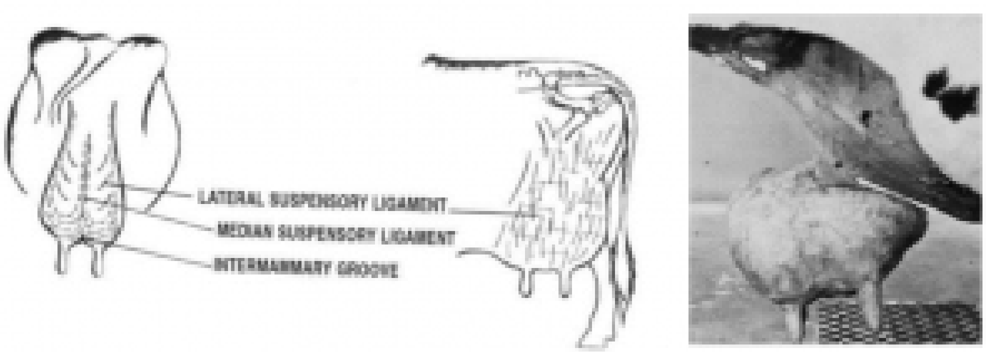
How to - Goat Mastectomy

Indications

Udders may be removed to treat chronic mastitis, tumors, injury and suspensory ligament breakdown. Bovine udder amputations are a referral procedure. Goats can readily be managed in the field.

Relevant anatomy

The udder is suspended from the flank and via the median suspensory ligament rather than being attached to the ventral body wall. It is well vascularized by the large pudendal vessels in the inguinal area.



The udder is minimally attached to the ventral body wall. It is primarily suspended by the medial and lateral ligaments. This makes it easy to remove.

Preoperative management

Food restrictions:

Ruminants should be held off feed for 48 hours. This procedure is performed in dorsal recumbency and will take some time; minimizing bloating is important.

NSAIDs/analgesics:

Preoperative NSAIDs are recommended.

Antibiotics:

Antibiotics are not generally needed required but a preoperative dose may be recommended if contamination is likely.

Local blocks:

An epidural or pudendal block might be helpful but may not be easy to perform.

Position/preparation:

Dorsal recumbency under general anesthesia.

Surgery Supplies:

- Standard surgery pack
- 0 and 2-0 absorbable suture for ligatures
- 0 suture for skin (cutting needle)
- stents for mattress sutures
- stent for seroma management (optional)
- Assistant to manipulate the udder (optional)

Surgical procedure

- A fusiform incision is a made through the skin, midway up the udder and oriented along the long axis of the patient.
  - This will help ensure enough skin for closure
- The skin is dissected off the udder down to the inguinal area.
- Using careful blunt dissection, the udder is lifted off the body wall. Vessels are double ligated as identified.
- Once the udder is removed, the skin is closed if possible. Mattress sutures with stents may be necessary and drainage holes or drains should be included. If closure isn't possible, the deeper tissues are tacked to the body wall and the wound left open.
- A rolled towel can be sutured to the wound to apply pressure and minimize seroma formation.

Postoperative care

- Stall rest; minimal exercise
- NSAIDs for 3 days
- Suture removal in 10-14 day

Complications

- **Dehiscence** is relatively common but is a minor issue.

Videos

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Resources

Mastectomy in 25 small ruminants (2002-2019). Veterinary Surgery. 2021;50:104–110.

Other stuff

Occasionally a prolapsed uterus is too damaged to replace or just won't go back in. These can be amputated. Be aware that other tissues can prolapse into with the uterus- intestines or bladder may be within the prolapse prior to amputation. Per a UMN graduate – two Callicrate banders work well and are more efficient than suturing!

Uterine neoplasia is a relatively common reason for hysterectomy in pigs, both full sized (rescue groups) and potbellied. Clinical signs typically include vaginal discharge, inappetance, weight loss and lethargy. Tumor types were similar but prognosis was more guarded for full sized pigs due to metastasis (delayed diagnosis) and intraoperative hemorrhage (increased vascularity and difficulty with fluid resuscitation using just auricular veins). Pigs that survived short term had similar long term survival rates.

