Equine Sports Medicine Center

2015 Annual Report

Prepared by:

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Director, Equine Sports Medicine Center
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### Appendix A (Blue)

- **Equine Health Update** - Equine Sports Medicine Center Newsletter  
  Vol. 17, Issue No. 1 – 2015
- **Equine Health Update** - Equine Sports Medicine Center Newsletter  
  Vol. 17, Issue No. 2 – 2015

### Appendix B (Gold) ~ Research Projects In Progress Supported with Pari-Mutual Funds

- **Hawkins J, Freeman L, Li J, Gillespie C.** *Investigation into the use of a topical application of a hyperosmolar nanoemulsion to wounds of the distal extremity in horses.*
- **Kritchevsky J, Croney C, Lescun T.** *Pasture Sound: The effect of lameness on behavior and other measures of welfare in horses.*
- **Main RP, Lescun T, Wallace JM, Siegmund T.** *Validation of an in vivo assessment for fracture risk in equine limb bones.*
- **Taylor SD, Bianco AW, Moore GE.** *Anti-endotoxin properties of ketorolac tromethamine in horses.*
Appendix C (Green) ~ Research Projects Completed Supported with Pari-Mutual Funds

- Taylor SD, Bianco AW, Constable PD, Cooper BR. Pharmacokinetics of ketorolac tromethamine, a potent non-steroidal anti-inflammatory drug, in healthy adult horses (for full report please see appendix D).

Appendix D (Purple) ~ Publications Supported by the Equine Research Internal Funds


Appendix E (Tan) ~ Refereed Scientific Publications


• Townsend, WM. Cataracts—Clinical presentations, diagnosis, and management. *Eq Vet Ed.* Published online 22 June 2015. DOI: 10.111/eve.12388.

MISSION
To provide first class veterinary diagnostic and investigative support to the horse industry in Indiana and to educate owners, trainers, and veterinarians.

GOALS:
The goals of the ESMC are to pioneer leading-edge research in the area of equine sports medicine, to provide training to future equine veterinarians and veterinary technicians, to offer continuing education to Indiana veterinarians and horsemen, and to diagnose and treat causes of decreased performance in horses.

ACHIEVEMENTS OF EQUINE SPORTS MEDICINE CENTER (ESMC)

Treadmill Evaluations:
Treadmill diagnostic work-ups are an important activity at the ESMC. Ten client-owned horses were evaluated on the treadmill in 2015. This brings the total number of horses evaluated since the opening of the ESMC in April 1996 to 464. Treadmill demonstrations at the ESMC continue to be a major attraction for local, national and international visitors to the Purdue campus. In the past year 14 treadmill demonstrations were given to groups or dignitaries who visited Purdue campus.

Continuing Education and Extension Service:

- Continuing Education presentations:
  - Adams S.B.
    Regional and State
  - Arroyo M.
    Regional and State
  - Bianco A.
    Regional and State
    Bute and Banamine: the good, the bad & the ugly. *Purdue Horseman’s Forum*, West Lafayette, IN, February 2015.
  - Couetil L.
    International
    What is the consensus on inflammatory airway disease? *The European College of Equine Internal Medicine Congress*, Utrecht, The Netherlands, November 2015.
  - National
• The Florida Association of Equine Practitioners Annual Symposium, Naples, Florida, October 2015.
  ▪ The ACVIM consensus statement on Exercise-induced pulmonary hemorrhage.
  ▪ Poor performance evaluation of the race horse.
• Hay molds associated with recurrent airway obstruction in horses. The 2015 Dorothy Havemeyer Workshop, Boston, MA, November 2015.

Regional and State
• What’s new with old horses? Purdue Horseman’s Forum, West Lafayette, IN, February 2015.
• Boiler Vet Camp. Purdue Veterinary Medicine, West Lafayette, IN, June 2015
  ▪ A Look Inside a Horse.
  ▪ The horse athlete: Treadmill demonstration
• Davern A.

Regional and State
• Anatomy 101: Horse anatomy is fun. Purdue Horseman’s Forum, West Lafayette, IN, February 2015.
• Farr A.

Regional and State
• Anatomy 101: Horse anatomy is fun. Purdue Horseman’s Forum, West Lafayette, IN, February 2015.
• Dentistry: Does the tooth fairy visit horses? Purdue Horseman’s Forum, West Lafayette, IN, February 2015.
• Vaccinations: What diseases are preventable by vaccination? Purdue Horseman’s Forum, West Lafayette, IN, February 2015.
• Gillespie C.

Regional and State
• Arthritis: Managing arthritis aches and pains. Purdue Horseman’s Forum, West Lafayette, IN, February 2015.
• Kritchevsky J.

National
• Led Special Interest Group on Equine Endocrinologic Disease, focus on PPID. American College of Veterinary Internal Medicine Forum, Indianapolis, IN, 2015.
• Taylor S.

National
• Septic pleuropneumonia in 97 horses. American College of Veterinary Internal Medicine Forum, Indianapolis, IN, 2015.
Regional and State


- Tinkler S.

International

- Equine Infections Diseases and Anemia, created and presented in Spanish for Central American veterinary students and volunteer veterinarians in Nicaragua on a RAVS (Rural Area Veterinary Services) volunteer veterinary trip, 2015.

Regional and State

- Pesky parasites: important considerations for horses of all ages. *Horsemans Forum*, Purdue Veterinary Medicine, West Lafayette IN, February 2015.
- Field colics: a review of adjunctive tests and techniques to aid in rapid diagnosis and referral. *Purdue Veterinary Conference*, West Lafayette, IN, 2015.
- Horse Health Workshop, Tippecanoe County 4-H, Keeping Your Horse Safe At Equine Events, Tippecanoe County Fairgrounds, Lafayette, IN, May 2015
- Participated in the Clinton County Vaccine Clinic (horses), April 2015
- State 4-H Horse Communication Contest, Judge, Purdue University, West Lafayette IN, March 2015

• Continuing Education – conference proceedings, articles, other publications:

  - Couetil L.

    - Couëtil LL. The impact of omega-3s on horses with lower airway disease. *The Horse*. May 2015; article #35821.

  - Taylor S.


  - Tinkler S.

Committee service

- **International**
  - Townsend W:
    Research Committee Member, International Equine Ophthalmology Consortium. 2013-present
- **National**
  - Couetil L:
  - Kritchevsky J:
    American College of Veterinary Internal Medicine, FAIM Resident Award Committee 2012-2015.
  - Lescun T.:
    American Association of Equine Practitioners, Avenues Task Force, 2012-present
    American College of Veterinary Surgeons, Examination committee, 2014-present
  - Taylor SD.
    American College of Veterinary Internal Medicine, LAIM Credentials Committee, 2012-2015.
  - Townsend W.
    Genetics Committee, American College of Veterinary Ophthalmologists, 2012-present

Outreach:

- Purdue’s Equine Website is dedicated to informing horse owners about equine-related activities at Purdue University has undergone a major update. The address of the site is: [http://www.vet.purdue.edu/horses/](http://www.vet.purdue.edu/horses/)

Outreach activities

- Couetil L:
  - Treadmill demonstrations. *Purdue Horseman’s Forum*, West Lafayette, IN, February 2015; *Open House*, Purdue University College of Veterinary Medicine, April 2015.

Lay Publications:

- The Equine Sports Medicine Center continued publication of its newsletter called “Equine Health Update” established as a source of information for Indiana’s horse industry. Dr. Stacy Tinkler is the editor for the newsletter since January 2012. Two issues were released in 2015 (summer and winter) and articles are accessible from our Website. The newsletters are included in Appendix A (Blue).
o Tinkler S:
  • “It’s No Choking Matter” Equine Health Update for Horse Owners and Veterinarians, Vol. 17, Issue No.2, December 2015 (Editor).
  • “Winter Hoof Care Tips” Equine Health Update for Horse Owners and Veterinarians, Vol. 17, Issue No.2, December 2015 (Editor).

o Taylor SD:

Research:

Research activities from investigators of the Equine Sports Medicine Center are summarized below. The names of members of the ESMC are underlined.

**Research projects in progress supported with Pari-Mutual Funds:**
Progress reports for the following projects are included in Appendix B (Gold).

Hawkins J, Freeman L, Li J, Gillespie C. **Investigation into the use of a topical application of a hyperosmolar nanoemulsion to wounds of the distal extremity in horses.**

Kritchevsky J, Croney C, Lescun T. **Pasture Sound: The effect of lameness on behavior and other measures of welfare in horses.**

Main RP, Lescun T, Wallace JM, Siegmund T. **Validation of an in vivo assessment for fracture risk in equine limb bones.**

Taylor SD, Bianco AW, Moore GE. **Anti-endotoxin properties of ketorolac tromethamine in horses.**

**Research projects completed supported with Pari-Mutual Funds:**
Complete reports for the following projects are included in Appendix C (Green).

Taylor SD, Bianco AW, Constable PD, Cooper BR. **Pharmacokinetics of ketorolac tromethamine, a potent non-steroidal anti-inflammatory drug, in healthy adult horses** (for full report please see appendix D).

**Competitive Equine Drug Testing Research Fund:**

Externally funded equine research projects conducted in 2015:


Publications supported by the Equine Research Internal Funds: Appendix D (Purple). The names of members of the ESMC are underlined.

Refereed Scientific Articles:


**Abstracts and Proceedings**


Smith AE, Taylor SD. Anti-endotoxin effects of equine peripheral blood mesenchymal stem cells. *Purdue University Summer Research Scholars Program*, Purdue University, West Lafayette, IN, July 2015. Poster presentation.


**Book Chapters:**
   a. Equine neorickettsiosis
   b. Equine infectious anemia virus

**Refereed Scientific Publications:** Appendix E (Tan)


Townsend, WM. Cataracts—Clinical presentations, diagnosis, and management. *Eq Vet Ed* Published online 22 June 2015. DOI: 10.111/eve.12388.

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APPENDIX A


Tail Alterations: An Unnecessary and Dangerous Procedure

By Dr. Kate Hepworth-Warren DVM, Dipl. ACVIM, Purdue University Class of 2010

In recent years, equine welfare activists have shed light on serious issues in the horse world, from soring in Tennessee Walking Horses, to illicit drug use in racehorses, and the controversial presence of carriage horses in Central Park in New York City. While great strides have been made in improving the health and well-being of animals of these breeds and disciplines, there remains an alarming numbers of practices that occur with frightening frequency in many other sectors of the horse industry. Despite the tail being one of the areas of the horse that is frequently altered to enhance appearance of the animal, practices that change the function and position of the tail are commonly overlooked in welfare discussions.

Tail carriage is something that varies dramatically from breed to breed, from the low, quiet carriage of the Quarter Horse to the long flowing upright carriage of the Saddlebred and other gaited breeds. Unfortunately, many of these animals have had procedures performed that alter the way that they hold their tails, and in many cases affect the ability of the animal to use its tail.

Practices that alter tail carriage and function are strongly opposed by many breed associations and groups of veterinary professionals, including the American College of Veterinary Internal Medicine (ACVIM) Large Animal Internal Medicine (LAIM) specialists, and the American Association of Equine Practitioners (AAEP). These procedures include blocking, nicking and docking. Blocking is defined by the American Veterinary Medical Association (AVMA) as “numbing the tail to cause it to hang limply,” whereas nicking is “cutting tail tendons to cause an elevated carriage of the tail.” Docking involves amputation of the distal boney part of a horse’s tail, and is generally performed in driving horses. Unfortunately, these procedures are viewed by many competitors as a necessity for high level competition.

