Equine Field Necropsy

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Abstract

Performing a complete post-mortem examination in the field can be a daunting task for the equine practitioner. Systemic examination of the entire carcass comes with a variety of challenges that are not encountered when carrying out a "cosmetic" necropsy, during which only a certain anatomical structure, organ system or body cavity is assessed.

In cases where a complete post-mortem examination is requested or required and the client does not insist on burial of the horse on the premises, transportation to a diagnostic laboratory with an autopsy facility is preferable. This might be associated with additional costs and logistic challenges but offers several benefits. Referral is also the better choice whenever foul play is suspected or the carcass cannot be safely disposed on-site, or when the horse is insured for mortality and a post-mortem exam is required by the insurance.

However, in cases where a complete autopsy must be performed in the field, preparation and a systematic approach can lead to a very satisfactory result for veterinarian and client. These proceedings and the seminar will focus on the equipment needed for an equine autopsy and show attendees how to (1) choose the best location, (2) position the horse, (3) systemically examine the carcass, (4) document all findings and (5) appropriately collect and preserve samples.

Equipment

A sharp necropsy (deboning) knife and a sharpening steel, rib cutters (gardening shears) and a hand saw are the tools required for a full examination. During the necropsy, appropriate protective clothing, eyewear and rubber gloves should be worn. Formalin, sterile containers, scissors, forceps and a cold sterile kit complete the list of essential items. The ubiquitous cell phone with digital camera allows for excellent documentation of gross abnormalities.

Location

The ability to remove the carcass following the examination as well as biosecurity concerns determine where the necropsy should be performed. The ideal site for a field necropsy allows access for the equipment used to dispose of the remains, is removed from the housing of other horses on the property and has a surface that can easily be cleaned and disinfected, e.g. concrete. While the number of people involved needs to be limited, a full equine necropsy can be very demanding for a single veterinarian and help from an assistant should be welcomed.

Procedure

Similar to any surgical procedure, following a routine for setup, positioning and the dissection itself will enable the examining veterinarian to complete the necropsy in an efficient manner. A systematic approach also minimizes the risk of overlooking a certain structure during the exam. The following is a brief, step-by-step outline for a field necropsy. Tissue samples, no thicker than 0.5-1cm, are collected and preserved in 10% buffered formalin (10:1 formalin to tissue ratio). The samples should be representative of any lesions identified and have to be labeled accurately.

Tissue from all organs should be collected, while microbiology or toxicology samples are acquired as needed.

The horse can be positioned in lateral or, if positioned against a wall or held in place by an assistant, in dorsal recumbency. The following text describes the procedure for a horse in lateral recumbency. Haircoat, skin, oral and nasal cavities, the perineal region, external genitalia and the eyes are examined and the BCS documented. The skin is incised at the uppermost axilla and the incision is extended cranially to the mandibular symphysis and caudally to the perineum, avoiding penetration of the underlying structures and cavities. Ex-articulating the coxofemoral joint and cutting the musculature that attaches the scapula to the thoracic wall allows for complete abduction of the upper front and hind limbs. Mammary glands or penis and testicles can now be examined.

The **abdomen** is opened by cutting the abdominal wall along the last rib (position the knife parallel to the skin to avoid puncture of abdominal viscera) and then dorsally along the transverse processes of the lumbar vertebrae until the pelvis is reached. After extending the incision towards the ventral midline, the freed abdominal wall can be flipped down, allowing access to the abdominal organs.

The diaphragm is now incised along its attachment to the rib cage, allowing the rib cutter to be inserted and to cut each rib at its dorsal and ventral extremity, opening the **thoracic cavity**. The ribs do not have to be cut ventrally, but can be forcefully reflected at the level of the costochondral junction. Using this technique, the chest wall can be reflected ventrally and can be used to close the thorax following completion of the exam. Slicing the rib just proximal to the costochondral junction allows collection of a wedge of metaphyseal bone with enclosed bone

marrow. After both major cavities have been opened, but before removal of any of the viscera, the best overall assessment of the organs can be completed, including position and appearance of the different parts of the gastrointestinal tract in horses that suffered from colic.

Following a thorough assessment in situ, the **gastrointestinal tract** is removed as a unit. The mesentery of the small colon and small intestine are cut close to their intestinal attachment (keep pancreas attached to duodenum) before the cecum and large colon are pulled over the back of the horse and their body wall attachments are digitally broken down. Cutting the esophagus and descending colon completes the removal. Now the different parts of the GI tract can be thoroughly assessed, including opening the lumen over sufficient lengths and collecting samples for histopathology.

Now the **liver** is removed, examined and samples are collected. The **adrenal glands**, located just craniomedial to the **kidneys**, are taken out together with their adjacent kidney. Transverse sections of the adrenal glands and tissue from the kidneys (from subcapsular cortex to pelvic lumen) are placed in formalin.

The **pelvic cavity** needs to be opened widely if the entire **urogenital tract** is to be assessed: the muscles ventral to the pelvis are cut away before the handsaw can be used to cut out the pubis. The urogenital system can now be dissected out.

Removal of the **cardiovascular system** ("the pluck") includes the cervical portions of the upper respiratory tract (larynx and trachea), the lungs and heart as well as the intimately attached upper gastrointestinal tract (tongue and cranial esophagus). Dissection starts by pulling the tongue ventrally between the rami of the mandible and then reflecting it caudally, cutting or bluntly breaking down the surrounding connective tissues as needed. This is continued all the way to the diaphragm. Aorta and vena cava are cut and "the pluck" is removed. The tongue, thyroid glands,

and lungs are visually inspected, palpated and sampled before esophagus and trachea are opened over their entire length, with the tracheal incisions extending into the mainstem bronchi. The heart is kept attached to the pulmonary system, the pericardium is opened and the heart is incised following the blood flow. The valves, musculature and the intima of the great vessels are examined systemically and at least one full section tissue sample should be submitted for further examination (left papillary muscle).

The difficulty of removing a **brain** often leads to the exclusion of its examination during a field necropsy. If clinical signs suggest an infectious (viral) neurologic disease, the necropsy examination should be completed at a laboratory to avoid exposure to potentially zoonotic diseases (rabies, virus encephalitides). For this purpose, the head can be removed from the carcass and submitted separately. In cases where infectious diseases are not a concern, the head is taken off and its dorsal musculature is removed before the calvarium is opened with a handsaw or cleaver. Using a handsaw, a transverse cut is made just behind the eye sockets, followed by two sagittal cuts that connect the corners of the transverse cut with the foramen magnum. The separated bone has to be pried open with a screwdriver or similar tool, but not the necropsy knife. The olfactory bulbs and cranial nerves are cut and the entire brain is removed and submitted to a laboratory for further analysis.

Examination of the entire **musculoskeletal system** is very challenging in the field, but a thorough assessment of an abnormal or suspicious area can be completed adequately. If sepsis or bacteremia are a concern in foals, several joints should be opened, examined and potentially cultured. It is recommended to open at least six joints in these cases, including one coxofemoral and one shoulder joint, as well as both stifles and hocks.

Documentation

A complete medical history should be acquired, necropsy findings need to be documented and collected tissue samples are submitted for analysis. A basic report should include number, size, shape, color and location of the lesions within each organ, as well as their consistency and texture (if possible). The percentage of an organ affected by a lesion is noted as well as a description of any fluid or material accumulations in cavities or spaces. Documentation of the lesions with a digital camera can be very helpful, especially when a ruler is available to demonstrate the size of an abnormal finding.

Summary

Although a field necropsy is a time-consuming and challenging task, it can be completed with minimal equipment and little assistance. Good preparation (site selection, setup and positioning of the carcass, sample container preparation), a well-structured dissection protocol and accurate documentation are critical for a successful post-mortem examination in the field.

Take Home Points

1. Transportation to a diagnostic laboratory with a necropsy facility is preferable.
2. A full field necropsy is a time-consuming task that needs to be carried out at an appropriate location, ideally with the help of an assistant.
3. Having a pre-packed “field necropsy kit” available ensures that all necessary equipment and instrumentation is available when a necropsy has to be performed.
4. Follow a well-structured dissection protocol.
5. Document your findings in written notes and with the help of a digital camera.

Suggested Reading

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Standing Surgery: Equine Skin Tumors

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Abstract

Skin diseases are one of the most important health problems in horses and the skin is the most common location for equine tumors. Equine sarcoids, melanomas and squamous cell carcinomas make up over 95% of equine cutaneous tumors, with the sarcoid being the most common form of skin cancer in horses. Identification of cases amenable to surgery in the field, the appropriate surgical techniques for different tumors and the use of adjuvant therapies following surgical removal of skin tumors are important for a successful outcome.

Sarcoids

The most important factor in the development of equine sarcoids appears to be an infection with bovine papillomavirus (BPV) type 1 and/or 2 (and, more recently, type 13). However, it is generally accepted that a BPV infection alone is not sufficient for neoplastic transformation. Genetic risk factors have been identified and Quarter Horses, Arabians and Appaloosas appear to be at a greater risk than Thoroughbreds, while Standardbreds are at a lower risk. Finally, sarcoids can develop at the site of any skin trauma (including lacerations, injections, insect bites), especially if the horse has sarcoids in other locations. It appears trauma does not only contribute to the neoplastic transformation, but also to the progression of the disease.

Diagnosis

The list of differential diagnoses for equine sarcoids is relatively long because of their very variable macroscopic appearance. To account for this, a system has been created that classifies sarcoids according to their gross appearance and clinical behavior. There are six clinically recognizable forms: occult, verrucose, nodular, fibroblastic, mixed, and malignant (malevolent). However, histological confirmation is often necessary (and highly recommended) to confidently diagnose an equine sarcoid. Because trauma can exacerbate the locally aggressive behavior of this tumor, a biopsy should only be taken if treatment is rapidly initiated after the diagnosis has been confirmed. A complete excisional biopsy should be considered whenever possible.

Treatment

The various clinical types of sarcoids require slightly different treatment regimens and many management protocols have been described – indicating that no single one is universally effective. Although a horse-owner favorite, "benign neglect" is only suitable for very few cases. Small, occult, or verrucous sarcoids that are not exposed to repeated trauma may be monitored, with the understanding that close observation is critical and removal mandatory if signs of deterioration are observed.

Surgical Excision: Conventional removal can be fast and effective if case selection is appropriate. If it is not, recurrence rates can be as high as 70% within 6 months. To maximize the chances of a successful surgical removal, only tumors that have a defined margin and are in a location where at least 12 mm of surrounding, healthy appearing skin can be excised, should

undergo surgery as a sole treatment. It is also important to minimize contamination of the wound bed with abnormal cells and ideally the wound is closed primarily.