Resources

McOnie et al. Surgical treatment of uterine neoplasia in 13 production size pigs with a comparison to pot-bellied pigs. Vet Surg 2021-10, Vol.50 (7), p.1434-1442

Practice- Level A

[Crossword puzzle](#)

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Food/Fiber Cesarean Sections

This section will cover C-sections in cows, small ruminants and camelids. Additional resources are found in the anesthesia section.

Left flank Cesarean section

Overview

Csections in cattle, ACVS

Csections can be performed from many different approaches. Left flank standing Csection is standard for large ruminants.

A left flank approach is easier than the right because the rumen functions to keep everything else inside the cow so you don't have to worry about intestines getting contaminated or traumatized, etc. An oblique incision provides more direct exposure to the uterus. This can be beneficial for smaller surgeons.

Complications

Almost all cattle will develop retained placentas. There is recent evidence that flunixin meglumine increases this risk. However, NSAIDs do a lot of good things and retained placenta is readily treated in cattle. These are not as life threatening as in horses and are left to resolve on their own.

Incisional infections may develop and are treated by removal of a distal suture to allow drainage

Prognosis is good for fertility if the uterus was healthy at the time of surgery.

Primary Resources

Surgical approaches for Csection in cattle, 2008 CVJ- Nice review of approach options (with pictures) and general dos/don'ts. While he says monofilament suture for the uterine closure, I do like braided absorbable suture to close the uterus; the uterus doesn't tear as easily if you take decent bites.

Field Csections, 2008 VCNA – Very detailed, step-by-step approach. Lots of hints so good for future reference. I would not give 2.2 mg/kg banamine BID to a fresh cow; too ulcerogenic. Either 2.2 mg/kg SID or 1.1 mg/kg BID and always iv. His PPG dose is what I recommend (22000 IU/kg) but needs to be BID. And not my first choice of antibiotics for a lactating animal due to milk withholding times. Please don't do abdominal lavage– with or without antibiotics! Cattle try to wall things off. If you spread it around, you are making it harder.

Perioperative antibiotics chapter

Secondary Resources

Trent Csection notes-covers a variety of species

Youtube video

Utrecht suture pattern

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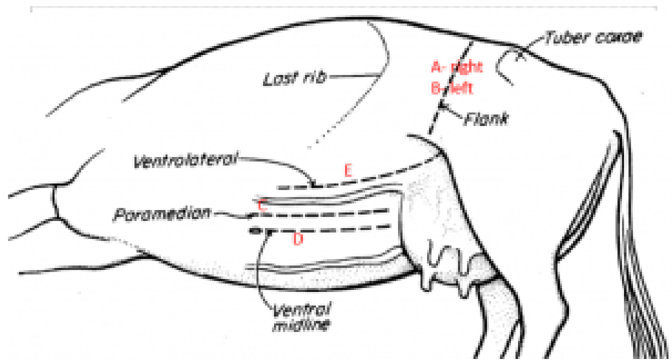
Other situations



If the cow has been in dystocia for a prolonged period of time (definition of prolonged varies by parity and by environmental temperature), recumbent csection is likely and you should just plan to perform the csection with the cow down. Many times the uterus is not healthy and pulling it to a flank incision can rupture it. A paramammary (ventrolateral, marcenac) approach in the recumbent cow is most useful as the incision is directly over the uterus and manipulation is minimal. See E in the picture.

[Youtube video]

If the calf is a fetal monster, fetotomy can be performed via the Csection incision. This will make it easier to fit it through the incision.

Double muscled breeds (Belgian Blue, Charolais, etc) have higher levels of dystocia due to the larger hindquarters of the calf. Veterinarians may be asked to perform elective Csection.

Elective Csection

The best indicator of readiness is cervical dilation. However, calves within 2 weeks of their due date will usually survive. To ensure maturity of the calf, dexamethasone (20-30 mg im) should be given to the cow 24 hours prior to anticipated calving or Csection. A combination of prostaglandin and dexamethasone is often used to induce calving while improving lung maturation. Labor usually starts in 24-72 hours.