Perhaps the most dangerous of these procedures is the cruel and potentially life-threatening administration of epidural or paravertebral alcohol blocks to create the appearance of a quiet, relaxed tail. Colloquially known as “tail blocking,” this practice is most often performed in horses in western disciplines, such as western pleasure or reining, where animals are penalized in the show ring for wringing of the tail, excessive side to side movement of the tail, or for holding the tail in an upwards position. Although it is most frequently performed in Western performance breeds, other breeds have also been subjected to this procedure.

(continued on pg. 2)
Tail Alterations (continued from cover)

Blocking the tail is not the same as blocking a joint, a procedure done frequently during lameness examinations. A joint block involves sterile preparation of the site of interest, and injection of sterile local anesthetic, such as lidocaine or mepivicaine, into a joint by a licensed veterinarian. These blocks are performed to help determine the cause of lameness, last for a few hours at maximum, and have no long-term effects. Conversely, tail blocking can be performed by anyone, often without full knowledge of the potential consequences of the procedure or consent of the owner. The technique of blocking a tail is crude and involves blindly injecting ethanol along either side of the tail bone near the base of the tail and affects the function of the nerves that activate the muscles controlling movement. The effects of the “block” last approximately 4-6 months in most horses, but the response depends on numerous factors; including the volume and location injected, how far or to what tissues the alcohol eventually migrates and the variable response each horse has to the procedure.

Tail blocking is not taught in veterinary schools, as it is considered a cosmetic procedure and provides no health or medical benefit to the horse, thus any individual who performs them has likely not had any credible training in the procedure, and may have minimal knowledge of the anatomy and function of the tail. Though there are isolated cases of veterinarians performing this procedure, it is not condoned by the veterinary profession and could result in a malpractice suit against a veterinarian if it can be proven that the horse’s health was compromised as a direct result of the procedure. The AVMA endorses the AAEP’s position statement opposing any alteration of the tail of the horse for cosmetic or competitive purposes.

Since the practice of blocking tails is against the rules of most major show and breed organizations there are no clear guidelines or data available on what exactly consists of a “block,” how it is to be administered, and the rate of complications. Many horse owners are encouraged by their trainers to have this procedure performed on their horse with no idea of how devastating the results could be. In a discussion on an equine blog, one individual stated “My trainer made it sound like it was nothing, like people do it all the time. She was like before the show I think we should switch to aluminum shoes and get his tail blocked. Call the farrier and vet won’t you?” Sadly, this is a sentiment that has been echoed time and again by horse owners.

Many trainers and exhibitors believe that a block still allows an animal to move its tail side to side, thus allowing them to still use the tail to swish at flies, and making the procedure acceptable in the eyes of many individuals. While a few animals may retain this function, many do not and suffer continuously as a result. As is highlighted by the earlier quote, some trainers lead their clients to believe that getting the horse’s tail blocked is as necessary and routine as having the animal’s feet trimmed or teeth floated. Blog posts from internet searches on tail blocks cite a less than 1% complication rate from the procedure, or claim that if a block is done “right” there are no real adverse effects aside from the initial discomfort of the injection. Unfortunately, as with any unregulated and inhumane practice, there is an assortment of negative results that develop from alcohol injections into the tail, likely with a far higher frequency than 1%. While some blocks may “only” lead to a horse that is unable to completely elevate its tail, there are far more serious consequences that can leave the animal permanently disfigured, unrideable, or dead.

Horses that have had their tails blocked often develop white hairs at the site of the injections, a tell-tale sign that the tail of that animal should be looked at more closely. There is no health benefit to a horse to have its tail blocked. The tail of a horse that has been “blocked” or “deadened” cannot be lifted above the horizontal plane. While the pain of the alcohol and the injection are temporary, one must still realize that the very act of injecting alcohol into areas surrounding the tail is painful, inhumane, and unnecessary. Once the burning sensation of the alcohol has dissipated, far more serious conditions can arise. Abscesses can readily develop at the site of the injection since these injections are unlikely to have been sterilely conducted. Inoculation of bacteria from the environment, such as Clostridium species, can occur and ultimately lead to death of the affected muscle groups, and can ultimately be fatal. The nerves and muscles that control the horse’s ability to move their tail up, down, and side to side are intimately associated with the nerves that control the ability to urinate and defeate, critical functions required in all animals. Alcohol, once injected into the horse, can also diffuse and spread through the tissues and can reach parts of the spinal cord and spinal nerves that may also control movement of the horse’s hind limbs, causing neurologic deficits or even paralysis.

Multiple cases have been described and published in the veterinary literature describing adverse effects of tail blocking procedures. Documented complications include permanent nerve damage that leaves a horse unable to completely empty its bladder or rectum, and invasion of the spinal canal and surrounding structures with bacteria or alcohol. Chronic stasis of urine within the bladder can lead to bladder infections, and ascending infections of the kidney. Horses that are unable to defeate are likely to develop impaction colic that is difficult or impossible to permanently resolve. Animals with chronic urinary or fecal incontinence are often subjected to euthanasia because of the level of management that they require, or due to the severity of colic that may develop secondary to the tail being blocked and defeation impeded. Infection of the vertebral bodies or spinal canal can lead to severe ataxia and pain, making animals unable to move normally and making them a danger to themselves and their handlers. One must consider if the horse’s ability to perform these most basic functions is an even trade for the appearance of a quiet tail in the show ring.

Testing protocols for horses suspected of having a blocked tail involve thorough physical examination of the tail and surrounding structures, assessment of the animal’s ability to move the tail, and application of specialized electro-diagnostic tests. When the anus of a horse with a normal, unaltered tail is massaged, the horse should lift the tail up above the horizontal plane, and many will lift the tail up into a vertical position. Musculature of the tails should be symmetrical over the entire tail, without presence of dimples or asymmetry. The muscles around the tail head should likewise be symmetrical and free of divots and areas of scar tissue. Additionally, when a horse tries to raise its tail when blocked, the tail will take on a concave arced appearance instead of the normal convex appearance.

(continued on pg. 6)
Rectal Tears in Horses Happen
What You Need to Know About Them

By Ava Nowak, DVM Student (Class of 2015)
Edited by Dr. Tim Lescun, BVSc, MS, Dipl. ACVS,
Purdue Large Animal Surgery

Rectal tears are unfortunately an inherent risk associated with rectal examination of horses. While rectal tears can be a complication, the amount of knowledge gained by performing a rectal exam outweighs the risk when proper precautions are taken. Lots of information can be gained by examining a colicky horse by rectal palpation. For example—assessing prognosis and determining if surgery is necessary or not—these are major decisions for the horse. Also with breeding soundness examinations, rectal examination can provide accurate information on where a mare is in her estrous cycle and when is the best time to breed. The risk of causing a rectal tear should not be the reason to skip performing a rectal examination as these risks can be minimized for the examination.

How rectal tears occur:

There are a variety of causes with the most common being iatrogenic trauma to the rectum. This means during a rectal examination, as the rectum contracts around the vet’s hand or arm or rectal probe, the rectum tears. It can also, although much less commonly, be caused by penetration of the rectal wall by fingertips. Other causes include parturition (delivering a foal) or dystocia (malpositioning of the foal during birth) leading to tears, breeding mishaps (such as a stallion accidentally penetrating the mare’s rectum during breeding) and trauma.

Which horses are more at risk:

Some risk factors have been identified with rectal tears. Breeds such as Arabian horses and miniature horses have been shown at higher risk due to restless behavior and small rectum size. Colicky horses are also at a greater risk of tearing due to repeated rectal exams. Colicky horses are also typically dehydrated which can lead to a dry and fragile rectal lining (mucosa). You may hear of age and sex predilection being risk factors however they vary in the literature and are not consistent between studies as to whether younger or older horses are more “at risk”.

Types of rectal tears:

You may hear rectal tears being classified on a 1-4 grade scale. This grading is based on which layer of the rectum is torn. It is important to classify a rectal tear to determine what course of treatment is best for the horse. The grades are broken down by which layer (or layers) of the rectum is (are) torn (see figure 1).

Measures your veterinarian takes to minimize risk:

For horses that are straining around the vet’s arm, drugs such as Buscopan® or xylazine can be administered to reduce the straining and thereby reduce the risk for tearing. Buscopan is an antispasmodic that relaxes the smooth muscle in the rectum therefore relaxing the rectum of a straining horse. A caudal epidural (similar to epidurals women can have during childbirth) can also be used to decrease straining. Using ample lubrication and adequate restraint (sedation or a twitch) while performing a rectal exam also decreases the chances of causing a rectal tear.

How your vet will manage a rectal tear if it happens:

A rectal tear is usually detected when blood is present on the arm or sleeve of the examiner. This is a serious incident and should be dealt with promptly. With adequate initial management and prompt referral to a surgical clinic, horses have a 79% survival rate. The rectum should be evacuated of feces and the tear will be classified based on the grade it is (what layers of the rectum are torn) by palpation. Then the rectum should be packed with a moistened cotton roll covered by a stockinette and sprayed in iodine to reduce the fecal contamination into the tear. Packing the rectum is intended to deliver a better surgical candidate to a referral center for further treatment. Starting the horse on broad spectrum antibiotics to combat any fecal contamination as well as an anti-inflammatory is also beneficial. Mineral oil can also be administered through a nasogastric tube to soften and lubricate the feces for a laxative effect. Horses will then need to be referred for further evaluation and surgical correction of the tear.

Prognosis:

Prognosis for horses with rectal tears depends on the size, grade of the tear, time between occurrence and treatment, as well as prompt initial first aid by your veterinarian. In various studies looking at the outcome for horses with rectal tears, the prognosis for each grade varies however it is fairly unanimous that grade 4 tears (which go through all layers of the rectum) typically have a poor prognosis and can be rapidly fatal.

In summary:

Rectal tears can happen, but that should not deter a rectal exam from being performed when it is a valuable diagnostic tool. There is so much information your vet can gain by rectal palpation which can sway decisions one way or another when deciding the best course of action for a horse. With proper and adequate restraint, the risk of tearing is very low.

References:

EHV-1 Rears its Ugly Head
How to Protect Your Horse from EHM while On-the-Go

By Abra Foster, DVM Student (Class of 2016)
Co-authored by Dr. Sandy Taylor, DVM, PhD, Dipl. ACVIM, Purdue Large Animal Internal Medicine

Traveling with your horse can be one of the most fun and exciting parts of your relationship. Whether you travel to a show or trail ride with friends, it’s one of the ways many people enjoy the companionship of their equine friends. Unfortunately, with any form of travel and interaction with other horses, there is a risk of exposure to contagious diseases. Within recent months, reports of outbreaks of disease caused by Equine Herpes Virus 1 (EHV-1) have been reported in the Midwest. Understanding this virus and how it could affect your horse is the first step to protecting him or her from this very scary disease. EHV-1 is a common virus that most horses are infected with at some point in their life. As with human herpes viruses, the virus lies dormant in lymphoid tissue and can be reactivated during times of stress. Vaccination of horses against EHV-1 helps prevent infection with other strains of EHV-1, and can help decrease shedding of virus in respiratory secretions if reactivation occurs.