Cryosurgery: In the absence of important underlying anatomical structures (nerves, significant vessels, synovial structures), three freeze-thaw cycles using liquid nitrogen at - 196°C can be an effective method in treating superficial lesions. It is also excellent as an adjunct therapy to surgery.

Laser Surgery: Success rates following excision with a CO2, Nd:YAG or diode laser have been reported to be as high as 80%.

Intralesional Chemotherapy: Injections of cytotoxic drugs directly into the tumor are often used in equine skin tumors. However, their overall efficacy is limited and the need for repeated injections over prolonged periods can lead to client frustration and, subsequently, a lack of compliance. Drugs that are frequently used include 5-fluorouracil (5-FU), cisplatin and carboplatin. More recently, electrochemotherapy has been shown to be a very effective way of treating localized individual tumors, although the relatively expensive equipment and need for general anesthesia will likely limit its availability to referral practices.

Topical Immunotherapy: The topical application of 5% imiquimod (Aldara^{TM}) cream has resulted in excellent outcomes in horses with small sarcoids. The drug is described as an immune response modifier with anti-tumor properties, although its precise mechanism of action remains unclear.

Other treatments modalities for equine sarcoids are available and regularly used in equine practice, but in many cases, reports about their success rates and potential negative side effects are limited.

Melanomas/Melanocytic Neoplasms

Predominantly found in gray horses over 5 years of age, melanocytic neoplasms can be benign or malignant. In contrast to the equine sarcoid, there is no generally accepted clinical classification system for melanomas. One review proposes four distinguishable clinical syndromes: melanocytic nevus, discrete dermal melanoma, dermal melanomatosis and anaplastic malignant melanoma. Melanocytic nevi are found in young gray and non-gray horses in locations that would be considered "non-typical" for classic melanocytic tumors (legs, trunk, neck). They are histologically benign and respond well to complete surgical excision. Dermal melanomas are small discrete nodules found in gray horses with an average age of 13 years. Although often encountered at "typical sites" (perineum, tail base, sheath, etc.), they also exist in the "non-typical" locations. Dermal melanomatosis is histologically indistinguishable from dermal melanomas, but is clinically characterized by larger, confluent masses usually found in horses that are slightly older than the ones affected by discrete dermal melanomas (average age of 17 years). While surgical excision can be effective to resolve complications caused by larger masses, visceral metastases are likely. Although it is not entirely clear if multiple masses in one horse should be considered as metastatic or as multicentric separate neoplasms, there is much evidence suggesting a high rate of metastasis in dermal melanomatosis. Lastly, anaplastic malignant melanomas are found in gray and non-gray horses between the ages of 7 and 20 years and are characterized by aggressive local growth and metastatic dissemination.

Diagnosis

Biopsy is definitive, although appearance and location is often characteristic. Fine needle aspiration is a very helpful tool but does not reliably provide information about the malignancy.

Treatment

Benign neglect: This has been the "treatment of choice" for a long time, because of the presumed benign nature of melanomas in horses and their tendency to grow slowly. However, this can no longer be recommended. Tumors will only grow larger, have an increasing risk of malignancy, and become more difficult to treat. Early intervention is highly recommended.

Surgical removal: Especially in early, smaller lesions, surgical removal is very rewarding and typically uncomplicated. Even horses with larger, confluent lesions can be helped, although referral to a hospital is advisable in more complicated cases.

Cryosurgery: Using three freeze-thaw cycles, cryonecrosis can be achieved in tumors (with or without prior surgical debulking) found in locations where complete surgical excision is difficult (anal sphincter, undersurface of the tail, etc.). Cryosurgery is not suitable in locations where important underlying structures may be damaged by the treatment.

Intralesional chemotherapy (see earlier): Injection of single tumors with cisplatin has been reported to be effective and should be considered for tumors that are difficult to access, e.g. within the parotid salivary gland.

Oral cimetidine: Systemic administration of cimetidine at 2.5 mg/kg TID or 3.5 mg/kg BID or 7.5 mg/kg SID has anecdotally been successful, especially in fast growing melanomas, but the scientific evidence supporting this treatment is missing.

Vaccination: First reports of the use of a DNA vaccine to treat melanocytic tumors in horses are encouraging. The vaccine, Oncept®, is available for treatment of canine melanomas and encodes

human tyrosinase, which shares a 90% homology with equine tyrosinase. However, resolution or dramatic improvement of the condition should not be expected.

Squamous Cell Carcinoma

Squamous cell carcinomas (SCC) are locally aggressive tumors that can be found anywhere on the body but are most often encountered on the head and genitalia. Presenting as ulcerated, proliferative or destructive masses, they preferentially grow on non-pigmented skin or muco-cutaneous junctions. There is increasing evidence that equine papillomavirus type 2 (EcPV2, *Equus caballus* papillomavirus type 2) plays a major role in the development of genital SCC in horses. Research is focusing on the potential role of smegma as a harbor for viral DNA and source of infection and on the development of a potent vaccine to prevent viral infection and tumor development. EcPV2 might also be involved in development of other equine SCC, although the common ocular masses are apparently not associated with papillomavirus infections.

Diagnosis

Impression smears can be diagnostic for ocular lesions, in most other cases a surgical biopsy is recommended.

Treatment

The appropriate management technique depends largely on location and size of the tumor, extent of tissue invasion and signs of metastasis.

Surgical removal: Complete removal with wide margins (e.g. partial phallectomy, enucleation, etc.) can carry a good prognosis as long as regional lymph nodes have not been invaded. Typically, proliferative tumors carry a better prognosis than invasive/destructive lesions. Many of the surgical procedures for SCC removal can be carried out in the field, but good surgical planning is recommended, because the size of resulting skin defects and complications of their healing can be difficult to manage outside of a hospital.

Cryotherapy: The technique has been described earlier. Only very small and early lesions are likely to respond well to cryotherapy. It is a valuable adjunct treatment in cases where clean surgical margins may not have been achieved.

Intralesional chemotherapy (see earlier): Slow release forms of cisplatin (biodegradable beads, emulsions) and 5-FU with epinephrine are effective treatment tools, especially as adjunct treatments after surgical removal.

Topical cytotoxic/antimitotic drugs: Application of a 5% 5-FU cream twice daily for three weeks can successfully treat superficial lesions that are readily accessible. Superficial penile masses have responded favorably to twice-weekly applications of the cream. Very good results have been reported for the treatment of small ocular lesions with mitomycin C (alone or in combination with surgery).

Take Home Points

1. Client awareness is critical for early recognition of skin tumors.
2. The best outcome is achieved in lesions that are diagnosed early and treated aggressively.
3. Histopathology is critical for a definite diagnosis.
4. Melanomas in gray horses must not be ignored.

5. Metastases in horses with squamous cell carcinoma might be more common than previously assumed.

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Standing Surgery: The Equine Head

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Abstract

Only 10-15 years ago, most surgeries on the head were performed with the horse under general anesthesia. This frequently required inhalant anesthesia due to the long duration of the procedures and possible associated complications. Nowadays, most surgeries on the head and upper neck, including upper airway surgeries, are performed in standing sedated horses and several of them can be done in the field. Case selection as well as knowledge of the relevant anatomy, appropriate diagnostic techniques and correct surgical management are important for successful case management.

Anatomy of the Paranasal Sinuses and Associated Soft Tissue Structures

Understanding the complex anatomy of the head is required to identify, pinpoint, and treat diseases that can develop in this part of the body.

There are seven, paired *paranasal sinuses* in the horse: frontal; caudal and rostral maxillary; dorsal, ventral, and middle conchal and the sphenopalatine sinus. The frontal and dorsal conchal sinuses are continuous and referred to as the conchofrontal sinus. The dorsal and ventral nasal conchal bullae are located within the rostral aspect of the dorsal and ventral conchae. They do not communicate with the paranasal sinuses but can become diseased in cases of chronic infection of the closely associated sinuses. The apices of the 109/209, and occasionally 108/208

teeth, form part of the floor of the rostral maxillary sinuses, while 110/210 and 111/211 extend into the caudal maxillary sinuses.

Knowledge of the course of the *facial (CN VII)* and *trigeminal nerve (CN V)* is particularly important when doing surgery on the head. The clinically most important branches of the trigeminal nerve are the infraorbital nerve (the rostral continuation of the maxillary nerve) and the inferior alveolar nerve (a branch of the mandibular nerve). The *infraorbital nerve* runs through the infraorbital canal and enters the face through the infraorbital foramen. It provides sensory innervation to the upper teeth, lips, nostrils, and nasal vestibule. The *inferior alveolar nerve* enters the mandibular canal on the inside of the mandible and exits via the mental foramen. It provides sensory innervation to lower teeth, lip, and chin. The *facial nerve* is the main motor nerve for the superficial muscles of the head and responsible for facial expressions. The nerve crosses the border of the ramus of the mandible 3.5 - 4 cm ventral to the temporo-mandibular joint and enters the face. Its buccal branches continue their rostral path subcutaneously and can be seen on the surface of the masseter muscle in thin-skinned horses. Facial and infraorbital nerve are the most encountered or damaged nerves during surgery of the head. The buccal branches of the facial nerve can be affected by disease, trauma, or by iatrogenic damage during tooth extractions or prolonged lateral recumbency. The infraorbital nerve can be affected by disease of the sinuses or by iatrogenic trauma during trephination and other surgical procedures involving the sinuses. When opening a sinus, iatrogenic damage to the infraorbital nerve is avoided by staying about 1 cm ventral to a line drawn between the medial canthus of the eye and the infraorbital foramen. This line does not only predict the course of the infraorbital canal, but also that of the *nasolacrimal duct*, which should also be avoided.

The *parotid salivary duct* has of be avoided when completing a buccotomy or laceration repair. Various branches of the external jugular vein and the common carotid artery may be encountered during surgical procedures of the head and damage to these vessels can result in significant hemorrhage.

Sinus Surgery

Trephination, sinus centesis and endoscopic exploration are useful field techniques to diagnose and treat sinus disease in horses. They can be completed in the standing horse with appropriate sedation and subcutaneous local anesthesia. In addition to basic surgical equipment, only a trephine (Galt or Michelle trephine of at least ½ inch in diameter) and an endoscope (≤ 15 mm in diameter) are required.