Other species

A flank incision in the recumbent animal is typically used in small ruminants. Heavy sedation is preferred over general anesthesia and intubation due to the risk to the babies. Goat babies can hide very well; extra attention needs to be taken with checking to make sure all are removed.

Camelid csections can be either flank or ventral midline, depending upon your anesthesia options and personnel availability. No need to grab a hindlimb, any body part will do.

Csections are rarely performed in production swine but can be needed in pet pigs. Porcine Csections are typically performed under epidural anesthesia with light sedation. Acepromazine may be used if the sow is agitated. Isoflurane gas anesthesia can be administered via face mask (this does carry increased exposure risks for nearby personnel). Several incisional options exist as the uterus is highly mobile. Flank incision, paramammary or ventral midline incisions are all potential options. The easiest is the ventrolateral or paramammary approach as it allows the pig to be in lateral recumbency. The upper limb is abducted an incision made just dorsal to the mammary chain. Both horns can usually be exteriorized via this approach. An incision is made into the uterus near the uterine body and piglets removed. Additional incisions into the uterus can be made if necessary. The uterus is typically closed in a double layer inverting pattern with 0 or 1 absorbable suture. Prognosis is generally good for survival and fair to good for future fertility. See images

Resources

Goplen Csection ppt– sm ruminant

Difficult Csections, 2014 In Practice

Trent Csection notes-covers a variety of species

Complications and outcomes of swine that underwent cesarean section for resolution of dystocia: 110 cases (2013-2018). Veterinary Surgery. 2021;50:38–43.

Detailed Csection hints and techniques, 2008 IJVS – nice details for breech, torsions etc. Good reference

Induction of parturition in cattle, September 2006, Australian Veterinary Journal 84(9):312-6

A variety of Csections – youtube

Another video

And a third video

another restricted video

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How to - Left Flank Csection

Indications

Cesarean section is indicated for many causes of dystocia, as a preventive measure for animals with anticipated dystocia and for gnotobiotic calves.

Relevant anatomy

The uterus can be accessed from either side. The rumen holds in the intestines on the left, making that the preferred approach. The uterus can be challenging to exteriorize via the left flank if the pregnancy is in the right horn or with uterine torsions. A ventrolateral approach is preferred for weak cows, damaged or emphysematous uteri.

The body of the calf will be in the pregnant horn, forcing limbs into the nonpregnant horn. That makes the nonpregnant horn easier to manipulate.

Preoperative management

Food restrictions: NA

NSAIDs/analgesics: Recommended preoperatively. Flunixin meglumine 1.1-2.2 mg/kg iv is standard.

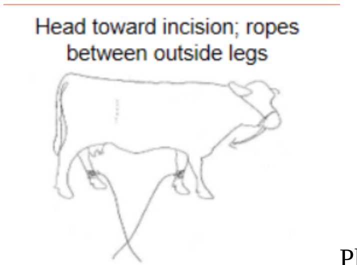
Antibiotics: Recommended if any vaginal manipulation or prolonged dystocia. In general, the cervix is open and preoperative manipulations ensure the uterine fluids are contaminated. Timing is important to ensure the drugs are at high concentrations at the time of surgery (see earlier chapter). If milking, ceftiofur 2.2 mg/kg im is standard. In beef or non-lactating cattle, other options do exist. Remember: the label dose of procaine penicillin is ineffective!

Local blocks: A line block, inverted L or paravertebral are all reasonable options. A line or inverted L is required for an oblique incision as the paravertebral will not cover the ventral aspect. An epidural can help minimize straining if the cow is actively in labor.

Sedatives: Local blocks are often sufficient. If more sedation is required, just try to avoid xylazine. I prefer acepromazine/butorphanol combinations. Detomidine does not cause uterine contractions and is another option; it can also be used with butorphanol.

Position/preparation: See How to- Standing GI Surgery

Position/preparation: Standing. Healthy cows tolerate standing surgery very well. Many do not need sedation but will do fine with just a local block. However, if they are heavily pregnant, (and particularly if they are Jerseys) they may just decide to lie down in the middle of the procedure. If this is a concern, we try to make it more likely that she will land incision side up.