EHV-1 infection usually results in respiratory disease, abortion, or early neonatal death. But just like many other viruses, there are different strains of EHV-1. One of the strains of EHV-1 can cause Equine Herpes Myeloencephalopathy (EHM), which occurs when the virus infects the central nervous system. This is a serious and sometimes fatal manifestation of EHV-1 disease, because the spinal cord (and occasionally the brain) are damaged. The affected horse presents with neurologic signs, including weakness or incoordination of the hind limbs, urine dribbling, and sometimes, impaired mental status. This manifestation of infection can lead to very serious complications, including the inability to rise and death.

Much research has been done in recent years to determine why some horses develop EHM while others do not. Recent studies have found that most cases of EHM are caused by a specific variant of the EHV-1 virus, which resulted from a genetic mutation. This EHM variant is not currently protected against with the vaccinations that are available to horse owners. Without the means to prevent infection through administration of a vaccine, it is imperative that you take precautions to decrease exposure to the EHM variant, and to be aware of clinical signs (symptoms) in order to administer treatment as soon as possible.

How to be proactive in protecting your horse from EHM while traveling:

Do not share equipment, water buckets, feed bins, pitch forks, etc with other horses

Decontaminate any equipment or environment (such as a stall) if you have to share, using a 1:10 bleach to water solution

Upon returning to your barn, monitor your horse’s temperature for 10 days, and call your veterinarian if the temperature is > 102F
  • Fever is often the first sign of possible infection and is strongly associated with EHM infection

Keep horses that regularly travel separated from horses in your barn that stay home

Vaccinate your horses against EHV-1 regularly
  • Although it does not provide protection from the EHM variant, it has been shown to significantly reduce the viral shedding in the event of infection and this is very important to slowing the spread of the disease to other horses

The mechanism by which the EHM variant of EHV-1 causes neurologic disease is not fully understood. White blood cells infected with the virus are believed to travel through the blood and then infect endothelial cells (cells lining the wall of the blood vessels) in the central nervous system. This can lead to thrombosis (blood clots), which cuts off blood supply to the spinal cord or brain. This leads to severe damage and results in neurologic clinical signs. The severity of the signs will factor strongly into the prognosis of the horse. Neurologic clinical signs of EHM often show up 6-10 days after infection and will happen very suddenly. Close daily monitoring of temperature and assessing for any neurologic changes will be key to your proactive approach to protecting your horse after traveling.

If you suspect that your horse has EHM, call your veterinarian immediately! The most important aspect of EHM treatment is supportive and nursing care, which often includes intravenous fluid therapy, nutritional support, and treating or preventing complications associated with recumbency (being unable to rise). Anti-viral drugs such as valacyclovir may improve the prognosis in horses with EHM, but not all horses respond/improve with this treatment. It is also important to administer anti-inflammatory drugs to decrease inflammation in the central nervous system. The majority of horses that survive EHM will show improvement within 10-14 days of treatment.

Information is power. Although EHV-1 infection is not completely preventable, you can take steps to help protect your horse against EHM during your next traveling adventure. If you have any concerns or suspect your horse has developed EHM, contact your primary veterinarian immediately to discuss the next step.

A Red Bag: NOT the Season’s Hottest Accessory, but…a Foaling Emergency!

By Ashley Miller, DVM Student (Class of 2015)
Edited by Dr. Teresa Buchheit, DVM, MS, Dipl. ACVIM,
Purdue Equine Community Practice

Foaling can be an event that is equal parts exciting and nerve wracking for novice and experienced horse owners alike. Every owner should be aware of the events of a normal foaling, as well as complications that can arise. One such complication that is an extreme emergency is premature placental separation, or “red bag delivery.” This complication makes up 5-10% of all abortion, stillbirth and perinatal death cases in horses.

In a normal foaling, the chorioallantois (the outer placental membrane that attaches to the uterus) ruptures and releases allantoic fluid—the horse’s “water breaks.” After this, a thin, clear membrane, called the amnion or water bag (the inner membrane of the placenta that surrounds the foal and contains amniotic fluid) will emerge from the vulva and as labor progresses the foal’s front feet and nose should be visible inside the bag. In a red bag delivery, the chorioallantois, which is a velvety dark-red color, prematurely separates from the uterine wall and protrudes through the vulva. This causes a dangerous decrease in oxygen transport to the foal and the foal can suffer from hypoxia (lack of oxygen) and may even die of asphyxiation if the condition is not corrected quickly.

![Normal – amnion emerging from vulva](http://www.miniatureventures.com/redbag1.jpg)

![Abnormal – chorioallantois emerging from vulva](https://www.azpinarabians.com/images/Amniotic-membrane_B.jpg)

Veterinarians should educate their clients on what to do if this condition occurs. Owners and those assisting with foalings should be instructed to have on hand a sharp, clean instrument (such as scissors or a knife) to immediately open the red placental membrane. The veterinarian’s number should be kept handy and called once the bag is opened and the foal should be delivered as soon as possible. If available, the newborn foal should be supplemented with oxygen as quickly as possible after delivery. Owners should continue to keep a close eye on the foal, as these foals can develop delayed signs of hypoxia even though they may appear normal at birth.

The causes of premature placental separation in the mare are many. Premature placental separation can occur with placental infections (placentitis), fescue toxicity, death of a fetal twin or when an abortion is about to happen. If an abortion is imminent, the delivery of the aborted fetus can be assisted to prevent a dystocia. If the cervix is closed and the fetus is still alive, progesterone and flunixin meglumine (Banamine®) therapy may permit the pregnancy to be carried to term. Antibiotic therapy should be started systemically if placentitis is suspected.

Owners should monitor all pregnant mares closely and contact their veterinarian if an abnormality is detected. Recognition of a red bag delivery and immediate intervention are key factors for survival of the foal.

Resources:
- Red Bag Image: http://www.miniatureventures.com/redbag1.jpg
- McCue, P. Red Bag – A Foaling Emergency. CSU Equine Reproduction Laboratory.
**Tail Alterations** (continued from pg. 2)

Electromyography (EMG) is the official diagnostic test utilized by the AQHA to identify destruction of the nervous control of the muscles involved in tail movement. Electromyography involves the insertion of small needles into the muscles around the tail to measure the electrical activity within the muscles. In muscles that are enervated from an alcohol injection, the normal activity of the muscle in response to the insertion of the needle is absent, and its place there will be spontaneous, disorganized electrical activity. Veterinarians trained in this technique use EMG to identify horses at AQHA shows suspected of having blocked tails so that they are penalized appropriately and disqualified from competition. It is mandated by the AQHA that any horse whose tail is confirmed by examination and EMG to have been altered that the horse is banned from competition in AQHA sanctioned events for at least a year, and longer if the function of the tail remains abnormal.

Despite statements in the rulebook of the American Quarter Horse Association (AQHA) clearly outlawing the practice of blocking tails, this procedure is still performed with potentially fatal consequences to the animal. While AQHA has in place specific parameters by which tail function is assessed, other breed associations involved in western disciplines do not clearly prohibit the practice. The American Paint Horse Association (APHA) states that “A judge may, at his discretion, penalize a horse for excessive or exaggerated switching of the tail or for a seemingly “dead” tail that merely dangles between the legs and does not show a normal response.” However, while the rulebook states that “any item or appliance that restricts the movement or circulation of the tail,” cannot be utilized while on show grounds, there is no statement barring the practice outside of the show grounds. The Appaloosa Horse Club (ApHC), like the APHA, states that “No horse is to be penalized for the manner in which he carries his tail nor for normal response with his tail to cues from his exhibitor or when changing leads.” Unfortunately, despite these statements that imply that tail paralysis is not to be tolerated, there are no specific testing strategies in place to identify horses whose tails have been blocked, nor are there specific statements.

Although many horse people think that the nicking of a Saddlebred’s (or other breeds where high tail carriage is desirable) is harmless, like blocking, a number of complications can arise. Nicking is a procedure where the tendons that attach to the tail are cut to allow the tail to be placed into the desirable upright position that a tail set the majority of the time that they are not being ridden by a tail set. Horses whose tails have been nicked often wear these tail sets the majority of the time that they are not being ridden by a tail set. Horses whose tails have been nicked often wear these tail sets the majority of the time that they are not being ridden. They generally need to be confined individually while wearing the tail sets, as it is impossible against such inhumane practices, making prosecution difficult or impossible. Exhibitors and owners, who may be found culpable, even without knowledge that their horse’s tail has been altered, need to educate themselves on any and all procedures and medications recommended by a trainer to ensure that their horses are not being subjected to inhumane procedures. Hopefully, judges will be properly instructed at judge’s education events and less reluctant to uphold current rules against tail alterations by not penalizing horses for normal tail position and movement. With time and pressure from owners and exhibitors, less weight will be placed on the appearance of a horse’s tail and more on the horse’s performance. Once judges fail to reward abnormal tail carriage, trainers and serious exhibitors will follow suit by discontinuing the practice to maintain a competitive edge. As with any change to a long standing practice, preventing people from altering horses’ tails will likely be a prolonged battle, but a necessary one to improve the welfare of our equine companions. Please join the concerned equine veterinarians of ACVIM—LAIM and AAEP in working to raise awareness of tail altering procedures, and to encourage competitors, judges, trainers, and other veterinarians to end this appalling practice. While organizations like AQHA have strict protocols and penalties in place in the event that a horse is suspected of having had its tail altered, others need to follow suit and continue to enforce these rules. Unfortunately, these practices have been in place for over 30 years, and likely will take a long term plan and involvement of many branches of the equine industry to abolish. There are few legal statutes in place to protect horses against such inhumane practices, making prosecution difficult or impossible. Exhibitors and owners, who may be found culpable, even without knowledge that their horse’s tail has been altered, need to educate themselves on any and all procedures and medications recommended by a trainer to ensure that their horses are not being subjected to inhumane procedures. Hopefully, judges will be properly instructed at judge’s education events and less reluctant to uphold current rules against tail alterations by not penalizing horses for normal tail position and movement. With time and pressure from owners and exhibitors, less weight will be placed on the appearance of a horse’s tail and more on the horse’s performance. Once judges fail to reward abnormal tail carriage, trainers and serious exhibitors will follow suit by discontinuing the practice to maintain a competitive edge. As with any change to a long standing practice, preventing people from altering horses’ tails will likely be a prolonged battle, but a necessary one to improve the welfare of our equine companions. Please join the concerned equine veterinarians of ACVIM—LAIM and AAEP in doing your part to end this inhumane, unnecessary and potentially dangerous procedure.

References:
2015 AQHA Rulebook; 2015 APHA Rulebook; 2015 ApHC Rulebook
2015 United States Equestrian Federation, Inc. Rulebook


**The Ration Balancer**  
By Stacy H. Tinkler, DVM, MPH, Dipl. ACVIM, Purdue Equine Community Practice

With the numerous feed options available for horses, it's a wonder any horse owner (or veterinarian) can keep anything straight! One thing we do know—gone are the days when it was thought that all every horse needed was some cracked corn and oats for a healthy diet. There is a lot more to equine nutrition than that, and feeding for life-stage (young growing vs older and less active), physiologic status (pregnant vs lactating), or activity level (idle, mild-moderate performance—intense exercise) requires different nutritional considerations. We know that most idle horses will maintain their body weight on a good quality pasture or hay without additional dietary supplementation; however, do you really know if all their nutritional needs are being met by your pasture or hay? Just like us, there are plenty of people who maintain an adequate body weight or are even overweight because they eat enough or too much food, but they are in fact nutritionally deficient in micronutrients due to a poor diet, and are actually less healthy. Without hay or pasture analysis, you really don’t know what your horse is getting in its diet, but there are some ways to provide your horse essential amino acids, vitamins and minerals if hay analysis doesn’t make sense for you. One feed option that owners or veterinarians may notice in the local feed store, or hear their clients talk about, is a product called a ration balancer.  