The conchofrontal (CFS), caudal maxillary (CMS), and rostral maxillary sinuses (RMS) are the sinus compartments that can directly be accessed via trephination or centesis. Trephination of the CFS is easiest and allows excellent access to the CFS and, via the frontomaxillary opening, the CMS. The approach is made in line with the medial canthi of the eyes and approximately 5 cm from midline. In a 450 kg horse, this will place the portal directly over the frontomaxillary opening. In addition to excellent diagnostic access to the CFS and CMS, the RMS can also be entered after the caudal outpouching of the ventral conchal sinus has been fenestrated. Consequently, CFS trephination is recommended for general sinoscopic explorations. However, access to the RMS is limited and not sufficient to lavage or treat a disease process in this sinus. The CMS is trephined 2 cm rostral and 2 cm ventral to the medial canthus of the eye. Trephination of the CMS gives some access to the sphenopalatine and conchofrontal sinuses, but

provides limited utility in young horses because of the long reserve crowns of the cheek teeth that reside in the maxillary sinuses.

Trephination of the RMS in mature horses should be performed at a location 40% of the distance from the rostral end of the facial crest to the medial canthus of the eye and 1 cm ventral to the line joining the medial canthus and the infraorbital foramen. In horses younger than 6 years, it is recommended to use radiographic guidance for the procedure, because of the increased risk of inadvertent damage to underlying tooth roots. A lateral radiograph with a radiopaque marker can ensure that the trephination will open the RMS, while a dorsoventral view provides information about the distance of the teeth from the overlying maxilla. However, examination of the RMS in young horses can be very unrewarding, since most of the sinus is occupied by the reserve crowns of the cheek teeth.

Once the site for trephination or centesis (completed in the same locations) has been identified, the site is blocked, clipped, and sterilely prepared. For trephination, a curvilinear incision large enough to accommodate a ½ - ¾ inch Galt trephine is created in the skin and underlying periosteum. The periosteum is elevated and a Galt trephine or a Michele trephine is used to access the sinus. The bony disk is discarded. If only a fluid sample is obtained from the sinus (centesis), a small skin incision is made before a 3-4 mm Steinman pin is used to penetrate the bone and allow fluid sampling with a 14-gauge catheter or needle. For placement of a lavage catheter (18-20 French Foley catheter), a larger opening must be created. Once the procedure is complete, closure of the skin can be accomplished with staples or nonabsorbable sutures in a simple interrupted pattern.

Soft Tissue Lacerations

Lacerations of the lips, cheeks and tongue are frequently caused by sharp external objects, the bit or blows to the head. They can also be the result of iatrogenic damage during intraoral procedures or occur when horses recover from general anesthesia. Minor injuries to the lips and cheeks can heal satisfactorily without surgery. More severe lacerations, including full thickness defects, require surgery to restore function or avoid unacceptable cosmetic outcome.

Tongue Laceration Repair

The tongue is a muscular organ that occupies the greater part of the oral cavity and consists of the intrinsic striated *lingual muscle proper*. It is anchored to the mandible and divided into three main anatomical regions: the root, the body, and the apex. The root, the posterior part of the tongue, begins at the palatoglossal arch, the anatomical border between the oral cavity and the oropharynx, and continues rostrally into the dorsoventrally thick body. The spatula-shaped apex is freely moveable and only its caudal aspect is connected to the floor of the oral cavity via the lingual frenulum. Blood supply comes from the lingual artery, a branch of the linguofacial trunk. The hypoglossal nerve (CN XII) is the sole motor nerve to the tongue.

Lacerations most commonly affect the apex, the most exposed part of the tongue, and transverse lacerations are more often found than longitudinal ones. The clinical signs vary with the degree of tissue damage and include oral hemorrhage, ptyalism, inappetence, dysphagia, halitosis and tongue protrusion. The severity of the trauma also dictates, in combination with duration and location of the injury, possible treatment options: partial glossectomy, primary closure of the wound or healing by second intention. Surgical procedures can be carried out in the standing, sedated horse with the help of local analgesia or under general anesthesia.

Partial glossectomy is required in cases of apical tongue trauma, where the lacerated part of the tongue is mostly separated and tissue temperature and/or lack of hemorrhage from the incision suggest that the tissue is not viable. Following amputation, the stump is debrided and closed (mucosa-to-mucosa) if possible. *Primary closure* of a tongue laceration is recommended whenever possible. After thorough debridement and cleaning of the wound, the defect is closed in up to three layers (full-thickness, muscle, mucosa). *Healing by second intention* can be considered for small lacerations and might be the only option in older wounds or in cases where the owner cannot afford surgery. During the healing process, the horse's ability to eat and drink has to be closely monitored.

Following primary closure of a tongue laceration, horses are typically able to eat normally. The same can be expected in cases where a small part of the tongue had to be removed. However, a horse that has lost most of the lingual apex might need several days to adjust to the altered anatomy and learn how to drink, masticate, and swallow. During this time, intermittent feeding and administration of water via a nasogastric tube might be required. Generally, soaked pellets or wetted hay should be offered in the days following tongue laceration repair.

Lip Laceration Repair

Small lacerations of the lips can be managed conservatively, but larger defects require primary closure to preserve lip function (selection and prehension of food) and cosmetic appearance. Delayed repair might be indicated in cases where viability of the wound edges is questionable. Surgical repair can be completed in the sedated horse with the help of local analgesia. Following debridement and lavage, the laceration is prepared for a multi-layer closure that minimizes the risk of dehiscence in this highly mobile tissue. Skin and oral mucosa are sharply

undermined for 1 - 1.5 cm before large, vertical mattress sutures are placed through the skin and lip musculature without penetrating the oral mucosa. Skin and mucosa are closed in a simple interrupted pattern or a vertical mattress pattern (skin). The main complication following surgical repair is wound dehiscence, which is particularly likely to occur in horses that rub the surgery site.

Cheek Laceration Repair

Partial thickness cheek lacerations can be closed or left to heal by second intention, while full-thickness lacerations should be closed to avoid the formation of orocutaneous fistulas. However, large transmural defects that cannot be closed primarily may heal well by second intention. While the defect is healing it is important to prevent loss of water and nutrients by keeping the wound bandaged.

Tracheotomy and Temporary Tracheostomy

Tracheotomy is best performed in the standing horse, at the junction of the upper and middle thirds of the neck where the trachea is located superficially. The horse is sedated, ideally placed in stocks, and the surgical site prepared for aseptic intervention. Before an incision is made, local anesthetic is injected subcutaneously on ventral midline and into the paired sternothyrohyoideus muscles. Now, a 10-cm incision is made through the skin, subcutaneous tissue and cutaneus colli muscle. The paired sternothyrohyoideus muscle bellies are bluntly divided along the ventral midline for about 8 cm and held in a retracted position. The tracheal rings are now easily palpable. A transverse tracheotomy is recommended in horses: using a scalpel, the annular ligament between two adjacent cartilage rings is incised parallel to the orientation of the rings.

This technique prevents postsurgical tracheal collapse and intraluminal granulation tissue formation. The incision between the rings is lengthened to allow placement of a tracheostomy tube but should not exceed 50% of the tracheal circumference.

A variety of tracheostomy tubes are manufactured and can be used to maintain a temporary tracheostomy. Self-retaining metal tubes do not require suturing for security and are easily removed and cleaned. Short, cuffed silicone tubes are usually tied around the neck and might be more comfortable for the horse. To avoid pressure erosions or necrosis of the tracheal mucosa, the cuff should not be inflated for prolonged periods of time. Any tracheostomy tube should be removed twice daily to allow for removal of the accumulated tracheal secretions from the tube and the tracheotomy site.

In emergency situations with near total upper airway obstruction, preparation of the surgery site and careful surgical dissection might not be possible. However, it is important to avoid damage to surrounding anatomical structures when approaching the trachea. Since tracheostomy tubes are often not available to maintain the opening in these situations, a segment of stomach tube, garden hose, or large plastic syringe casing with the tip removed can provide an airway until a better option is available.

The use of aseptic technique and limited soft tissue dissection reduce the risk of acute post-operative complications. However, this might not be feasible in an emergency. Accidental placement of the tube into the surrounding loose areolar tissue is easily recognized by the lack of airflow. Obstruction of the tube with mucous secretions is the most common problem in temporary tracheostomies. This can be avoided by cleaning or replacing the tube at least every 24 hours, preferably every 12 hours. Infection of the surgery site and subcutaneous emphysema are occasional complications. Damage to the cartilage rings, intraluminal granulation tissue

formation and mucosal stricture are possible long-term complications and highlight that the described technique is not appropriate for the creation of a permanent stoma.

Take Home Points

1. Know your anatomy – it might not be that difficult after all!
2. Sinusotomy and lavage are simple and effective diagnostic and treatment methods.
3. Conchofrontal trephination is a safe way to access the most relevant sinuses.
4. Sinoscopy is an interesting and (in the right cases) very effective diagnostic tool.
5. Soft tissue lacerations heal well, but closure in different layers is important to minimize complications.

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Acute Upper Airway Obstructions in the Horse

Timo Prange, Dr. med. vet., MS, DACVS

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Raleigh, NC

Abstract

The equine upper airway (UA) begins at the nares and includes the nasal passages, pharynx, paranasal sinuses, guttural pouches, larynx, and trachea and is also referred to as the "*extrathoracic airway"*. It is the only (with horses being obligate nasal breathers) conduit for airflow to and from the lungs, making a normal UA essential for the horse. Obstructions of the UA often result in characteristic symptoms that allow a differentiation from lower airway problems without pursuing further diagnostics. Familiarity with these symptoms can be particularly helpful in cases where severe respiratory distress requires emergency treatment before a thorough diagnostic workup can be performed.

Causes of Acute Upper Airway Obstruction

Nasal Obstruction

Obstructions of the nasal passages must be bilateral to cause significant airflow reduction and are an unusual reason for respiratory distress.

Laryngeal and Pharyngeal Obstruction

Like nasal obstructions, edema is often a significant component of laryngeal and pharyngeal conditions that cause acute airway obstruction. The swelling results in increased respiratory

effort and airway turbulences, which, in turn, encourage further edema formation. This vicious cycle can facilitate the development of a life-threatening airway obstruction.

Tracheal Obstruction

Tracheal *stenosis* can develop following neck trauma or be the result of a mass (*S. equi* or *Rhodococcus equi* abscesses, tumors, etc.) that compresses the trachea. Chondromalacia of the tracheal rings is the cause of tracheal *collapse*, a condition that most commonly affects ponies and American Miniature Horses.

Symptoms of Acute Upper Airway Obstruction

Sudden onset of severe respiratory distress in the resting horse is an uncommon presentation that can rapidly develop into a life-threatening situation. Respiratory distress is characterized by an inappropriate effort to breathe; this can include an increased respiratory rate, exaggerated intercostal and/or abdominal effort, flared nostrils, an extended head/neck position and respiratory noise.