Place ropes on the far legs and tie her head toward the incision. If she starts to lie down, nonsurgical personnel pull on the ropes and pull her legs out from under her. With the head tied in this direction, she is also more likely to fold that way and stay incision side up.

An assistant is almost always necessary. This can be an untrained assistant that is garbed in sterile gloves (rectal sleeves are fine) and told what to touch and not touch. If the calf is alive, another person is needed for calf care and should be asked to set up an area for drying and warming the calf. This person can act as a nonsterile assistant and help with calf removal etc.

Surgery Supplies – Supplemental

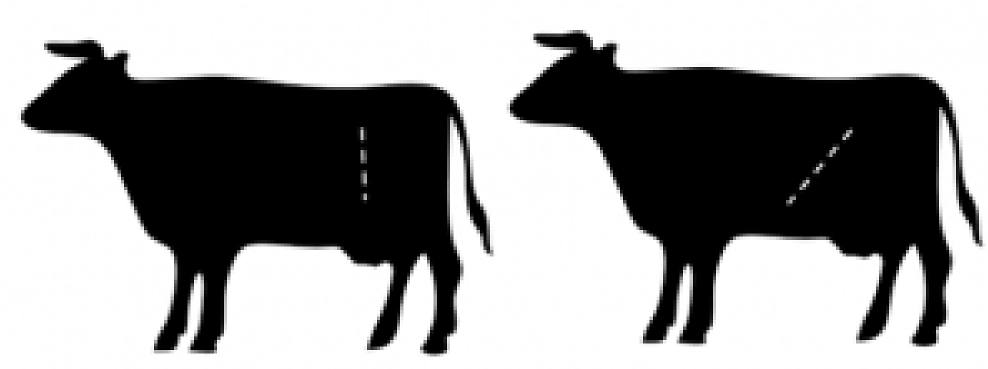
- 2 absorbable suture material for uterine closure
- Calf hooks and chains
- Oxytocin
- Uterine forceps – optional
- Sterile envelope cutter – optional for incising the uterus
- Gigli wire and handles – optional

Surgery Supplies – Standard

- Standard surgery pack
- Sterile sleeves for internal palpation
- Scalpel blade and handle
- 2 or 3 absorbable suture material for muscle closure
- 3+ nonabsorbable suture material for skin closure

Surgical procedure

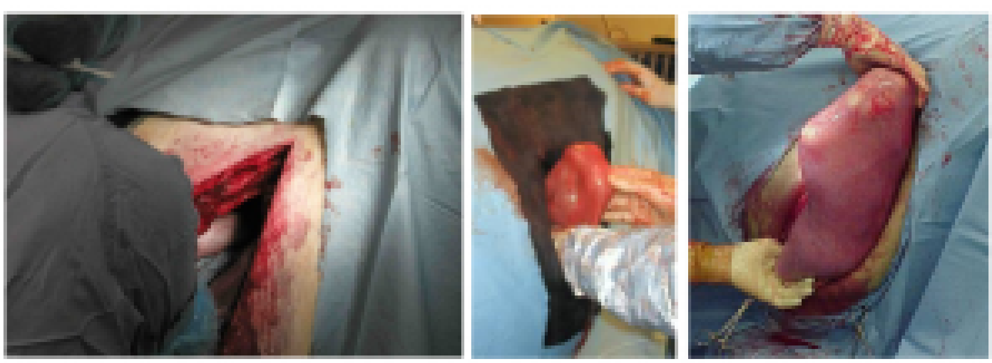
After the cow is clipped and prepped, a 40 cm vertical or 40-50 cm oblique incision in made starting in the caudal third of the paralumbar fossa and continued through all muscle layers and the peritoneal cavity. The flank incision should be just long enough to exteriorize the calf's hindlimb from toe to point of hock. An incision smaller than this will prevent calf removal; a larger incision much longer will make it hard to hold the calf out during the Csection.



Once the cavity is open, sterile sleeves and overgloves (surgery gloves that are a size bigger) are placed on both arms. Instruments for closure should be separated and covered to keep them clean.