Almost all feed companies have their lines of ration balancers, some are called “diet balancers,” or “grass balancers” but they are all similar products. Let’s see what you know about ration balancers and if these could be a good fit for you and your horse!

**MYTH or FACT? My horse is on an all-forage diet so he doesn’t need a ration balancer.**  
**MYTH:** Mature horses able to maintain their weight on an all-forage diet of hay or pasture, otherwise known as “easy keepers,” would benefit from a ration balancer. Why? Well, there are lots of types of legume and grass hays out there and the nutritional content of these hays varies greatly depending on the region where they are grown, and when and how they are harvested. Protein, vitamin, and mineral deficiencies may be present in your forage and ration balancers are often used to compensate for these deficiencies. One important thing to note is that if your horse eats 50% or more of its diet as grass hay, it needs a balancer meant to be fed with grass or a grass formula. The same is true of alfalfa, if the diet is 50% or more alfalfa you should use the alfalfa formula to keep protein and minerals balanced for this type of forage.

**MYTH or FACT? Feeding too much protein to my weanlings will make them grow too quickly and end up with crooked legs.**  
**MYTH:** Young horses need a high protein diet for optimal growth. Ration balancers were formulated for the growing horse, and are meant to be fed in conjunction with a high-quality forage source so they can provide the amino acids, vitamins, and minerals a horse needs without the excess calories (from too much energy from carbohydrates or fats) that could put young horses at higher risk of developmental orthopedic diseases such as physisis (joint swelling), angular limb deformities, contracted tendons, OCD (osteochondrosis dissecans) or wobbler’s/CVM (cervical vertebral malformation).

Regarding mature horses, ration balancers typically have lower feeding rates than regular concentrates. Because ration balancers contain concentrated levels of amino acids, vitamins, and minerals, most mature horses can get the necessary nutrients by consuming 1-2 pounds per day. The crude protein level in grass ration balancers generally ranges from ~28-32%, with some other supplements that go even higher. Due to the smaller overall amount fed, the total daily protein consumed by your horse on a 32% crude protein ration balancer is not much different than following the bag tag and feeding the recommended amounts of a 12% crude protein feed—it’s just that you feed more of the 12% protein feed to your horse. When feeding ration balancers, you need to make sure that the rest of the horse’s diet consists of high quality forage—either grass or pasture.

**MYTH or FACT? Ration balancers are low in starch so they are a good option for my laminitic pony/horse.**  
**FACT:** A ration balancer is a good option for those horses that cannot tolerate high sugar and starch levels in some grains or concentrates, such as those with Cushing’s disease (pituitary pars intermedia dysfunction or PPID), insulin resistance/equine metabolic syndrome (EMS), or chronic laminitis. As ration balancers are fed in small amounts and consist of amino acids, vitamins and minerals primarily, by feeding them you are not contributing significantly to starch or sugar levels in your horse’s diet. This can be especially important in horses that have their hay soaked to remove simple sugars—when you soak hay, you can remove up to 30% of the water soluble sugars in it, which is great for lowering the sugar content, but you are also losing essential water soluble vitamins and minerals in that process. By providing a ration balancer you can minimize nutrient deficiencies due to hay soaking. Additionally, the lower glycemic index (sugar spikes in the blood) of a ration balancer has the potential to lessen a horse’s hyperactive behavior making it a less “hot” option for your horse. Protein does not make horses “hot”, excess energy in the form of too many calories does.

**Take Home Messages**
All of the feed companies have their version of a ration balancer. When choosing one that is right for you, cost and convenience will likely be part of the decision making process. Feeding ration balancers is less expensive than feeding grain, even though the cost per bag may be higher. This is because a balancer is concentrated and you feed much less of it daily than you would when feeding grain or other concentrates. The ration balancer is a great feed option for all classes of horse. Because you feed smaller amounts of it, and it has lower sugar and starch levels, it can be incorporated into any feeding program with a high quality forage source and often no other additional supplementation is needed. Read the bag carefully as some ration balancers are meant to be fed with a primarily grass forage diet, and others with legume-based forage diets. Contact your veterinarian or consult an equine nutritionist if you have any questions about integrating a ration balancer into your horse’s diet.
The Equine Sports Medicine Center

Purdue’s Equine Sports Medicine Center is dedicated to the education and support of Indiana horsemen and veterinarians through the study of the equine athlete. The Center offers comprehensive evaluations designed to diagnose and treat the causes of poor performance, to provide performance and fitness assessments, and to improve the rehabilitation of athletic horses. Other integral goals of the Center are to pioneer leading-edge research in the area of equine sports medicine, to provide the highest level of training to future equine veterinarians, and to offer quality continuing education to Indiana veterinarians and horsemen. For more information visit our website:

www.vet.purdue.edu/esmc/
Purdue Veterinary Medicine Breaks Ground for $8.8 Million Equine Facility

In Purdue Veterinary Medicine celebrated the start of construction of the new $8.8 million Centaur Equine Diagnostic and Surgical Center with a groundbreaking ceremony Tuesday, October 20 in Shelbyville, Ind. The satellite facility will provide specialty medical and surgical services for horse owners, while supporting equine research and education of future equine specialists. With site work already underway, the ceremony took place trackside at the Indiana Grand Racing and Casino.

Dean Willie Reed started the ceremony by welcoming guests and sharing about the facility’s importance in enhancing the College’s outreach and engagement efforts in support of the state’s equine industry. “This is an exciting day that marks a major milestone in our dream of creating a state-of-the-art equine referral hospital on location in the heart of Indiana’s horse racing industry, enabling our College to bring advanced medical and surgical services directly to the equine athletes and their owners,” said Dean Reed. “This center will house the most technologically advanced medical equipment to diagnose and treat equine patients while also facilitating groundbreaking research and vital educational opportunities for students preparing for careers as equine specialists.”

(continued on pg. 2)
The 18,000 square foot state-of-the-art facility is slated for completion by late 2016. Located just a few miles from the Indiana Grand Racing & Casino’s track in Shelbyville, and within an hour’s drive from Hoosier Park in Anderson, Ind., the facility will be part of the Purdue Equine Sports Medicine program based on the West Lafayette campus. It will offer advanced diagnostic imaging, shockwave therapy, regenerative medicine, endoscopy laser surgery and specialized equine orthopedic surgery and specialized equine surgery.
Dean Willie Reed, Chairman and CEO of Centaur Gaming Rod Ratcliff, President Mitch Daniels, President of the Shelby County Board of Commissioners Kevin Nigh, and Shelbyville Mayor Tom DeBaun ceremonially break ground for the Centaur Equine Diagnostic and Surgical Center.

“This new facility compliments Purdue University’s longstanding commitment to serving the equine industry and will continue to build on what the Indiana Horse Racing Commission and so many in Indiana’s horse racing industry have worked toward for the last 20 years—making Indiana a top-notch racing state and a recognized leader in the sport,” said Rod Ratcliff, Centaur Gaming chairman and CEO. Indianapolis-based Centaur Gaming, founded in 1993, owns and operates Indiana Grand Racing & Casino in Shelbyville; Hoosier Park Racing & Casino in Anderson; the Winner’s Circle Pub, Grille & OTB in Indianapolis as well additional off-track betting operations in Clarksville and New Haven, Indiana.

“Shelbyville and Shelby County are excited about the groundbreaking for the new Centaur Equine Diagnostic and Surgical Center,” said Shelbyville Mayor Tom DeBaun. “This project is a great model of public and private partnerships between the City of Shelbyville, Shelby County, Centaur Gaming and Purdue University. Now that construction is beginning, we look forward to the completion of a beautiful equine specialty referral hospital that will have a significant positive impact on our community.”

The ceremony also featured remarks by Kevin Nigh, President of the Shelby County Board of Commissioners and Purdue President Mitch Daniels. Then Dean Reed joined the others on the stage to ceremonially break ground. A reception followed as well as a commemorative horse race—the “Purdue Veterinary Medicine Classic,” named in honor of the College. After the race, Indiana Grand presented a commemorative horse-blanket embossed with the date of the event and the College’s logo.

Horses race to the finish line at a race during the Centaur Equine Diagnostic and Surgical Center groundbreaking celebration.

(Photo courtesy of Ed Lausch)
Choke in horses can be a dramatic experience for both horse and owner. In people, choke refers to an obstruction of the airway, while choke in horses refers to an obstruction of the esophagus. While the horse is still able to breathe, choke is a veterinary emergency and requires immediate attention.

**Presentation and Clinical Signs**

Horses presenting with esophageal obstruction commonly have excessive salivation and nasal discharge that contains saliva and feed material. As the horse attempts to swallow, muscle spasms can be seen along the neck. Horses will try to extend their head and neck, cough, may show signs of colic, or be anxious or depressed. In over 80% of cases, horses presenting for choke had a palpable mass on the left side of the neck.

** Causes and Diagnosis**

Causes for choke include poor dentition, improper mastication (chewing), types of feed (pelleted or cubed), or treats (apples or carrots). Sedated horses are at risk of choke because the drugs used for sedation also have an effect of slowing down the normal motility of the esophagus allowing for slower passage of feed and more of a chance of feed accumulation in the esophagus. Greedy eaters are also at risk because they eat large amounts of feed faster than the esophagus can move the feed through normally. Lastly, geriatric horses are naturally more predisposed to choke, either from poorer dentition from inadequate dental care over their life, or from natural age-related changes in dentition and tooth loss. Your veterinarian will make the diagnosis of choke based on history, clinical signs such as nasal discharge containing saliva and/or feed material, and passage of a nasogastric tube into the esophagus to estimate the extent of the obstruction.

** Interventions**

Some horses can pass the obstruction without veterinary intervention. However, choke is a veterinary emergency as the horse can become quickly dehydrated or develop pneumonia from aspiration of feed material if it is severe or long-standing. A veterinarian will heavily sedate the horse in order to get the horse to lower its head. A nasogastric tube will be passed and attempts to soften and push the mass into the stomach will be done by lavaging (rinsing) the esophagus with water. Most obstructions will resolve with sedation, rehydration, and withholding feed for a short time; however, prolonged or untreated esophageal obstruction can result in permanent scarring and narrowing of the esophagus and be life-threatening to your horse.

Endoscopy can potentially be utilized to detect the presence of an obstruction and any significant damage to the esophagus. With longer-standing obstructions, the esophagus can become irritated, inflamed, and ulcerations may be present. Feed should be reintroduced slowly once the obstruction is relieved by feeding a slurry or mash. Depending on the severity and duration of choke, some horses may require anti-inflammatories and/or antibiotics to prevent pneumonia from aspirated feed. Prognosis for horses following esophageal obstruction is favorable provided the clinical signs are detected early and treated; however, complications include aspiration pneumonia (inhalation of feed material into the lungs), esophagitis (esophageal inflammation), stricture formation (narrowing or scarring of the esophagus), and esophageal rupture.
Inside the Equine Medicine Cabinet: Analgesics
By Dr. Alex Bianco, DVM, Purdue Equine Community Practice

Though it may be difficult to believe, the concept of animal pain has been historically controversial. The definition of pain is the feeling of suffering, and describes an emotional rather than a physical response to unpleasant stimuli. Animals were thought to be incapable of feeling pain because they were unable to communicate such an emotion. The physical response to negative stimuli is called nociception; early research on animal behavior focused on the animal’s physical response to stimuli without acknowledgement of an emotional response.