Stridor, an abnormal, intense respiratory noise that is audible without a stethoscope, is more likely to be present in horses with obstruction of the upper rather than in animals with a problem in the lower airway. Although some UA diseases result in abnormal in- *and* expiratory noise (e.g. deviated nasal septum), UA obstructions predominantly cause noise during *in*spiration. This is the result of the sub-atmospheric airway pressures that develop during inhalation and can cause collapse of the nostrils, larynx, and pharynx; the structures of the extrathoracic airway that are not supported by bone or cartilage.

If stridor is apparent at rest, it is best to assume that ≥80% of the airway is compromised. Once noise and labored breathing are clinically noticeable, the progression towards complete obstruction can be rapid and it is advisable to treat any acute respiratory noise at rest as an emergency.

Treatment for Selected Conditions

While identification and resolution of the underlying disease are the ultimate goals when treating a horse with UA obstruction, it may be necessary to secure or establish a patent airway before a thorough diagnostic workup can be completed. If available, oxygen insufflation (10 – 15 l/min in a 500kg horse) should be offered until adequate airflow has been restored.

Nasal Obstruction

Nasal trauma: When treating a horse with blunt trauma to the nose, considerate use of tranquilizers is recommended. Prolonged lowering of the head leads to increased edema formation, and most sedatives tend to increase upper airway resistance and thus further decrease airflow. Icing of the nose is most likely to help in cases where the nares are swollen, while swelling within the nasal passages is better addressed by spraying lidocaine with epinephrine 2% (25ml per nostril in and adult) or 0.1% epinephrine spray (25-30ml total/adult) into the nose. If concerns about continued swelling exist, introduction of a small naso-tracheal tube may be helpful (diameter should be at least 1-1.5 cm). In cases where these treatments fail, a tracheotomy is recommended.

Choanal atresia: The hallmark of this congenital defect is persistence of the bucconasal membrane that separates the nasal cavity from the nasopharynx. If present bilaterally, foals will

show signs of extreme respiratory distress immediately after birth. Prompt emergency tracheotomy is required to establish airflow. The diagnosis is made via UA endoscopy after the foal has been stabilized.

Bilateral acute jugular vein thrombosis: In horses where thrombosis of one jugular vein is present or developing, the contralateral vein should only be used for blood collection or administration of fluids/medication if other veins (lateral thoracic, facial sinus) are not available. If both jugular veins are affected, maintaining the head of the patient at or above shoulder level is important to avoid the development of additional, dependent edema. Administration of furosemide should be considered. Depending on the extent of the swelling, a temporary naso-tracheal tube can be placed in the nasal passages, or an emergency tracheotomy may be necessary to ensure sufficient airflow.

Bee stings and ant bites: Insect stings can lead to severe swelling around the nares and insertion of a naso-tracheal tube, shortened stomach tube, or syringe case into the nostrils may prevent airway obstruction. Furthermore, cold compresses, an elevated head position and the administration of antihistamines should be considered. Administration of dexamethasone and epinephrine as well as a tracheotomy may be necessary in severe cases.

Snake bites: Severe swelling can result from snakebites and is often followed by necrosis and infection of the affected tissues. In addition to the above-mentioned steps (head elevation, securing airway with tubes, etc.) NSAIDS and broad-spectrum antimicrobials should be administered. The use of metronidazole, to prevent the development of an infection with anaerobe organisms, is recommended. Antivenin (equine origin) should be given if it can be injected within 24 hours of the bite.

Laryngeal and Pharyngeal Obstruction

Even though tracheotomy is the treatment of choice in severe cases, naso-tracheal intubation should be considered in cases where instruments for a tracheotomy are not available. If the patient has collapsed, naso-tracheal intubation is the fastest way to secure the airway. Since pharyngeal and laryngeal as well as pulmonary edema are common findings in horses with severe upper airway obstructions, administration of furosemide is recommended.

Epiglottitis: The cause of this condition is unknown. Affected horses, usually racehorses, present with a history of respiratory noise and exercise intolerance. Occasionally, epiglottitis can lead to respiratory distress, like croup in people, and require immediate attention. Once the diagnosis has been made with UA endoscopy, horses should be rested and treated with throat-spray, NSAIDs and broad-spectrum antibiotics (e.g., Trimethoprim-sulfamethoxazole). Feeding pelleted or cubed hay may help to reduce epiglottic irritation and swelling. Tracheotomy is rarely necessary.

Arytenoid chondropathy: Even though arytenoid chondropathies usually develop over an extended period, affected horses can present with acute UA obstruction. Once the condition has been diagnosed endoscopically, treatment with throat spray, systemic antibiotics and NSAIDs should be initiated. In severe cases, an emergency tracheotomy may be required. This procedure should be performed caudal enough to allow subsequent creation of a permanent tracheostomy, which may become necessary to permanently secure the airway in bilaterally affected horses. Partial arytenoidectomy is the surgical treatment of choice in unilateral cases.

Guttural pouch tympany: Guttural pouch tympany is the distention of one or both guttural pouches with air. Affected foals usually present with an easily compressible, retropharyngeal swelling and respiratory noise shortly after birth, even though symptoms can develop at any time

in the first year of life. The condition can also cause respiratory distress and predisposes the foal to aspiration pneumonia. In many cases, temporary relief can be achieved by decompressing the distended pouches with manual pressure or by inserting a catheter into the distended guttural pouch(es). Transcutaneous needle decompression should be avoided since hemorrhage may occur and lead to further complications. Radiographs usually show extension of the guttural pouches beyond the second cervical vertebra in affected foals. Tracheotomy is rarely necessary and various surgical treatments are available for persistent cases.

Retropharyngeal lymphadenopathy: Obstruction usually occurs in horses that suffer from a septic lymphadenopathy of the retropharyngeal lymph nodes as part of a Streptococcus equi equi infection. In cases where a mature abscess is present, draining may sufficiently open up the airway, but it is not unusual that a tracheotomy is needed to improve airflow until the horse has recovered from the disease.

Tracheal Obstructions

Depending on the location of the tracheal obstruction, diversion of airflow from the site of compression/collapse may not be accomplished with a routine tracheotomy. In most cases of tracheal obstruction, endoscopy and/or radiographs are recommended to identify the exact location and extent of the lesion.

Tracheal trauma: Tracheal injuries are relatively uncommon, since especially the thoracic part of the trachea is well protected. However, the cervical trachea can be severely damaged by a kick to the ventral neck or by collision with a solid object or a rope. If the trauma results in serial cartilage ring fractures, the tracheal wall may collapse during inspiration and cause acute, severe UA obstruction. Even in less severe cases, formation of granulation or scar tissue can lead to

airway stenosis in the weeks following the injury. Similarly, prolonged intubation with an overinflated, cuffed endotracheal tube can result in circular mucosal trauma with subsequent fibrosis and tracheal narrowing. A tracheotomy caudal to the injury site can redirect airflow temporarily, but surgical correction of the actual injury (possibly including tracheal resection and anastomosis) may eventually be necessary.

Tracheal collapse: Idiopathic, primary collapse of the trachea has been reported in American Miniature Horses (AMH) and Shetland Ponies and is typically characterized by dorso-ventral flattening of the cartilage rings. Lateral collapse is uncommon. In AMH, the disease usually occurs in middle-aged animals, but has been documented in foals as young as 2 months. In most cases, the intra- as well as the extra-thoracic trachea is compromised, leading to respiratory distress with honking noises during inspiration and increased abdominal expiratory effort. Radiography and endoscopy are the imaging modalities of choice. Since larger aspects of the trachea, including the intra-thoracic part, are commonly affected, a tracheotomy may not relieve the respiratory distress. Severe tracheal collapse can also lead to shifting of the surrounding anatomical structures, increasing the risk of inadvertently incising the esophagus, jugular vein or external carotid artery. Naso-tracheal intubation with a small nasogastric tube may therefore be a better method to bypass the affected trachea temporarily. However, long-term prognosis, even with surgical intervention, is guarded to poor.

Take home points

1. Inspiratory stridor and an inappropriate respiratory effort are typical signs of upper airway obstruction.
2. If stridor is apparent at rest, it is best to assume that >80% of the airway is compromised.

3. Endoscopy is the diagnostic tool of choice for horses with (acute) upper airway obstruction.
4. A tracheostomy secures the airway in *most* cases of upper airway obstruction.
5. Treatment of the underlying disease needs to commence as soon as the airway has been secured.

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Management of Distal Limb Wounds

J.T. Vaughan Equine Conference
October 5-7, 2023

Fred Caldwell, DVM, MS, DACVS, DACVSMR

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Distal limb wounds

- Common condition requiring emergency treatment in horses
- Can involve critical structures due to minimal soft tissue protection
- Prone to formation of exuberant granulation tissue
- Horses return to function is the ultimate goal

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REVIEW ARTICLE

Equine Veterinary Journal WILEY

BEVA primary care clinical guidelines: Wound management in the horse

Sarah L. Freeman[1] | Neal M. Ashton[2] | Yvonne A. Elce[3] | Anna Hammond[3] | Anna R. Hollis[4] | Greg Quinn[5]

Equine Vet J. 2021;53:18-29

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Overview

- Wound healing
- Evaluation
- Management
- Photobiomodulation

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Wound type

- Closed
  - Hematoma
  - Contusion
- Open
  - Abrasion
  - Puncture
  - Incision
  - Laceration
  - Burn

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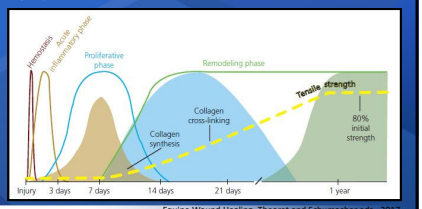
Wound healing

- Goal to re-establish tissue integrity, strength, and function
- Described in phases;
  - Vascular (hemostasis)
  - Inflammatory
  - Proliferative
    - Epithelialization
    - Fibroplasia
    - Angiogenesis
  - Remodeling
    - Contraction
    - Maturation



Equine Wound Healing, Theoret and Schumacher eds., 2017

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Considerations

- Factors affecting wound healing;
  - Contamination
    - Clean
    - Clean-contaminated
    - Contaminated
    - Infected
  - Location
    - Head
    - Body
    - Extremities
  - Tension
    - Wound over joint
    - Tissue loss
  - Environment
  - Age of injury
  - Other factors
    - Signalment
    - Health status
    - Temperament

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Initial assessment

- Appropriate environment
- History and physical exam
  - Vaccination status
  - Blood loss
  - Other injuries
- Restrain/sedate
  - α_2 agonist ± opioid
  - Use caution w/tranquilizers

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- Wound preparation
  - Objective; to examine/explore the wound without causing more contamination and trauma
  - Procedures;
    - Protect wound
    - Clip hair in a wide margin
    - Scrub wound margins
    - Copiously lavage with sterile saline