The uterus and any torsions are identified. If the calf is in typical position, a hindlimb is grasped and brought to the incision (forelimb if the calf is breech). With careful rocking and manipulation, the nonpregnant horn containing the hindlimbs is brought to the incision. The healthy uterus can tolerate a fair bit of force but whole hand manipulation should be used rather than fingers which can cause more damage. If the pregnancy is in the far (right) horn, the surgeon reaches underneath, grasps the top of the uterus and pushes it down and pulls it over to the left side, creating a 180 degree torsion.

Once the hindlimb is identified, it is grasped and brought out the incision. If the limb can be hooked out the incision, that helps prevent the calf from moving away again.



At this stage it is important to ensure everyone knows the plan.

1. Someone must keep the uterus held out so that the uterine contents drain outside of the cow. [The uterine contents are considered contaminated due to the vaginal manipulations in most dystocias.] The

sterile assistant is generally given this job. A moist hand towel or padded uterine forceps can be used to maintain a grip on the uterus at the top and bottom. Holding in the middle means being in the way of the scalpel blade during the Csection. It is tempting to let go once the calf is out; it is important that this person stay holding the uterus. The job is hard until the calf is removed.

2. Someone will take the chains and pull the calf out. This person can be nonsterile. The calf will need to be pulled upwards first and then horizontally. A taller person can be helpful (or a stepstool). This person must follow the surgeon's direction on when to pull.
3. Someone to create the incision in the uterus; typically the surgeon. The surgeon will also manage the rest of the team, directing when to start and stop pulling.

The incision is made between caruncles (to avoid bleeding) starting at the tip of the toes. The eponychium will protect the calf from damage if the scalpel goes a little too deep. Either a scalpel or envelope cutter can be used. The amnion is incised.

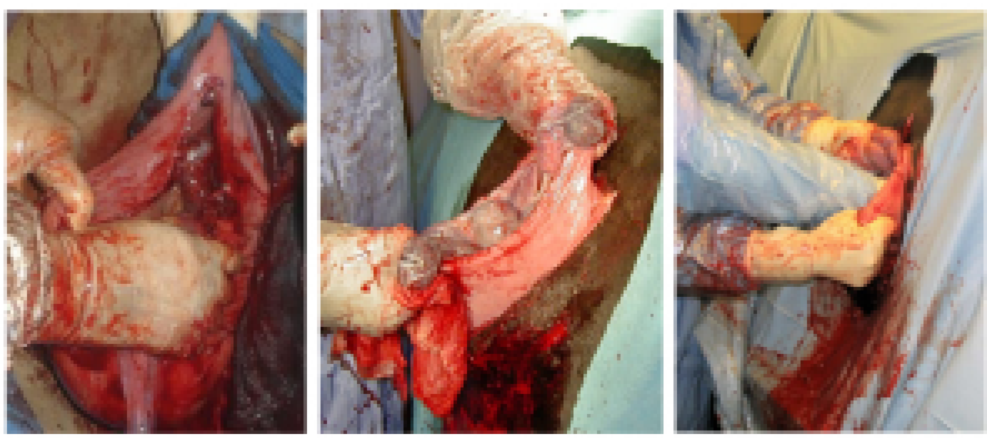
Grasping uterus with towel   Incising wall   Amnion exposed

Once the foot is accessible, chains can be put on the limb to prevent the calf from moving away. A double loop is recommended to avoid too much pressure in one site. The chain is passed off to the nonsterile assistant to grab with a hook. No pulling is needed yet, just holding. The incision can then be lengthened sufficiently to find the other matching foot. Another chain (or other end of a long chain) is placed on this foot and handed off as before.