In the past 50 years, however, the role of companion animals in our lives has drastically changed. One major area of change has been in recognition of the human-animal bond, i.e. the emotional attachment we have with our animals. As a result, the paradigm has shifted, and current research is focused on how we, as humans, can better recognize and interpret animal emotions, including pain.

Animals are assumed to experience pain in any situation that would cause a human to experience pain, such as after an injury, surgery, or with chronic disease, namely osteoarthritis (OA). Treatment of animal pain is best achieved through a multimodal approach. This may include a combination of pharmaceuticals (drugs), physical therapy, bandaging, cryotherapy (ice), and alternative modalities such as chiropractics or acupuncture. Because most pain is caused by inflammation, the most common drugs used to treat pain in horses are non-steroidal anti-inflammatory drugs (NSAIDs). These drugs work by decreasing the body’s normal inflammatory response to tissue injury through the inhibition of the cyclooxygenase (COX) enzymes. Because NSAIDs only work when there is an inflammatory response and do not affect the transmission of pain, they are non-habit forming.

Many horse owners are familiar with NSAIDs in their own medicine cabinets, e.g. Ibuprofen, Aleve®, as well as in their barns, e.g. phenylbutazone (“bute”) and flunixin meglumine (“Banamine®”). However, while there are many different types of NSAIDs used in humans, there are only 3 approved for use in horses. This includes the two previously mentioned as well as firocoxib (Equioxx®).

Prevention
Proper dental care and feed management should be discussed with your veterinarian to prevent future esophageal obstructions. Remember, older horses are particularly at risk as they age and their teeth start to wear abnormally. This normal aging and change in dentition can prevent horses from chewing their hay well and could put them at greater risk of choke. Feeding a diet consisting of pelleted feed and/or hay cubes instead of hay may be best for your horse if this is the case. Management strategies for preventing choke include scheduling regular dental exams annually, feeding away from other horses to reduce competition, slowing down fast eaters by using bricks or stones in the bottom of the feed bucket, feeding smaller amounts more frequently over the course of the day, and by having adequate drinking water available at all times.

(continued on pg. 6)
Due to the limited drug options, veterinarians often rely on the same drugs and drug dosages to treat a wide variety of painful conditions. A horse that undergoes major abdominal surgery, suffers a mild laceration, tendon sprain, or has a corneal ulcer will likely receive the same NSAID at the same dosage despite the differing degrees of pain. Not surprisingly, several studies have found that horses that undergo abdominal or orthopedic surgery still experience pain despite appropriate use of NSAIDs. This underscores the importance of accurate pain recognition, as such animals should receive additional analgesic medications.

In human medicine, opioids such as hydrocodone, oxycodeone, or morphine, are much more heavily relied on to provide pain relief. Opioids, unlike NSAIDs, are centrally-acting, which means they affect the nervous system’s ability to acknowledge and transmit pain to the brain. This is why opioids are addictive; they produce an affect even when the body is not experiencing any pain. Opioids such as butorphanol and morphine are also used in horses, but usually only in horses that experience pain despite NSAID use. While addiction is not a major concern for most equine patients, opioids have other well established side effects, the most significant of which is a decrease in gastrointestinal motility, which can lead to colic.

Unfortunately, NSAIDs can also have side effects. The COX enzymes affected by NSAIDs play a role in maintenance of normal body functions in addition to inflammation. Most importantly, COX enzymes help maintain the tissue that lines the gastrointestinal tract, called the intestinal mucosa. The COX enzymes also help to maintain blood flow to the kidneys in times of dehydration. With an overdose or even after long term usage of an appropriate dose, NSAIDs can lead to ulceration of the stomach and/or large intestine, diarrhea, and kidney failure.

At Purdue University, we are currently looking at the safety and efficacy of the NSAID ketorolac tromethamine in horses. Kitorolac is an NSAID widely used in human medicine to treat severe pain, such as after abdominal or orthopedic surgery. One of the benefits of ketorolac is that it is formulated for intravenous (IV), intramuscular (IM), or oral (PO) use. The first step to using a human medication in animal patients is a pharmacokinetic trial to examine how the body metabolizes the drug after administration. The pharmacokinetics of ketorolac in horses was determined here at Purdue and was recently published. Currently, more research is underway to determine ketorolac’s ability to decrease inflammation in horses.


Winter is here, and it brings many challenges for horse owners. Water buckets are freezing over and there is the constant question of whether to keep your horse shod or not. Keeping these hoof care tips in mind will help keep your horse comfortable and sound during this cold season.

**Keeping hooves healthy from the inside out**

Healthy hooves start with good nutrition. Poor nutrition can result in brittle, cracked hooves despite applying every type of hoof dressing that the tack store offers. A proper balance of amino acids, vitamins, and minerals are important for proper hoof growth and quality. As winter approaches, horses transition from grazing pasture to a predominantly hay-based diet. Even when baled from the same field, hay can vary in nutrients from year to year and between first, second, and third cuttings. To ensure that your horse is getting enough nutritional building blocks for healthy hooves, a ration balancer can be fed to compensate for any deficiencies in the hay. Hoof supplements can also be added to the complete nutrition plan for horses that have especially poor quality hooves.

**Regular farrier care**

Hoof growth can be slower in the winter months, but it is important to continue routine farrier visits to maintain hoof balance. Discuss with your farrier an appropriate interval between visits for your individual horse during the winter. When the temperature increases enough for the snow to melt, paddocks can become very muddy. Keep an eye out for thrush or white line disease during these wet conditions. Regularly cleaning hooves and providing your horse with dry areas out of the constant mud will help prevent these issues. The sole of the hoof can also become bruised in frozen and icy conditions. Monitor your horse for signs of lameness, a foul smell coming from the hooves, black discharge, or areas of separation of hoof integrity at the white line. Speak with your veterinarian and farrier with any concerns.

**Shod or barefoot?**

Some horse owners prefer to have their horse’s shoes pulled for winter. This can be beneficial because metal shoes decrease traction on icy ground and snow does not pack into the barefoot hoof as easily. Snowballs can form in the middle of the shoe and build up so that it is like your horse is walking in high heels. This can cause strain on the tendons and ligaments in the legs and can be dangerous and uncomfortable on icy ground. However, some horses do not do well barefoot during the winter due to thinner soles that results in sole bruising and other factors. If you choose to keep your horse shod over the winter, you might consider snow pads to help prevent the formation of these snowballs. Rim type snow pads are made of rubber or plastic, and a ring runs along the inside of the shoe. As the horse walks, the movement of the ring prevents the snow from packing and freezing into the shoe. Another type of snow pad is a full pad that covers the bottom of the hoof, and a raised bubble pops snow out of the shoe as the horse walks. Horses who are ridden often in snow and ice may also need the help of borium or studs to increase traction in these conditions. Speak to your farrier about these options to decide the best plan for your horse.

References:


The Equine Sports Medicine Center

Purdue’s Equine Sports Medicine Center is dedicated to the education and support of Indiana horsemen and veterinarians through the study of the equine athlete. The Center offers comprehensive evaluations designed to diagnose and treat the causes of poor performance, to provide performance and fitness assessments, and to improve the rehabilitation of athletic horses. Other integral goals of the Center are to pioneer leading-edge research in the area of equine sports medicine, to provide the highest level of training to future equine veterinarians, and to offer quality continuing education to Indiana veterinarians and horsemen. For more information visit our website:

www.vet.purdue.edu/esmc/
APPENDIX B

Research Projects in Progress Supported with Pari-Mutual Funds

- **Hawkins J, Freeman L, Li J, Gillespie C.** *Investigation into the use of a topical application of a hyperosmolar nanoemulsion to wounds of the distal extremity in horses.*

- **Kritchevsky J, Croney C, Lescun T.** *Pasture Sound: The effect of lameness on behavior and other measures of welfare in horses.*

- **Main RP, Lescun T, Wallace JM, Siegmund T.** *Validation of an in vivo assessment for fracture risk in equine limb bones.*

- **Taylor SD, Bianco AW, Moore GE.** *Anti-endotoxin properties of ketorolac tromethamine in horses.*
Effects of topical application of silver sulfadiazine, triple antibiotic, hyperosmolar nanoemulsion under a bandage on wound healing, bacterial load, and granulation tissue formation in equine full thickness wounds: A randomized controlled study

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Key words: horse, wound, silver sulfadiazine, triple antibiotic, hyperosmolar nanoemulsion, granulation tissue

Funding: Funded by Purdue University Competitive Equine Research Funds

Ethical considerations: The study was approved by the institutional Animal Care and Use Committee

Conflict of interest: Dr. Jianming Li and Sean Connell are the developers of the hyperosmolar nanoemulsion used in the study.

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Abbreviations:

CFU – Colony forming units
EGT – Exuberant granulation tissue
HNE – Hyperosmolar nanoemulsion
SSD- 1% Silver sulfadiazine cream
TAO – Triple antibiotic ointment (neomycin, polymyxin, bacitracin)

Introduction:

Skin wounds are one of the most common conditions treated by equine veterinarians, and they have a significant negative financial impact on the equine industry. According to one report, between 19 and 24% of equine euthanasias were the result of either skin wounds or trauma.1 Distal limb wounds account for 7% of all injuries that lead to retirement of racehorses.2 Equine distal limb wounds are usually infected and are prone to formation of excessive granulation tissue. Distal limb wounds have a longer preparatory phase of healing, a greater retraction of the wound margins, and a slower rate of wound contraction and epithelialization compared with wounds on the trunk of the horse.3 Excessive fibrosis and EGT can be detrimental to functional and aesthetic outcomes.4 Healing is delayed, in part, because the protrusion of EGT above the skin margins of the wound inhibits re-epithelialization. A complex pathway and multiple factors are associated with the formation of EGT, which is thought to originate from a chronic low-grade inflammatory state. One of the key factors implicated in EGT formation is wound contamination.2 Bandages are commonly used on distal limb wounds to reduce contamination and edema, minimize movement, and protect the wound from further trauma.4 However, bandages are often associated with EGT.5 Many different treatments (platelet rich plasma, sunflower-seed oil, 1% silver sulfadiazine slow-release matrix, 25% propylene glycol hydrogel, silicone containing dressings) have been investigated to combat EGT, but none have proven universally successful.5–8 While these products may show improvement in the early stages of wound healing, none have prevented EGT formation nor reduced the healing time compared to untreated control wounds.5–8
Hyperosmolar nanoemulsion (HNE) is a novel compound that combines lipophilic (membrane disrupting) nanoemulsions with hyperosmotic saccharides. The hyperosmotic saccharides are similar to sugar/honey treatments, but when combined with the lipophilic emulsions (thymol), the two components act synergistically to inactivate a wide range of pathogenic organisms including *Escherichia coli*, *Enterococcus faecalis*, *Staphylococcus aureus* and its MRSA variant. The components act together to disrupt the membrane and then dehydrate the microorganisms. The product has been investigated in guinea pigs and swine and has shown to decrease the bacterial flora present on the wound surface and time of healing. These species, however, rarely produce EGT.