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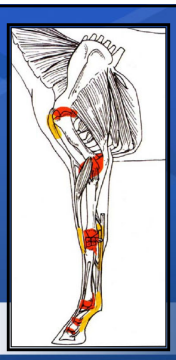
- Wound exploration
  - Determine structures involved
    - Synovial structures
    - Tendons or ligaments
    - Osseous structures
    - Neurovascular supply
  - Procedures;
    - Sterilely gloved hand
    - Probe or teat cannula
    - Needle in synovial space



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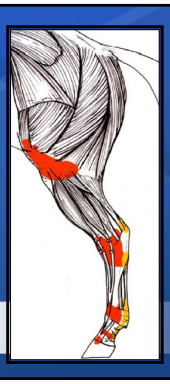

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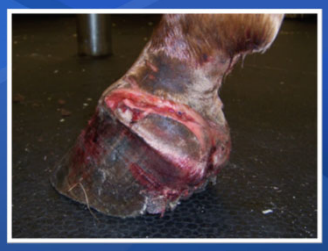

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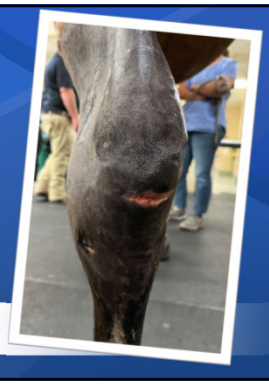
Case example

- 16 year old WB mare
- Evaluated by ambulatory for injury to left hind
- Small wound distal to point of tarsus
- Purulent discharge
- Mild lameness



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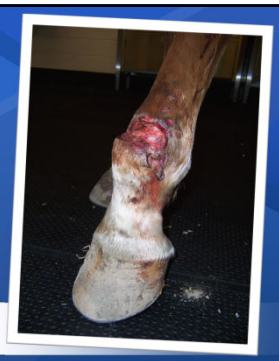
Case example

- 13 year old QH gelding
- Fell into milking parlor
- Wound to dorsal LH fetlock
- Bandaged by owner
- Six hours old at presentation



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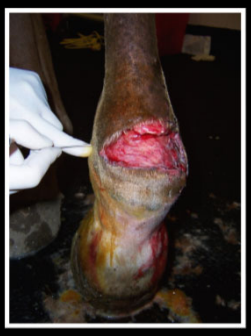
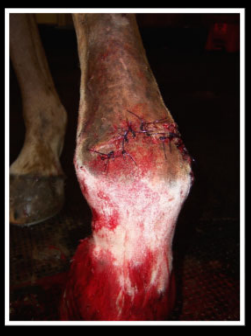
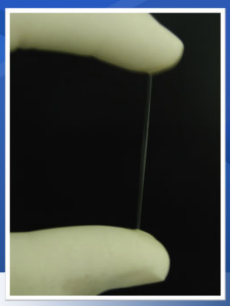




- Synovial involvement
  - Collect fluid for analysis and culture/sensitivity
  - Flush with large volumes of sterile fluids
  - Inject antibiotics directly into synovial cavity
  - Regional perfusion of antibiotics



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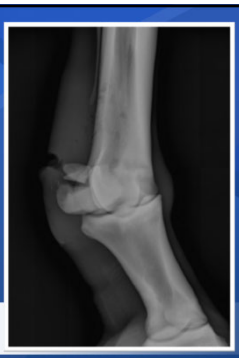
- Tendon or ligament injury
  - Evaluate extent of disruption
    - Manually
    - Ultrasound
- Osseous involvement
  - Radiography
  - Contrast studies
- Formulate a plan
  - Manage on site
  - Refer



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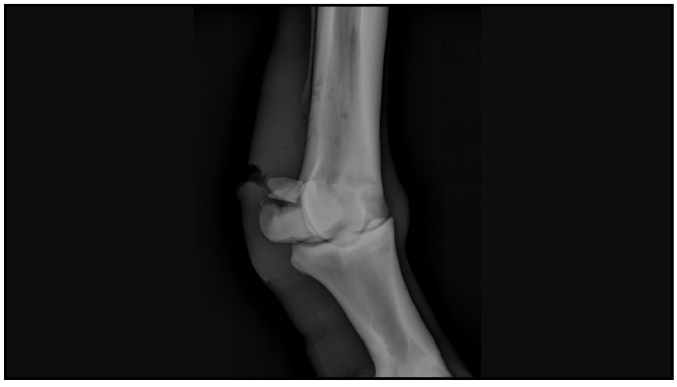
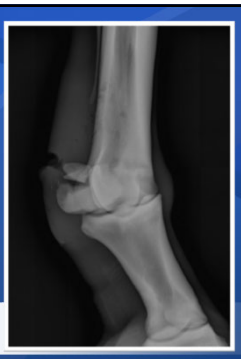


- Tendon or ligament injury
  - Evaluate extent of disruption
    - Manually
    - Ultrasound
- Osseous involvement
  - Plain radiographs
  - Contrast studies
- Formulate a plan
  - Manage on site
  - Refer



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Treatment

- Wound lavage
  - Isotonic crystalloid
  - Deliver under pressure (10-15 psi)
    - Syringe system
    - Fluid pressure bag
  - Avoid excessive pressure
    - Drives contaminants deeper into tissues
    - Generates significant tissue edema

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- Wound debridement
  - Enhance healing
  - Remove devitalized tissue, bacteria, foreign material, and debris
  - Surgical
    - Preserve viable tissue at all costs
    - Avoid contaminating deeper tissues
  - Non-surgical
    - Bandaging
    - Biosurgical

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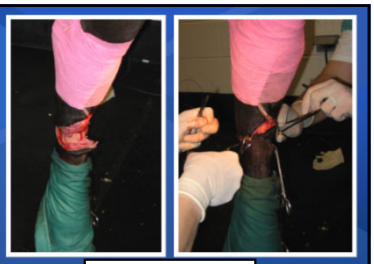
- Wound closure?
  - Goals;
    - Minimize exposure/secondary infection
    - Cosmesis
    - Return to function
  - Techniques;
    - Primary
    - Delayed primary
    - Delayed secondary
    - Second-intention



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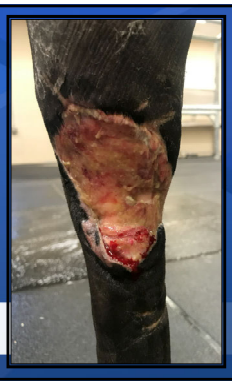
Case example

- Delayed closure
  - Allows better preparation of wound environment and improve chances of success with closure
  - Partial closure is preferable to second intention healing
  - Can reduce formation of EGT
  - Wound expansion following injury is a major drawback in horses
  - Suture techniques (tension, retention, or adjustable) can be beneficial in select cases



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Exuberant granulation tissue (EGT)

- Develops almost exclusively in distal limb wounds healing by second intention
- Inflammatory phase is less intense, but more prolonged in limb wounds compared to thoracic wounds
- Highly disorganized tissue healing response that frequently extends beyond epithelial margins

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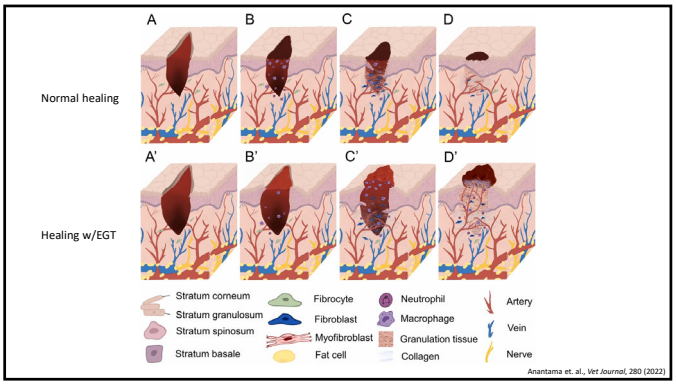

Anantama et. al., *Vet Journal*, 280 (2022)

EGT management

- Resection of any granulation tissue above wound margins
- Short term bandaging to control hemorrhage
- Levels wound surface and "resets" epithelial healing
- Bandaging with hydrogel pads, +/- topical corticosteroids

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- Skin grafting
  - Can achieve rapid healing
  - Does not require extensive equipment
  - Can be performed in the field setting
  - Should be considered for large wounds or those that cannot be sutured

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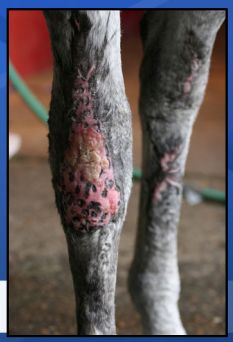

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Additional therapies?

- Fluorescent light energy (photobiomodulation)
- Modulation of biological processes through activation of photoacceptors in tissues
- Human and veterinary studies
  - Antimicrobial properties
  - Reduction of inflammation
  - Improved wound healing
  - Upregulation of growth factors

PHOVIA

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ORIGINAL ARTICLE - CLINICAL

WILEY

Veterinary Surgery, 2020;1-9

Effect of the topical Klox fluorescence biomodulation system on the healing of canine surgical wounds

Alberto Salvaggio DVM, PhD | Gian Enrico Magi DVM, PhD, DECAAH | Giacomo Rossi DVM, PhD, DECZM | Adolfo Maria Tambella DVM, MSc | Cecilia Vullo DVM, PhD | Andrea Marchegiani DVM, PhD | Riccardo Botto DVM | Angela Palumbo Piccionello DVM, PhD

- Healthy dogs undergoing orthopedic surgeries
- Increased growth factor expression in treated vs. control incisions
- Improved re-epithelialization, reduced inflammation, greater collagen deposition

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PHOVIA IS A TWO PART SYSTEM THAT CONSISTS OF

A light energy emitting lamp

A photo converter carrier gel

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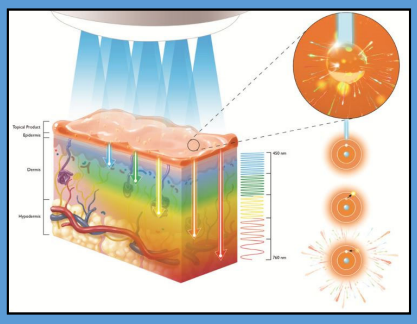

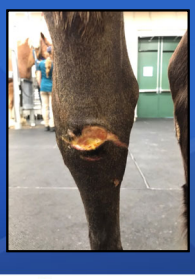
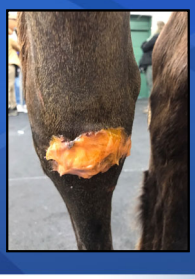
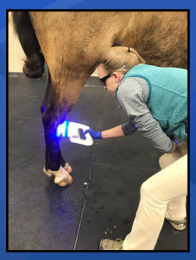

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Summary

- Thorough initial evaluation of wounds
- Consider methods to improve wound healing to ensure best chance for return to previous function
  - Wound closure techniques
  - EGT management
  - Skin grafting
- Photobiomodulation can be useful in improving wound environment and enhancing healing

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vetoquinol

ACHIEVE MORE TOGETHER

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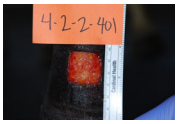
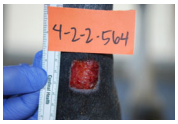
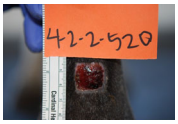
Horse 4

	Day 3	Day 17	Day 31
Phovia			
Control			

EQUINE PLACENTITIS: DIAGNOSIS AND TREATMENT OPTIONS

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INTRODUCTION

Placentitis remains a leading cause of abortion and stillbirths in the equine industry and can account for almost 1/3 of all late term abortions and neonatal mortality. This presents significant economic losses with the loss of a foal and the loss of a breeding season. Therefore, prompt diagnosis and treatment is vital in order to save a pregnancy.