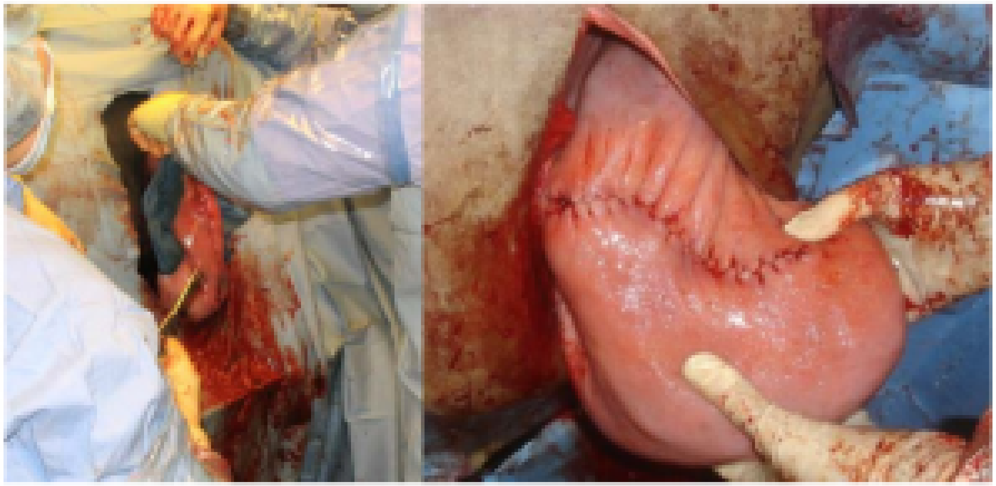
At this stage the uterus is firmly grasped by the sterile assistant and the incision in the uterus lengthened to the point of the hock. If the incision is not long enough, the uterus will tear. The surgeon can and should stop the action at any point if it is deemed a longer incision is needed. The calf is pulled out (upwards and then horizontally) as it is supported by the surgeon. The umbilicus should tear naturally. If not, the cord is held at each end and torn by pulling the ends apart. The calf can be taken to the prepared area.

Note how the uterus is still held!

The amnion can be pulled off or pushed into the uterus. Any fluid can be dumped on the ground outside of the cow. The surgeon should check for any other calves or uterine tears.



The uterus is closed in two layers. One layer is often described in the literature but that suture line becomes loose as the uterus contracts, making a second advisable. Any **inverting** pattern can be used (Lembert, Utrecht, Cushing). Absorbable #2 with a swedged on needle is advised. Full thickness patterns are not recommended and **appositional** and **everting** patterns can lead to adhesions. The placenta is not usually ready to be removed so should be pushed into the uterus. Care should be taken to avoid suturing the placenta into the incision line.



Once the first layer is completed, the sterile assistant can relax. Blood clots are removed from the uterine surface and a second layer of closure performed. The cow should be given oxytocin after the first layer is closed to ensure good involution (and a tighter suture line) during the second. The uterus is returned to the abdominal cavity and checked once again to ensure normal position, no other calf and no tears.

Closure : Follow the guidelines for standing GI surgery.

Postoperative care

- NSAIDs and antibiotics should be continued for at least three days if any risk of uterus contamination
- Oxytocin (10-40IU im) helps with uterine contraction but does not help with retained placentas.
- The placenta is tied in a knot to add traction but is left to pass on its own

Complications

Almost all cattle will develop retained placentas. There is recent evidence that flunixin meglumine increases this risk. However, NSAIDs do a lot of good things and retained placenta is readily treated in cattle. These are not as life threatening as in horses and managed with oxytocin and time.

Incisional infections may develop and are treated by removal of a distal suture to allow drainage

Videos

Youtube video

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http://mediamill.cla.umn.edu/mediamill/embedqt/154851

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Video 1

Video 2

Video 3

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Video 5

Video 6

Resources

Pregnant anesthesia animal sedation and anesthesia

Anesthesia is tricky during pregnancy, particularly in large animals.

The first trimester is risky due to the teratogenic effects of many drugs. Anesthesia is avoided in this trimester whenever possible.

The third trimester is risky as the large fetus can impair venous return to the heart by pressure on the vena cava and diaphragm. Avoid dorsal recumbency whenever possible.

Generally elective procedures are scheduled during the second trimester or after the birth.