Since wound contamination has been implicated in the development of EGT, we hypothesize that topical administration of antimicrobials under a bandage may reduce wound bioburden, minimize EGT, and promote re-epithelialization. Therefore, our objective was to evaluate the effects of a novel HNE and to compare it to the traditional wound medications, silver sulfadiazine cream and triple antibiotic ointment, for their effects on wound healing in an equine distal limb injury model. The model involved contaminating the wounds with a bacterial and fungal load and tracking the microbial populations of each wound over time to determine their effects on wound healing as especially on the formation of EGT.
Materials and Methods:

All procedures were approved by the Purdue Animal Care and Use Committee (PACUC). Eight horses between the ages of 4 and 15 were used in this study. All horses underwent a physical and lameness examination to rule out any systemic conditions that would impede would healing. Horses were included if auscultation of the heart and lungs were normal and no scars or defects were noticed on the distal limbs.

Wound creation time line- On day 0, the horses had a single, 2.5 x 2.5cm wound (4 wounds total) created on each distal limb over the dorsal medial cannon bone in the mid-metacarpal region using a standardized template. Full thickness skin wounds were created by scalpel incision and the skin and subcutaneous tissue was removed. The wounds were bandaged with a nonstick pad (this should be footnoted), sterile gauze, and elasticized wrap. Phenylbutazone (4.4 mg/kg, PO) was administered and continued for three days after wounded (2.2 mg/kg, PO, q 24 h). Horses were sedated as needed for bandage changes with xylazine hydrochloride (0.4 -0.5 mg/kg, IV) or detomidine hydrochloride (0.01mg/kg, IV). On day 1, the bandages were removed and wounds were contaminated by applying a filter paper inoculated with a combination of bacteria Staphylococcus aureus, Enterococcus faecalis and Escherichia coli and 1 fungal strain of Candida albicans. A total concentration of 5.0x10^6 CFU were applied to each wound in a 1:1:1:1 ratio. The wounds were then bandaged again. On day 2, the bandages were removed and the wounds were cultured. The wounds were first wiped with sterile gauze to remove visible exudate and then a sterile cotton tip applicator was rolled on the wound and then used to directly inoculate a Tryptic Soy Agar plate. Wounds on each horse were randomized to receive: SSD, TAO, HNE, and control (no ointment) applied. Each horse received all four treatments, with one treatment per limb. The wounds were re-bandaged. On day 3, the wounds were cultured, treated, and bandaged again. The wounds were treated and bandaged daily from day 4 to 9, bandaged every other day from day 10 to 21, and bandaged every third day from day 21 until day 45. Treatment of the wounds occurred at bandage changes until day 21, when treatment was discontinued. Cultures were obtained prior to treatment on days 2, 9, and 21. Beginning on day 45, the bandages were discontinued. Wounds were then observed and photographed on days 50, 61, 71, 81, 91, 101, 111, 121, 131, and 135. A 6mm biopsy sample was taken from each wound and normal skin on day 135 for histologic examination to assess wound healing including epithelialization. Two horses had additional 4 mm biopsies when the bandages were removed on day 45. If EGT
began to grow above the level of the skin or advancing epithelium, the granulation tissue was trimmed with a No. 10 scalpel blade and bandaged without treatment.

*Surgical procedures (Day 0)-* Horses were sedated with detomidine hydrochloride (0.01mg/kg, IV) and butorphanol tartrate (0.01mg/kg, IV). All four limbs were clipped on the dorsal aspect between the carpus/tarsus to the fetlock. The area was aseptically prepared with chlorhexidine, saline, and alcohol. A dorsal ring block was used at the proximal aspect of the clipped area with 12 cc of mepivicaine. A rubber template with a 2.5 x 2.5 cm square outline was fixed to the limb, and the skin was incised using a #10 blade. A full thickness 2.5x2.5cm piece of skin was removed over each site. The template was removed, and a non-stick pad with 4x4 gauze squares was placed over the wound. Sterile gauze was then used to wrap the limb and hold the non-stick pad and gauze in place. Elastic tape was then used to cover the bandage and partially fix the bandage to the skin. This allowed for all of the treatments to remain on the wounds; as the SSD and TAO would wipe on easily, but the HNE would not stay in place without a bandage.

*Evaluation-* Digital photographs were taken at each bandage change using a set focal distance and ruler for calibration. The ruler was also used as a label to identify the horse, wound location, and day. Total wound area, wound perimeter, and granulation area was determined from the digital photographs using an image analysis software program. The wound area was determined by tracing the hair margin of the wound periphery. The granulation tissue area was determined by tracing the margin between granulation tissue and epithelial edge. Each measurement was repeated 3 times by the same individual and a mean was determined. The percent of closure was calculated for each wound by determining the percent difference of the initial wound area on day 0 and wound area for each day. Healing was assessed by: the number of days until healing (complete epithelialization or closure with an eschar), the number of granulation tissue excisions and the rate of epithelialization. Quantitative cultures were obtained on days 2, 3, 9, and 21. These plated samples were submitted to a laboratory where the colony forming units were counted after 24 hours. The wound biopsies from day 45 and 135 were placed in 10% neutral buffered formalin and submitted for histopathology.

*Histopathology-* One 6-mm punch biopsy specimen from each wound and from normal (non-wounded) skin from the left forelimb approximately 5cm dorsal to the wounded site from each horse was obtained at 135 days post-injury. Biopsy specimens were also obtained from horses 9 and 10 at 45 days post-injury when bandaging was
discontinued. Each biopsy specimen was placed in an appropriately labeled (horse identification number, plus indication of leg as left fore, right fore, left hind, or right hind) formalin container. After 2-5 days formalin fixation, each biopsy specimen was bisected longitudinally and transferred to a tissue cassette. The formalin fixed tissue was processed routinely, then both halves of each specimen were embedded in paraffin. Formalin-fixed paraffin-embedded sections (4 μm thickness) were stained with hematoxylin and eosin (H&E) and with Masson’s trichrome. Histochemical stains were performed on the same day with the same solutions for all specimens. H&E- and trichrome-stained sections were examined with a microscope and were also digitalized using the Aperio (Aperio Technologies; Vista, CA) scanning system at 400x magnification. Digital images were analyzed using ImageScope (Spectrum Analysis algorithm package and ImageScope analysis software, version 9; Aperio Technologies, Inc.).

All histologic evaluations and image analysis were performed without knowledge of the treatment group. Epidermal healing was scored as 0 = absent, 1 = present only at edge, 2 = surface spanned by loosely attached epithelium, 3 = surface spanned by hyperplastic (acanthotic) epidermis with rete pegs. Cutaneous adnexa (hair follicles, sebaceous and sweat glands) were scored as 0 = absent, 1 = present only at edge of section, and 2 = spanning the section. Inflammation was recorded as present or negligible to absent. Granulation tissue was scored as 1 = minimally organized, densely cellular fibrovascular proliferation; 2 = organized with plane of neovascularization (still the predominant component) perpendicular to plane of fibroplasia, and 3 = well organized with increased fibrous collagen and diminished vascularity. Mitotic index in granulation tissue was recorded as number of mitotic figures in fibroblasts or vascular wall cells per ten 400x fields. All biopsy specimens of normal (non-wounded) skin were considered to be within normal limits and were not graded, but were used as the standard for grading wounded skin.

The granulation tissue in the healing wounds was further evaluated by color deconvolution of collagen staining (Masson’s trichrome stain) and vascular density morphometry (H&E stain). The normal skin specimens were used as the dermal standard for color deconvolution image analysis, but were not included in the vascular density morphometry because granulation tissue was not present in the normal skin specimens.

For color deconvolution of collagen staining in Masson’s trichrome-stained Aperio-scanned images, the perimeter of each histologic section (both halves of the biopsy specimen; hence, two histologic sections per wound) was traced with the pen tool, omitting epidermis and any serocellular crusting, then an algorithm was applied to calculate the area of positive staining within the tracing, as well as the percentage of weak, medium, and strong positive staining.
The algorithm was calibrated\textsuperscript{1} for concordance with visual observation to set the intensity thresholds for positivity and separation into weak, moderate, and strong staining. The algorithm also calculated a score (1 X % weak staining + 2 X % moderate staining + 3 X % strong staining) for each section.

To measure vascular density in the wounds, two 1-mm-diameter squares were drawn in the dermal granulation tissue in H&E-stained, Aperio-scanned images. One square (superficial square) was placed near (but not contiguous with) the ulcerated surface or just beneath intact epidermis. The second square was placed just deep to the superficial square. The squares were placed in what was interpreted as closest to the center of the wound. Once the squares were placed, all clusters of neovascularization or individual immature vessels were traced with the pen tool at 7-8X magnification so that the 1-mm square filled the monitor screen. Vascular density was recorded for each square as cross-sectional vascular area/area within the 1-mm square.

\textit{Statistical analysis-} Using all treatments on the same horses, eight horses were required to demonstrate, with 80\% power and 95\% confidence, a significant difference in healing times between treatment (83+/- 14 days vs. 101+/-25 days). The means and standard deviations were adjusted from Berry et al\textsuperscript{6}. Paired T tests and an ANOVA were utilized to determine if there was a statistical difference between the treatments in the areas of wound closure, bacterial load, granulation tissue excision, and histopathology.

Wound trimming, epidermal healing, cutaneous adnexa, granulation tissue organization and inflammation presence were analyzed using the Freidman test procedure in SAS (v9.4). This rank-based non-parametric test was chosen as it allows comparisons of more than two groups with ordinal data. Post-hoc pairwise comparisons of significant Friedman Tests were ran using the pairwise multiple comparison of mean ranks package (PMCMR) in R (v3.2.0) (Pohlert, 2014) with Hommel adjustment. Mitotic index, color deconvolution of collagen staining, and vascular density morphometry were analyzed with a one-way repeated measures ANOVA using Proc Mixed in SAS (v9.4). Horse was the subject of the repeated statement. All of our data were independent, linear, and normally distributed. All models used a significance criterion alpha = 0.05.

\textbf{Results}

\textsuperscript{1} The authors thank Dr. YL Jones-Hall for assistance with image analysis.
Demographics- 8 horses were utilized in the study ranging in age from 4-11 years of age. There were 5 geldings and 3 mares (2 Appaloosas, 2 Quarter Horses, 1 Standardbred, 1 Thoroughbred, 1 mixed breed horse, and 1 Warmblood).

Wound size- All of the wounds expanded for the first week after wound creation then began to contract and epithelize. The average number of days until wound closure for each treatment group were: control (43.43 ± 2.20 days), TAO (43.38 ± 1.41 days), SSD (42.71 ± 1.44 days), and HNE (42.50 ± 1.54 days). The days to closure ranged from 36 days to 50 days (median = 42 days). All of the wounds developed a dry eschar after the bandages were discontinued. There was no significant difference seen between any of the treatments and the time to wound closure (p=0.730).

Bacterial load- Hyperosmolar nanoemulsion treated wounds had the highest bacterial load, followed by the control, then SSD and the least bacterial load was TAO treated wounds. The HNE treated wounds had a significantly higher CFU than the wounds treated with SSD and TAO (p=0.021 and p=0.026). This was particularly true at the beginning of treatment as the CFU increased with the SSD and TAO treated wounds as the study progressed but did not reach the same level as the control wounds or HNE treated wounds. The HNE, TAO, and SSD treated wounds did not significantly differ in CFU from the control wounds.