PATHOPHYSIOLOGY

Ascending infection through the cervix is by far the most common route of infection in most cases. Infectious organisms often enter through the cervix and infect the chorioallantois. This causes an increase in inflammatory cytokines which leads to a release in prostaglandins. This inflammatory response initiates the foaling cascade that ends in premature delivery of the fetus. With an ascending infection, the cervical star of the placenta is the most affected as the infection begins here and then moves cranially into the body of the uterus. Common pathogens include *Streptococcus zooepidemicus, Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumonia, Staphylococcus species* or fungal (*Candida species* or *Aspergillus species*)

A notable exception to this traditional route is nocardioform placentitis. Eighty-five percent of nocardioform placentitis were caused by *Amycolatopsis* spp. and *Crossiella. equi,* which are gram positive branching actinomycetes. The route of infection is currently unknown, but the lesions are located not at the cervical star, but at the bifurcation of the uterus. These bacteria cause a thick tan exudate and often go undiagnosed because the cervical star area remains normal.

CLINICAL SIGNS

Clinical signs often are not observed until well into the disease process making successful treatment even more difficult. Mares tend to be aged mutiparous mares and often have poor perineal conformation. The most common clinical sign associated with placentitis is premature udder development well before the mare's due date. This mammary development occurs as a response to the initiation of the foaling cascade and is in preparation for the imminent delivery of the fetus. The second most common clinical sign is vulvar discharge. This is not a consistent finding as the amount of discharge produced varies. When examining a mare for premature udder development, the underside of her tail should be examined closely for matting of tail hairs caused by vulvar discharge. The presence of vulvar discharge may help differentiate placentitis from the other major cause of premature udder development, twins.

DIAGNOSIS

Ultrasound

A complete physical examination of the mare should be performed. They are rarely systemically ill or febrile with placentitis alone. A thorough examination of the pregnancy should then be performed. A transrectal palpation should assess fetal viability by movement of the fetus as well as cervical integrity. Transrectal ultrasound of the caudal reproductive tract has become one of the most used diagnostics for placentitis. Assessing the placenta at the area of the cervical star allows for detection of placental abnormalities such as thickness or areas of detachment. By placing the ultrasound probe rectally and just off midline (either left or right depending on location of the fetus), the uterine artery can be found. The combined thickness of the uterus and placenta (CTUP) can be measured between the artery and allantoic fluid (figure 1). Several measurements should be taken, averaging thick and thin areas to get and accurate assessment. Measurements should be within the following guidelines:

151-270d: <7mm
271-300d: <8mm
301-330d: <10mm
331-delivery: <12mm

Transrectal ultrasound also allows assessment of the fetal fluids surrounding the cervical star. The fluids should be anechoic early in gestation, but will become slightly more flocculent as the due date approaches. Placental

detachment typically occurs surrounding the cervical star area first. Often, a fluid pocket can be seen between the uterus and the chorioallantois indicating separation.

Transabdominal ultrasound is the best way to evaluate fetal health. Locating the fetal heartbeat is important to assess the overall stress of the fetus. The ultrasound probe should be placed on the ventral midline near the sternum in a late term pregnant mare and moved caudally until rib shadows are observed. If none are seen, move the probe laterally and try again. Once the fetal rib shadows are seen, rotate the prove to find the heartbeat. The fetal heartrate can be taken manually or using M mode. The heart rate of the fetus may vary with activity, but should be around 75-120 beats per minute (bpm). If the heart rate is consistently low (60 bpm) or high (150 bpm), fetal stress is likely. Recheck the heart rate every 30-60 min to assess trends. The fetal fluids and placenta can also be examined transabdominally. The CTUP is less reliable transabdominally, but can be measured to show trends.

Endocrine Analysis

Progesterone is the main hormone of pregnancy early in gestation. Starting at 60 days and complete by 150-180 days gestation, the fetal-placental unit (FPU) begins to take over the maintenance of pregnancy. Progesterone is broken down into metabolites (progestins) at the placenta and the actual hormone, progesterone, is virtually undetectable by gestation day 180. Measuring total progestins during pregnancy will give an idea of fetal stress. An elevated total progestin indicates that the fetus is compromised and under stress. A low total progestins is a poor prognostic indicator and is often followed by delivery of the fetus. Total progestins should range between 4-10ng/mL until gestation day 320. Progestins then increase the last 15-21 days before foaling and then drop 24-48 hours before foaling. In one study using mares with experimentally induced placentitis, 14 of 15 mares showed a change in plasma progestins. Plasma progestins decreased dramatically in mares that aborted within 7 days of inoculation and increased in mares that carried the fetus over 15 days from inoculation. Therefore, if total progestins change (high or low), fetal stress should be highly suspected.

Estrogen concentration in the mare's serum follows gonadal development in the fetus. The fetal gonads provide the precursors for estrogen formation by the placenta. Therefore, estrogens can also be a marker for fetal health and well-being. Total estrogens in a normal pregnancy should remain greater than 1000 pg/mL from gestational day 150-320 before decreasing gradually as foaling approaches. Treatment with supplemental estrogens (ECP) in cases of placentitis and when total estrogens are low has been reported to be beneficial in the delivery of a viable foal in cases of experimentally induced placentitis[4].

Serum Amyloid A (SAA) is an acute phase protein that increases in conditions such as infection, inflammation, stress, etc. However, SAA decreases rapidly when the inflammatory process has resolved. SAA was shown to be elevated in the aborted fetus in mares that aborted due to placentitis or other inflammatory condition. In the mare, SAA was shown to be elevated in mares with experimentally induced placentitis starting 2-3 days after inoculation. Therefore, SAA may be an additional tool in the diagnosis of placentitis[5].

Alpha-fetoprotein (AFP) has been shown to increase in mares with experimentally induced placentitis. AFP was detected in the fetal fluids of all pregnant mares, but elevations were detected in the plasma of affected mares when compared to controls[6].

Other

If placentitis is suspected, a vaginal speculum exam should be performed to assess the cervix and acquire a sample of any discharge. A cervical exam in the pregnant mare should be performed with caution and only when the benefits outweigh the risks of the exam. Risks include the entry of environmental bacteria and contaminants into the cranial vaginal vault and through the cervix, causing a placentitis. In cases of placentitis, the external cervical os should be cultured to determine what bacteria is present. This is best accomplished by using a double guarded swab through a disposable vaginal speculum. A cytology of the discharge can also be obtained.

TREATMENT

The goals in treatment of placentitis are to inhibit or eliminate bacterial growth, maintain uterine quiescence by decreasing uterine contractions, increasing cervical tone, and increasing blood flow to the uterus and placenta. Because inflammatory cytokines initiate the foaling cascade, blocking the release of cytokines and prostaglandins by counteracting the sequellae of endotoxemia is also critical.

Antimicrobials
Antimicrobials used must be broad spectrum until the causative agent is identified, and, must have the ability to penetrate the uterus and placenta. Studies evaluating placental drug transfer were performed by either serial allantocentesis or placing a microdialysis device into the allantoic cavity in late term pregnant mares [1,2]. Trimethoprim sulphamethoxazole showed similar concentrations in the serum and allantoic fluid, whereas potassium penicillin and gentamicin were 20% lower in the allantoic fluid than in serum. It should be noted that the rate of clearance of potassium penicillin was slower than in the serum indicating that dosing regimen may need to be adjusted when treating placentitis. Recently, ceftiofur (Excede) has been evaluated in normal mares and mares with induced placentitis. Drug concentrations in the fetal fluids, placental tissue, and foal serum were below the minimum inhibitory concentration necessary for successful treatment. Therefore, it is not recommended in cases of placentitis[3].

Length of treatment with antibiotics depends largely on response to therapy. Typically, treating for 10-14 days is recommended with frequent assessment of the fetal well-being and placental thickness.

Progestins
Treatment with altrenogest is a standard recommendation in cases of placentitis. Progesterone promotes uterine quiescence and was shown to improve outcome when combined with trimethoprim sulfa and pentoxifylline. A dose of 0.088mg/kg is recommended. Duration of treatment is varied from a few weeks to deliver of the foal. This author recommends discontinuing treatment between 320-330 days gestation.

Nonsteroidal Anti-Inflammatories (NSAIDS)
A nonsteroidal anti-inflammatory agent is key to blocking the inflammatory cytokines that initiate the foaling cascade. Flunixin meglumine is the most commonly used NSAID at a dose of 1.1mg/kg IV or orally twice daily. Other NSAIDS have not been evaluated for efficacy in cases of placentitis. Duration of treatment will depend on response to therapy, but is typically 5-7 days. Care should be taken if treatment continues longer term to prevent GI complications.

Other Treatments
Pentoxifylline improved blood flow to the uterus by decreasing the viscosity of the blood and making the red blood cells more malleable. It also has anti-inflammatory properties. The recommended dose for placentitis is 8.5 mg/kg, orally, twice daily.

Clenbuterol can be added as a tocolytic agent. Research has shown contradicting results using the oral form that is available in the United States. It has not been shown to prolong gestation length in late term mares, but may have some tocolytic effects in cases of placentitis. Clenbuterol has a narrow spectrum of safety and should be used with caution, but can be added to the drug protocol in selected cases.

MONITORING
Mares diagnosed with active placentitis should be monitored frequently (daily to every other day) using transabdominal and transrectal ultrasound. The fetus and placenta should be evaluated with each examination. If treatment is effective, the CTUP should normalize, the vaginal discharge and mammary development should improve, and the fetal heart rate remain stable. Weekly serum samples monitoring progestins and estrogens may also help guide response to treatment.