During Csections, avoid agents that increase tone to the uterus (for the surgeon) or compromise the cardiovascular or respiratory system of the fetus/baby. Drugs that can be reversed or have minimal depressive effects are ideal. Multimodal anesthesia helps to minimize the amount (and side effects) of each drug.

PRIMARY RESOURCES

FA Sedation chapter – xylazine increases uterine tone and is considered abortigenic for cattle in the last trimester

FA Anesthesia chapter

Local blocks chapter – for epidurals

Drugs and the placenta, Open Anesthesia (human)- good resource for what drugs cross the placenta

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SECONDARY RESOURCES

the daily moos

Anesthesia for pregnancy and reproductive disorders , Wendt-Hornickle

Anesthesia for reproductive disorders, Graham

Two methods for casting:

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Uterine torsions

Uterine torsions are not uncommon in cattle and are relatively common in camelids. Horses are rarely affected, with uterine torsions causing colic early in the last trimester.

Camelids are theorized to develop torsions due to the uneven distribution of weight in the uterus and their tendency to roll when in a new environment. However, everything is just a theory.

Diagnosis

Uterine torsions are identified in cattle at the time of parturition. Labor does not progress. On examination, the vagina often has a noticeable twist and the cervix is usually closed.

Uterine torsions in camelids are identified anytime (or multiple times) in the last few weeks of gestation. The vagina may or may not twist.

Uterine torsions in horses are identified early in the trimester and are associated with abnormal rectal findings (and normal vaginal findings). The broad ligaments of the uterus may be palpably abnormal, with one extending over the top of the uterus and the other diving below. The rectum may be tighter than usual and may twist.

Treatment

Ideal treatment is nonsurgical and early in the process. Delayed therapy means constricted blood supply to the fetus and to the uterus. This can lead to death of the fetus or hypoxic babies. The uterus may rupture or necrose.

Detorsion rods

If the cervix is open, detorsion rods or manipulation of the fetus can be used to untwist the uterus. These methods can damage a compromised uterus.

Rolling

The dam is rolled to catch up to the baby (in the twisted uterus) while holding baby still. In camelids, the uterus is held in place with gentle hand pressure while the dam is rolled in the direction of the torsion. In larger animals, a “plank in the flank” is used to hold the uterus still. For this option, a long flat board is placed across the flank of the laterally recumbent animal. A person stands on the flank to hold the uterus in position while the dam is rolled in the direction of the torsion. This method is not advised in a compromised uterus.

Csection

If rolling doesn't work or isn't an option, Csection can be performed. Ideally the uterus would be detorsed prior to removal of the fetus; however, this can be challenging and works best early in the disorder. The uterus is rocked back and forth until enough momentum develops to carry it through the loop (like taking the swing over the top of the swing set). This works better if fluid is still present within the uterus.

If the uterus cannot be detorsed, it can be very challenging to bring the uterus outside of the flank incision (to enable the fluids to drain out). If the cervix is still closed and the calf isn't too deteriorated, this is less of a concern as the uterine fluid should be sterile. In this situation, it is generally okay if some uterine fluid is spilled while getting the calf out. Once the calf is out, it is relatively easy to hold the uterus in place for it to be sutured. After it is closed, detorsion is easy.

Resources

Uterine torsions in the bovine, a review, 2008 IP- lots of good details on potential causes, diagnosis, and treatment

A study of 55 field cases of uterine torsion in dairy cattle, 2008 CVJ – epidemiologic analysis of risk factors and intervention successes

Comparative study 2 detorsion methods, 2016 VA- a variant of the plank method (no plan); and camelids can act like cattle (torsion palpable vaginally) or like horses (not).

Vet student explanation– lots of images and literature review

Dystocia in camelids 2012 OJAS – mostly about camels

Uterine torsion and Csection in llamas and alpacas, 2009 Sm Rum Research – nice review of pathophysiology and prognosis

Managing Reproduction Emergencies in the Field, 2021 VCNA Vol 37 pp 339-366- preparturient disorders of mares and stallions

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Exercises - Bovine standing Csection

Exercises- Level A

Make a comparison chart for the various Csection approaches

Try your hand at these questions. The video moves at warp speed but you can replay as needed!

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