Granulation tissue excision- Out of 8 wounds with each treatment, 7 wounds treated with SSD required trimming of exuberant granulation tissue, 5 wounds treated with HNE, 3 control wounds, and only 1 wound treated with TAO. Using a Fishers exact test the wounds treated with TAO needed exuberant granulation tissue trimmed significantly less than wounds treated with SSD. There was a difference between how many times wounds were trimmed with the different treatments ($\chi^2(3) = 12.00$, $p = 0.01$). SSD treated wounds were trimmed more than antibiotic treated wounds and control wounds and emulsion treated wounds were trimmed more than antibiotic treated wounds.

Histopathology-

There was no difference between the treatments for wound inflammation ($\chi^2(3) = 4.38$, $p = 0.22$; table B). Furthermore, there was no difference between treatments of the H&E stains for epidermal grading ($\chi^2(3) = 4.56$, $p = 0.21$), cutaneous adnexa grading ($\chi^2(3) = 0.00$, $p = 1.00$), granulation tissue organization ($\chi^2(3) = 2.02$, $p = 0.57$), or mitotic index in granulation tissue ($F(3, 21) = 0.30$, $p = 0.83$). There was also no difference of Masson’s trichrome
stain for collagen fibers between treatments when normalized again a normal dermal tissue sample (weak stain: \( F_{(3, 21)} = 0.24, p = 0.87 \); mod stain: \( F_{(3, 21)} = 1.89, p = 0.16 \); strong stain: \( F_{(3, 21)} = 0.42, p = 0.74 \); overall score: \( F_{(3, 21)} = 0.40, p = 0.76 \)). There were no differences of the vascular density morphometry between treatments (superficial: \( F_{(3, 21)} = 0.68, p = 0.57 \); deep: \( F_{(3, 21)} = 1.33, p = 0.29 \); mean: \( F_{(3, 21)} = 0.88, p = 0.47 \)).
**Discussion:**

This study showed that full thickness excisional skin wounds inoculated with bacteria or fungi on the extremities of horses that were managed with bandages did not differ in the rate of healing when SSD, TAO, or HNE were applied topically and compared to control. This is consistent with previous studies and indicates that application of medications to wounds under bandages is not necessary, particularly after the formation of granulation tissue.5–7,13

When the wounds were cultured, all of the treatments initially decreased the number of bacteria in the wounds. At day 9, the HNE treated wounds had a significantly higher bacterial load than those treated with either SSD (p<0.004) or TOA (p<0.001). Additionally, the TAO treated wounds had significantly less bacterial load than untreated control wounds (p=0.0267). On day 21, HNE treated wounds had a significantly greater bacterial load than TOA treated wounds (p=0.0122). HNE was developed to help decrease bacterial load in wounds, it was not effective in this model. This may be due to the frequency of bandage changes from days 9-21 as dressings were changed every other day and every third day thereafter. Since HNE is composed primarily of hygroscopic saccharides, its effectiveness may require more frequent dressing changes. Indeed, other studies with medicinal honey and sugar require daily or multiple dressing changes per day. Frequent bandage changes were not practical in this study because horses often needing sedation for the bandage changes. In addition, daily dressing changes are very expensive when used in chronic wounds and daily bandages are not routinely performed for a long duration on a clinically similar wound.

Despite the differences in bacterial load observed at days 9 and 21, there was no difference in wound healing among the wounds treated with topical agents. This was unexpected, as wound infection is known to delay wound healing. This may be different in clinical wounds that do not all have the same initial bacterial load or that have more extensive tissue damage. What are you trying to say here? Basically wound treatments are not necessary for this model when compared to a control in this model.

The number of wounds requiring excision of granulation tissue was interesting. Seven of 8 SSD treated wounds needed granulation tissue excised, compared to only 1 of 8 treated with TAO. The wounds treated with SSD subjectively had more exudate and appeared less healthy while being treated. In this study 3 of 8 control wounds developed EGT, and clinical practice recommendations are to treat EGT by topical application of steroids or
excision because EGT interferes with orderly progression of wound healing. From this study, we have determined that TAO may possibly minimize EGT formation when distal extremity wounds in horses are covered with bandages.

Bandages are used for distal extremity wounds in horses for large wounds over high motion areas. Previous studies have shown that wounds with minimal motion treated without a bandage produce less granulation tissue than those treated with bandages. This study was designed to evaluate three potential medications that might be used when a bandage is necessary. While none of the products tested demonstrated a significant reduction in time to closure, topical application of TAO reduced the number of wounds requiring excision of EGT. In this model the formation of the EGT was not directly correlated with the bacterial wound load because SSD treatment decreased the number of bacteria in the wound but more of the SSD wounds required excision of EGT. The HNE treated wounds were among those with the higher bacterial counts and were intermediate in the number of wounds requiring excision of EGT.

This wound healing model has innate limitations. The wound may not completely represent the wounds seen in clinical practice in terms of size and tissue damage. However, the model has been used commonly to access treatment protocols for distal limb wounds. An additionally limitation was identified with the colony forming units and bacterial load. Since the colony forming units were counted by an individual, there was error associated with the plates with a large number of CFUs. Finally, the wounds were created over a relatively low motion area when considering the equine distal limb. The time to closure may drastically change in wounds that are over high motion areas. Not sure what this sentence adds.

In conclusion, the original objective of the study, to evaluate the effects of novel HNEs as well as SSD and TAO on wound healing of the distal limb under a bandage, was achieved. However, our hypothesis that topical administration of antimicrobials under a bandage may reduce wound bioburden, minimize EGT, and promote re-epithelialization was not confirmed. In fact, all treatment groups achieved the same time until healing, and the only differences that were seen were in bacterial load early and in number granulation tissue excisions per treatment group. Based on this study, we would recommend treating distal limb wounds of the horse with TAO until a granulation tissue bed is present when using a bandage.
Bibliography


Kritchevsky J, Croney C, Lescun T. Pasture Sound: The effect of lameness on behavior and other measures of welfare in horses.

Progress report

Title: The effect of lameness on behavior and other measures of welfare in horses.

Principal Investigator: Janice E. Kritchevsky

Co-Investigators: Croney C, Lescun T.

2 horses have gone through the complete program (determination of lameness and behavioral evaluation before and after neurectomy). Data collection will resume in spring 2016.
**Significance:**

Bone fractures are a significant cause of morbidity and mortality for individual horses and the general horse population. For the individual horse, fractures cause pain and suffering, are challenging and costly to treat, and in some cases result in euthanasia. In the general population, fractures have been estimated to account for approximately 10% of overall equine mortality.\(^1,2\) Over the last decade, major fractures in high profile equestrian sports have attracted national media attention.\(^3,4\) Media scrutiny has also linked the issues of rider safety and musculoskeletal injury in horses, and highlighted the animal welfare concern of these injuries,\(^4,5\) prompting several initiatives by equestrian sports governing bodies to address the safety and welfare of equine athletes. In Thoroughbred racing, the Equine Injury Database was established in 2008 to accurately identify racing injuries at a national level. Currently, the database includes over 1.8 million race starts over 5 years.\(^6\) The database shows an overall fatal injury rate of 1.9/1000 horse starts. As over 80% of fatalities in racing are due to fractures and a similar or greater number of injuries occur during training,\(^7,8,9\) it can be estimated that approximately 1,400 horses are euthanized each year in the U.S. due to fractures that occur during racing or training. However, this estimate does not account for non-fatal fractures. Over a 14 year period at 10 Japanese racetracks, the average fracture incidence (fatal and non-fatal) was reported at 1.83% of all race entrants.\(^11\) Applying this fracture incidence to racing starts in the U.S., over 6,500 fractures would be estimated to occur in Thoroughbred racing each year. Similar overall rates of musculoskeletal injury have been reported in Quarter Horse and Standardbred racing, although injury distributions vary between racing breeds.\(^8,12,13\)

There is strong evidence that the majority of racing fractures are the result of accumulated bone tissue changes and not a single “bad step” during racing or training.\(^14\) The evidence includes common bone fracture locations and configurations, pre-existing pathology in both fractured and non-fractured bones in the same horse and incomplete fractures identified in the same locations as common complete fractures.\(^14,15\) The tissue and bone material changes that occur with repetitive high strain loading ultimately decrease fracture resistance of the bone tissue and the entire bone.\(^14,16\) The cumulative impact of training and racing on the musculoskeletal system, reflected in changes in its resistance to injury, means that it should be possible to reduce the incidence of fractures, when we are able to determine and detect the relevant changes in structural and bone tissue properties in advance of reaching the point of high injury risk. Dr. Tim Parkin, epidemiologist and consultant to the Equine Injury Database, has written previously that “…it is imperative that novel techniques are developed that enable the identification of the at-risk horse. It is only when we can predict with some degree of certainty that an individual is at significantly increased risk that we will see a significant reduction in the number of racehorses that are injured in training or during racing.”\(^17\)

Measurements used in vivo to determine bone toughness, or its resistance to fracture, have primarily been based on bone mineral density (BMD). In humans, the use of dual x-ray absorptiometry to measure BMD has been a benchmark method for the evaluation of patients at risk for osteoporosis.\(^18\) However, other factors such as bone turnover rate, microdamage accumulation, bone matrix properties and bone geometry contribute to skeletal fracture resistance as well.\(^19,20\)

In the human clinical setting, peripheral quantitative computed tomography (pQCT) is being increasingly utilized to identify individuals at risk for fracture as it provides accurate measures of not only BMD, but also aspects of trabecular and cortical architecture, and estimates of biomechanical properties (stiffness).\(^18\) Recently, pQCT has been used to examine sections of MC3 condyles in horses with condylar fracture and other limb fracture. It was found that the bone volume fraction (bone volume/total volume) of the metacarpal epiphysis tended to be higher in horses with condylar fracture, horses with other limb fracture and horses older than 3 years of age.\(^21\)
Another diagnostic method recently introduced into the human clinical setting to assess bone quality and fracture risk is reference point indentation (RPI).\(^{22}\) This novel bone indentation technique has been employed in preliminary studies to assess bone tissue mechanical properties in people,\(^{23-25}\) and has been shown to correlate with traditional mechanical measures of bone toughness.\(^{26}\) Bone toughness measures using this method have been shown to correlate with whole bone fracture resistance, even at skeletal sites distant to the measurement site.\(^{23-24}\) An RPI instrument known as the Osteoprobe, has been developed to allow measurements to be performed directly through the skin in a conscious patient. We have performed preliminary testing using this instrument in standing horses, showing that this technology could be transferred into the equine clinical setting.\(^{27}\)

Raman spectroscopy is a pre-clinical technology that has been used to evaluate bone matrix and mineral composition as it relates to aging, disease and injury.\(^{28}\) Raman spectroscopy has been successfully applied to equine cortical bone in laboratory conditions and has the potential to be applied in an in vivo clinical setting.\(^{29,30}\) Raman spectroscopy is uniquely complementary to other diagnostic technologies currently being investigated in the evaluation of bone quality in that it provides information on the mineral and matrix composition of bone.