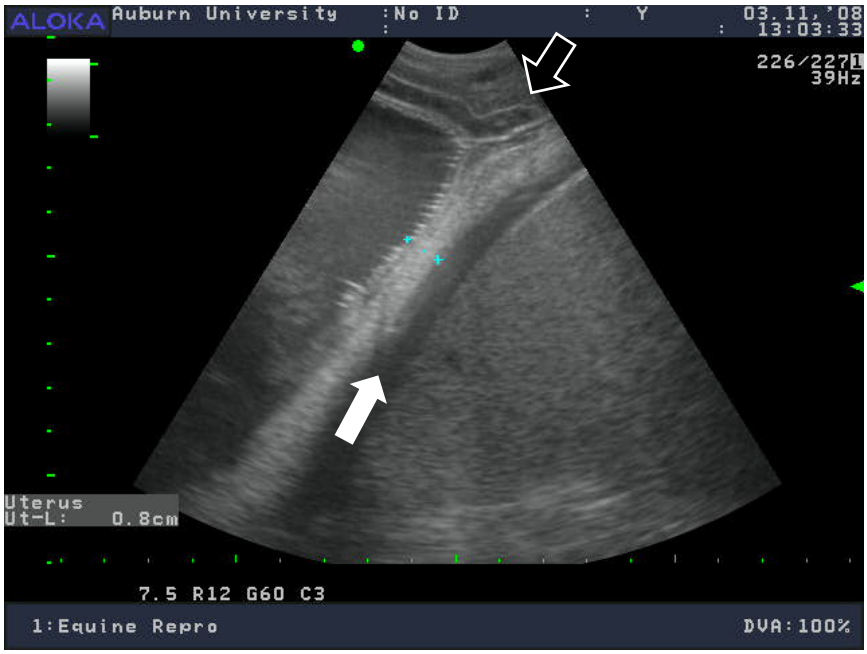
MANAGEMENT AFTER DELIVERY
Owners should be made aware that placentitis places their foal at risk of premature delivery and sepsis which could affect the desired athletic outcome of the foal. Once the foal is delivered, a complete placental evaluation should be performed. This assessment will provide a guide for continued treatment of the mare and foal. Cultures of the mare's uterus may also provide a sample of the causative agent and can be correlated to a blood culture taken from the foal at birth. Supportive care for the foal should be performed and include antimicrobial therapy. Foals are often compromised and foaling at a full care facility should be considered.

Few studies are available to determine the best treatment of the mare's uterus following a placentitis delivery. In most cases, several days of uterine lavage of the postpartum mare is indicated as well as intrauterine antibiotics once the lavage fluid is clear. A complete breeding soundness examination including uterine culture and cytology should be performed prior to re-breeding. If a cause could be identified (poor perineal conformation), treatment should be initiated to prevent recurrence.

CONCLUSION

Diagnosis of placentitis is still reliant on clinical signs. Effective treatment plans are multimodal and anti-inflammatories, tocolytics, and antibiotic therapies all show effectiveness in delaying premature parturition.

Figure 1



Transrectal ultrasound of the combined thickness of the uterus and placenta (CTUP). The bladder can be seen on the right of the picture and the allantoic cavity is on the left side. The CTUP is measured by identifying the uterine artery (white arrow) adjacent to the cervix (white arrow).

References:

1. Rebello SA, Macpherson ML, Murchie TA, Leblanc MM, Vickroy TW. Placental transfer of trimethoprim sulfamethoxazole and pentoxifylline in pony mares. Anim Reprod Sci 2006;94:432–3.

2. Murchie TA, Macpherson ML, Leblanc MM, Luznar S, Vickroy TW. Continuous monitoring of penicillin G and gentamicin in allantoic fluid of pregnant pony mares by in vivo microdialysis. Equine Vet J 2006;38:520–525.

3. Macpherson ML, Giguère S, Hatzel JN, Pozor M, Benson S, Diaw M, Sanchez LC, Vickroy TW, Tell L, Wetzlich S, Sims J. Disposition of desfuroylceftiofur acetamide in serum, placental tissue, fetal fluids, and fetal tissues after administration of ceftiofur crystalline free acid (CCFA) to pony mares with placentitis. J Vet Pharmacol Ther 2013; 36:59-67.

4. Curcio BR, Canisso IF, Pazinato FM, Borba LA, Feijó LS, Muller V, Finger IS, Toribio RE, Nogueira CEW. Estradiol cypionate aided treatment for experimentally induced ascending placentitis in mares. Theriogenology 2017; 102:98-107.

5. Coutinho da Silva MA, Canisso IF, MacPherson ML, Johnson AE, Divers TJ. Serum amyloid A concentration in healthy periparturient mares and mares with ascending placentitis. Equine Vet J 2013; 45:619-624.

6. Canisso IF, Ball BA, Scoggin KE, Squires EL, Williams NM, Troedsson MH. Alpha-fetoprotein is present in the fetal fluids and is increased in plasma of mares with experimentally induced ascending placentitis. Anim Reprod Sci 2015; 154:48-55.

Maximizing success using cool-shipped and frozen semen in the mare

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1

What is the Society for Theriogenology?

2

What can we do to maximize success?

- Asking the right Qs
- Semen factors:
  - Cool-shipped vs Frozen semen
- Timing of insemination
- What can we adjust within our methods?
- Techniques/equipment for AI

3

What your clients need to know:

- Buyer beware!
- Mare owner usually assumes all risk
- Encourage owners to ask good Qs
- DVM as an agent of the mare owner

4

What questions should be asked?

- Is this mare a good candidate for a frozen semen breeding?
  - Young to middle-aged
  - Proven
  - *No Hx of endometritis or delayed uterine clearance*
  - Lactating mares; cycle following foal heat

5

What questions should be asked?

- What Q's should be asked regarding the semen?
  - Stallion tested for EVA
  - **Post-thaw progressive motility**
  - # of progressively motile spermatozoa (PMS)
  - **One breeding dose or two?**
  - Has this frozen semen produced pregnancies?

6

What questions should be asked?

- Tested for EVA?
  - Serologic test of the stallion at the time of semen cryopreservation
- No test performed?
  - If stallion still alive, test him now (should be seronegative unless Vx)
  - If stallion deceased, can sacrifice individual semen straw for virus isolation (Gluck Lab; Lexington, KY)
- Risk?
  - Naïve mare may become systemically ill following breeding (arteritis)
  - No large effect on conception rates
  - **Mare sheds virus in vaginal discharges following breeding and puts other horses (esp. foals) at risk**
  - ***Fomites at your clinic***

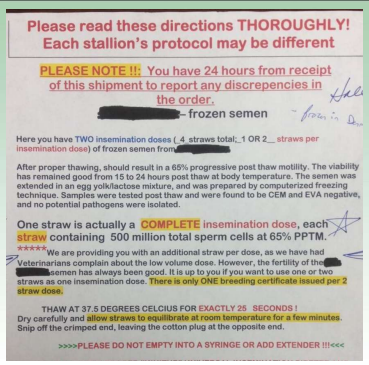
7

What questions should be asked?

- Post-thaw progressive motility?
  - Should be ≥30% (bare minimum)
- # of progressively motile spermatozoa (PMS) in each straw?
  - Varies
- How many straws do they consider a breeding dose?
  - Varies
- **<u>Best question</u>: How many PMS do they consider to be a breeding dose?**
  - **~200-300 million PMS**

8

Example



Please read these directions THOROUGHLY!
Each stallion's protocol may be different

PLEASE NOTE !!: You have 24 hours from receipt of this shipment to report any discrepencies in the order.

[redacted] – frozen semen

Here you have TWO insemination doses (_4_ straws total; _1 OR 2_ straws per insemination dose) of frozen semen from [redacted]

After proper thawing, should result in a 65% progressive post thaw motility. The viability has remained good from 15 to 24 hours post thaw at body temperature. The semen was extended in an egg yolk/lactose mixture, and was prepared by computerized freezing technique. Samples were tested post thaw and were found to be CEM and EVA negative, and no potential pathogens were isolated.

One straw is actually a COMPLETE insemination dose, each straw containing 500 million total sperm cells at 65% PPTM.

*****We are providing you with an additional straw per dose, as we have had Veterinarians complain about the low volume dose. However, the fertility of the [redacted] semen has always been good. It is up to you if you want to use one or two straws as one insemination dose. There is only ONE breeding certificate issued per 2 straw dose.

THAW AT 37.5 DEGREES CELCIUS FOR EXACTLY 25 SECONDS !
Dry carefully and allow straws to equilibrate at room temperature for a few minutes. Snip off the crimped end, leaving the cotton plug at the opposite end.

>>>>PLEASE DO NOT EMPTY INTO A SYRINGE OR ADD EXTENDER !!!<<<

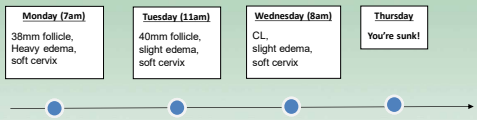
9

Cooled, shipped vs Frozen semen

Type of semen:	Cooled, shipped	Frozen
Longevity	24-48 hrs (after arrival)	12-24 hrs
Peak fertile window	< 12-24 hrs	< 8-12 hrs
Inflammatory reaction of uterus	++	+++++
Total cost	$$	$$$$$

10

Protocol for cooled, shipped semen



- Call for today's semen collection
- **Get tracking number**

4pm:
2500 units hCG
OR
1.8 mg Deslorelin

11am:
Semen arrival + AI

3pm:
Post-brdg lavage + 20 units oxytocin

6pm:
Owner gives 0.5 ml Estrumate IM

8am:
What if there's uterine fluid??

+/- Lavage?

Ecbolics (oxytocin only)

Misoprostol on cervix

11

Protocol for 2 doses of frozen semen

- How many breeding doses are included in this contract?
  - **Prefer 2 breeding doses**

1pm:
- Lavage
- Misoprostol on cervix
- Oxytocin q 2-3 hrs
- Single dose of 0.5 ml Estrumate
- EXERCISE

4pm:
2500 units hCG

8pm:
AI (first dose)

8am:
AI (second dose) if CL present; should have ovulated ~4am

If no CL, recheck every 6 hrs; only AI when ovulation confirmed

12

Protocol for 1 dose of frozen semen

- If only 1 breeding dose:
  - Mare should be checked minimum of every 12 hrs
- Newcombe JR, Paccamonti D, Cuervo-Arango
  Reducing the examination interval to detect ovulation below 12h does not improve pregnancy rates after postovulatory insemination with frozen/thawed semen in mares. J.Anim Reprod Sci. 2011;Jan;123(1-2):60-3.
- **Logistically challenging (esp if q.6-8 hrs)**
- **$$ Must charge accordingly $$**

Society for Theriogenology

13

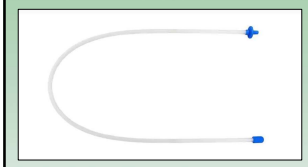
Techniques for insemination

- Deep horn insemination
  - Transrectal manipulation
  - Via hysteroscopy
- Deep horn pipettes
  - Cost
  - Type

Society for Theriogenology

14

Deep horn AI pipettes - Minitube



Equine Universal AI pipette, length: 57 cm, 1/bag, sterilized
REF.: 17209/0001

Equine Universal IUI pipette with inner catheter, 65 cm, 5/package
REF.: 17207/1165

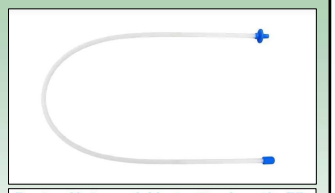
Society for Theriogenology

15

How do I use just one straw at a time?