The common diagnostic imaging modalities currently utilized in equine clinical practice to detect fractures include radiography, computed tomography, nuclear scintigraphy, MRI, and ultrasonography. Radiography, while ubiquitous clinically, has limitations in the detection of subtle early changes associated with bones at risk of fracture. However, it can provide basic structural information (dimensions) as well as identification of gross or macroscopic fractures. Standing low-field MRI or high-field MRI under general anesthesia is becoming more widely available in equine practice. Recently, evidence of edema in the cancellous bone surrounding condylar fissures and fractures in the equine MC3 were reported as a consistent finding associated with these pathologies,\(^{31}\) as an indication of stress related bone injury.\(^{32}\) We have chosen to utilize radiography in this study, as it is the most common method utilized to detect gross MC3 fracture, and MRI, as it is currently the most promising clinical method for detection of early pathology indicating stress related bone injury and possible impending fracture.

**Specific Aims:**

**Aim #1:** Validate currently available imaging methods (radiographs, MRI) and in vivo approaches for measuring bone tissue material properties (reference point indentation, RPI) for predicting limb bone fracture in the individual horse. Our goal is to establish criteria for specific diagnostic measures from which an accurate assessment of skeletal fracture susceptibility can be determined for an individual horse.

**Aim #2:** Validate human clinical imaging (peripheral quantitative CT, pQCT) and pre-clinical tools for assessing bone composition (Raman spectroscopy) for improving prediction of skeletal fracture occurrence in horses beyond the methods validated in the 1st specific aim. Our goal is to improve the accuracy in assessing skeletal fracture susceptibility in horses, thereby justifying development of these technologies for use in the clinical setting.

**Progress:**

1. **Summary.**

Our fundamental objective in this project is to validate existing clinical diagnostic tools and to advance pre-clinical tools for characterizing bone structure and tissue properties to form a small battery of non-invasive tests that can be used clinically to assess skeletal fracture susceptibility in the standing horse. To this end, we use the MC3 from cadaveric racehorses to relate fracture likelihood to measures made using imaging modalities and diagnostic tools currently used in veterinary and human clinical settings as well as pre-clinical tools with potential for clinical translation. The MC3 is the focus of these diagnostic tests because it is one of the most commonly
injured bones in racehorses, and provides the greatest clinical access to the bone’s surface, which is critical for the tissue-level tests we will conduct. While we expect that our tests will detect specific pathologies in the MC3 related to racing, we will also use this bone as a proxy for overall skeletal health. Similar approaches have been taken previously in human clinical assessments of bone health.

To assess the efficacy of the different diagnostic tools for predicting skeletal fracture, the MC3s from six groups of horses are examined:

1. racehorses in race training euthanized due to fracture of the MC3
2. racehorses in race training euthanized due to a fracture of another bone
3. racehorses in race training euthanized for reasons other than fracture
4. untrained horses euthanized due to a MC3 fracture
5. untrained horses euthanized due to a fracture of another bone
6. untrained horses euthanized for reasons other than a fracture

2. Sources for equine skeletal material.

Working in partnership with the Indiana Animal Disease Diagnostic Lab (ADDL), we have been granted access to skeletal material from racehorses euthanized in Indiana. Dr. Lescun has also been able to gain access to a limited number of horses donated through the Purdue Veterinary Teaching Hospital. To date, through two years of the project, we have achieved the following sample numbers for our six experimental groups: (1) 4 (2) 21 (3) 10 (4) 0 (5) 0 (6) 0.

2. We have recently entered into a partnership with the University of Kentucky Veterinary Disease Diagnostic Lab (UKVDL), to gain access to skeletal material from racehorses euthanized in Kentucky and submitted to the UKVDL.

3. Preliminary Data.

Using the assessment techniques outlined in the Significance section, we are able to identify differences in the bone structure, mineral density, and material properties between fractured and non-fractured MC3s in thoroughbred racehorses. Preliminary validation of these assessment techniques (pQCT, reference point indentation, Raman spectroscopy) was conducted on paired limbs from n=2 horses that had suffered unilateral MC3 fracture. This sample is composed of a 5yr old gelding and 2yr old female, submitted to the ADDL at Purdue University, following humane euthanasia at an Indiana racetrack. The MC3 fracture in the female was in the distal lateral condyle in the right forelimb (Fig. 1A). The MC3 fracture in the gelding was a comminuted fracture of the midshaft in the left forelimb (Fig. 1B). The contralateral limbs in each were free of noticeable pathology by x-ray. Paired fractured and contralateral intact MC3s were scanned at five anatomic levels by pQCT with the skin intact along the dorsal, medial, and lateral surfaces of the bone (Fig. 2A) and reference point indentation (Biodent & Osteoprobe) and Raman spectroscopy measures taken at
six sites on the bone. In the MC3 with the lateral condylar fracture, the original position of the slab was approximated through reconstruction with elastic bandaging prior to making pQCT measures. Therefore some pQCT measures could still be made at 75% and 90%. Raman and RPI measures at M75% were unaffected by this lateral surface fracture. In the comminuted left MC3 of the gelding, reconstruction of the midshaft was not possible, so pQCT could not be made at 25%, 50%, or 75%. Thus, these data were not included in our analysis here. Raman and RPI measures were still achieved from large dorsal and medial midshaft fragments, since only a small window (2cm²) is required to make these measures. These measures were made on the large fragments at a distance greater than 1cm from the fracture surface. These comminuted fractures are much less common than condylar fractures17, but their presence in our larger sample would prevent some paired measures (fractured vs. non-fractured MC3s) from being made in samples showing this fracture pattern.

Trabecular bone strength index and cortical bone mineral density were reduced in the fractured MC3s, indicating reduced structural properties and bone density in the proximal and distal metaphyses (Fig. 2B). The quality of the bone tissue in the fractured MC3s was also compromised. Mineral crystallinity, as measured by Raman spectroscopy, was decreased at D75% in the fractured MC3 (Fig. 2C) as were the mineral:matrix (CH2 wag)(D50%) and carbonate:amide I ratios (M50%) (data not shown). Reduced crystallinity, mineral:matrix, and carbonate:amide I all indicate a relatively immature bone tissue at these surfaces33, perhaps consistent with pathological bone formation at these periosteal sites34. Consistent with these observations, the RPI measures on the dorsal surfaces of the fractured MC3s showed decreased bone tissue stiffness (D75%, average unloading slope, Fig. 2E) and reduced fracture resistance (increased IDI at D75%, Fig. 2E). Interestingly, the medial surface (M25%) showed an opposite pattern from the dorsal surface, where both stiffness (unloading slope, Fig. 2E) and bone material

Figure 2: Measures made to assess MC3 structural and bone tissue properties. (A) Position of the pQCT, Raman, and RPI measures on the horse MC3. pQCT measures were made at 10%, 25%, 50%, 75%, and 90% of bone length, relative to the proximal end. Raman and RPI measures were made at 6 locations: 3 on the Dorsal surface [proximal (D25%), midshaft (D50%), and distal (D75%)] and 3 on the Medial surface at the same proximal-distal levels (M25%, M50%, M75%). (B) Trabecular bone strength index (Tb.BSI) and cortical bone mineral density (Ct.BMD) were decreased in fractured MC3s at proximal and distal locations. (C) Trends exist for reduced crystallinity in the fractured MC3s at D50%. (D) Osteomeasure RPI indicates increased bone material strength on the proximal medial surface of the fractured MC3s. (E) Fracture toughness and stiffness, measured by BioDent RPI, were reduced in the fractured MC3s at D75%, indicated by increased IDI and decreased unload slope, respectively, in the fractured MC3s. By contrast, bone tissue stiffness increased (greater unload slope) in the fractured MC3s at M25%. Mean±SD.
strength (Fig. 2D) were greater in the fractured relative to the control limbs, demonstrating that there is clear heterogeneity in the pathological regional response of the MC3, and reinforcing the value of analyzing multiple bone sites in our studies.

Table 1: Bone measures that hold potential for distinguishing between paired (fractured and intact contralateral) MC3s with n=25 samples/group (power analysis based upon paired t-test, p<0.05, 80% power). The dorsal-distal site (D75%) shows particular promise in being able to distinguish at risk MC3s based upon bone structural and material properties. The critical sample size (n=25) is the estimated number of samples we expect to gain in Experimental Group #1 (race-trained with MC3 fracture) over a 3 year period, based upon recent submission numbers to the ADDL and UKVDL.

<table>
<thead>
<tr>
<th>pQCT</th>
<th>Raman Spectroscopy</th>
<th>RPI (Biodent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ct.BMD</td>
<td>90%</td>
<td>Crystallinity</td>
</tr>
<tr>
<td>ct.BMC</td>
<td>90%</td>
<td>Min:Mat (CH2 wag)</td>
</tr>
<tr>
<td>tb.BSI</td>
<td>10%</td>
<td>Amide:Amide III</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carb:Amide I</td>
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<td></td>
</tr>
<tr>
<td>RPI (Osteoprobe)</td>
<td></td>
<td>Avg. CID</td>
</tr>
<tr>
<td>BMS</td>
<td>M25%</td>
<td>Avg. ULS</td>
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<td></td>
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<td>Avg. LS</td>
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</tbody>
</table>


Power analyses were conducted for all variables measured in the n=2 paired MC3 samples discussed above. The difference reported between fractured and non-fractured MC3s in our current sample (n=2) were either significant at p<0.05, or showed trends that would likely become significant with the inclusion of the n=25 horses expected to be collected per group. Assuming that the preliminary data measured for the n=2 horses examined here is characteristic of the means and variences of a larger population, Table 1 describes the variables and anatomical sites at which significant differences would be expected between fractured and intact contralateral MC3s based upon power analysis.

Publications arising from this work: None

Extramural funding stemming from this work: None in the past year. We do presently have a funded NIFA Hatch Grant for this work: Validation of an in vivo assessment for fracture risk in equine limb bones (2012). In 2015, we applied for funding from Grayson-Jockey Club Research Foundation (pending).

Literature Cited:


Taylor SD, Bianco AW, Moore GE. Anti-endotoxin properties of ketorolac tromethamine in horses.

**Progress report**

**Title:** Anti-endotoxin properties of ketorolac tromethamine in horses

**Principal Investigator:** Sandra D. Taylor

**Co-Investigators:** Alex W. Bianco, George E. Moore

Specific Aim 1 is completed and Specific Aims 2 and 3 are underway. Delays have been due to difficulty in isolating equine monocytes from the PBMC population, problems with ELISA assays, and limited research time for Dr. Alex Bianco. We have been successful in isolating equine monocytes, and new ELISA kits were ordered from a different company that appear to be functioning as expected. Thus, we expect to complete this entire project by summer of 2016. Results from Specific Aim 1 will be presented at the American College of Veterinary Internal Medicine (ACVIM) Annual Forum in June of 2016 (abstract accepted December 2015).
APPENDIX C

Research Projects Completed Supported with Pari-Mutual Funds

• Taylor SD, Bianco AW, Constable PD, Cooper BR. Pharmacokinetics of ketorolac tromethamine, a potent non-steroidal anti-inflammatory drug, in healthy adult horses (for full report please see appendix D).
Publications Supported by the Equine Research Internal Funds


APPENDIX E

Refereed Scientific Publications


• Townsend, WM. Cataracts—Clinical presentations, diagnosis, and management. Eq Vet Ed. Published online 22 June 2015. DOI: 10.1111/eve.12388.