Flexible stylet used with Universal insemination pipette 57 cm and 0.5 ml straws

REF.: 17209/1057



Equine Universal AI pipette, length: 57 cm, 1/bag, sterilized

REF.: 17209/0001

16

Troubleshooting

17

Hazards of insemination using frozen semen

- Two-fold
  1) Exacerbated inflammatory response
     - Expect fluid accumulation
     - Intervene early (~4 hrs post AI) and often
  2) Cervical closure
     - Breeding post-ovulation
     - Progesterone begins to rise rapidly = cervical closure
     - Fluid accumulation in the face of a closing cervix = ☹

18

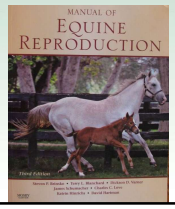
What's in your toolbox?

- Post-breeding lavage
  - ≥ 4 hrs post-AI
- Ecbolics, ecbolics, ecbolics
  - Oxytocin
  - *No $PGF_{2\alpha}$ after ovulation* (<18 hrs ok?)
- **Exercise**
- PGE_1
  - Misoprostol
  - 200-400 ug (usually 1-2 tabs)
  - Direct application to cervix at time of breeding or post-breeding lavage

19

Considerations

- Educate clients to ask good questions and have reasonable expectations
- Choose mares carefully
- Timing is everything
- Intervene early and often for fluid accumulation (4 hrs)



20

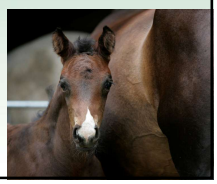
Tips for uterine clearance

- Post-breeding lavage
  - 4 hrs post-AI
- Oxytocin
  - Foal at side
- $PGF_{2\alpha}$ as ecbolic
  - Lutalyse or Estrumate
- Misoprostol topically for cervical relaxation
  - 200 ug crushed
- Exercise
- Exercise
- Exercise

21

Changes to consider…

- Cytology with every culture
  - Include in price?
- More uterine biopsies
- Package pricing for breeding mgt
  - All palpations
  - AI + semen evaluation
  - (Ovulation induction agent)
  - (Pregnancy exam)



22

Preparing Horses for Standing Ophthalmic Surgery

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1

Background

- Improve care for horses with ophthalmic diseases or problems
  - Anatomy suited for standing surgery
  - Earlier surgical intervention
  - Multiple procedures

2

Background

- Eliminate GA/recovery risks
- Increase in case management efficiency
- Hospitalization/ convalescence
  - Reduced duration

3

Overview

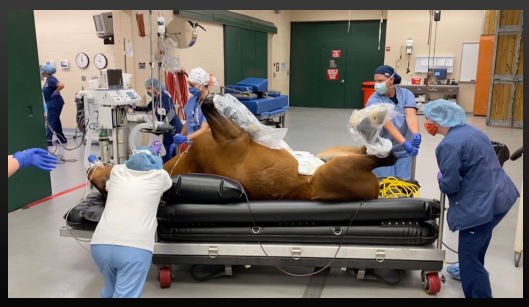
- General anesthesia
- Standing sedation
- Local anesthesia and head support
- Surgical procedures
- Other considerations

4

General anesthesia

5

General anesthesia



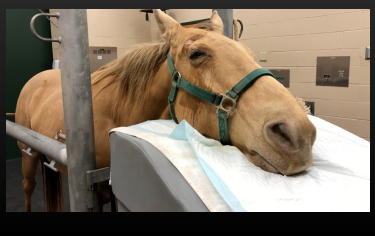
6

Standing Sedation

7

Sedation

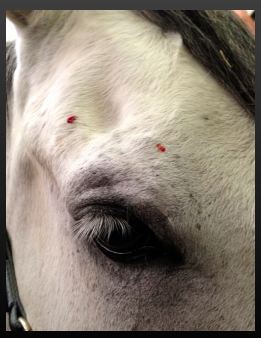
- Detomidine (0.01-0.02 mg/kg) i.v.
- Butorphanol (0.01—0.02 mg/kg) i.v.
- Butorphanol (0.02-0.04 mg/kg) i.m.



8

Analgesia/akinesia

- Frontal/palpebral/ auriculopalpebral
- 2% mepivacaine s.c.
- 0.5% proparacaine HCL



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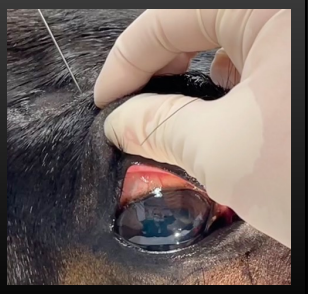
Analgesia/akinesia

- Frontal/palpebral/ auriculopalpebral
- Retrobulbar block
- 2% mepivacaine s.c.
- 0.5% proparacaine HCL



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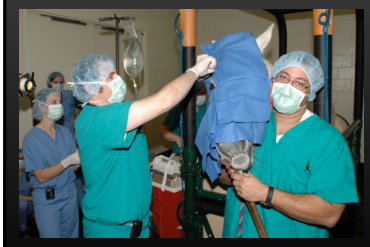
Retrobulbar block

- Immobilization of the globe
- Prevents horse from watching the surgery – INCREASES compliance & decreases movement
- But…also effective intra-/perioperative analgesia
  - Improved postoperative comfort

11

Head position & support



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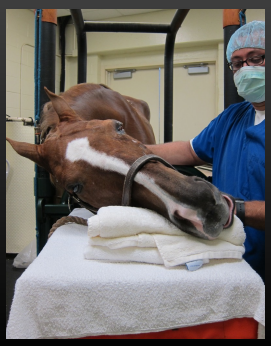
Head position & support

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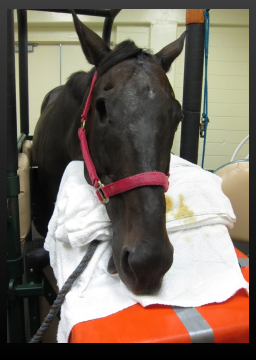
Head position & support

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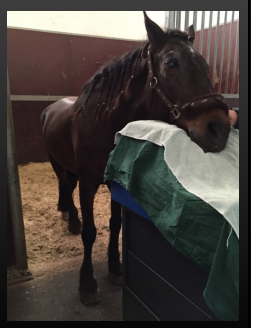
Head position & support

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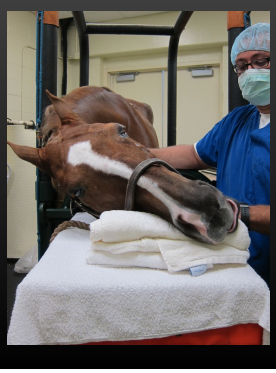
Head position & support



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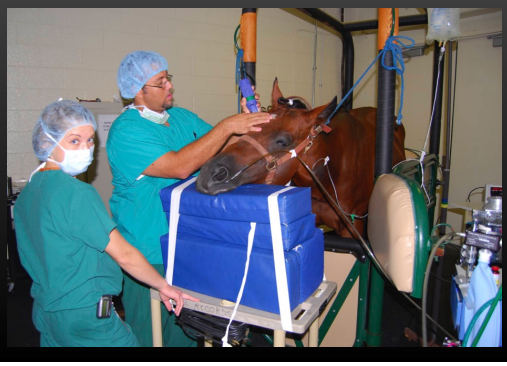
Head position & support



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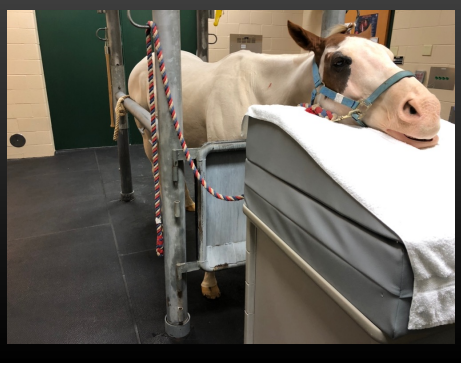
Head position & support



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Clinician position

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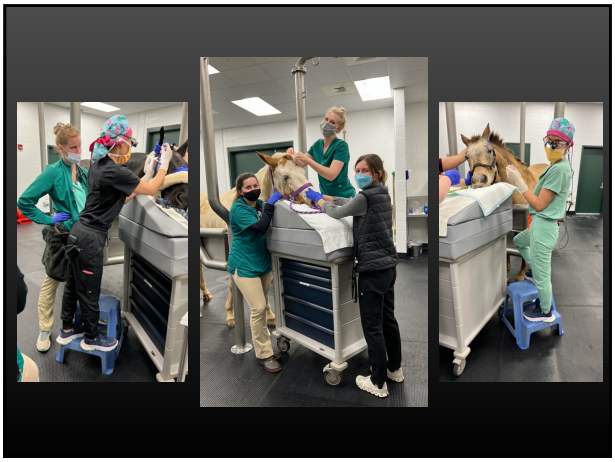

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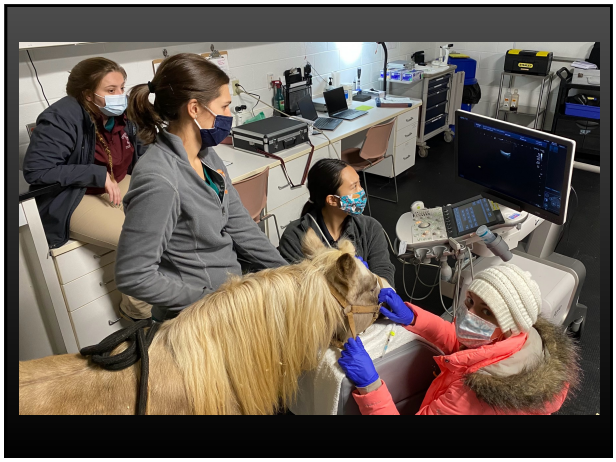

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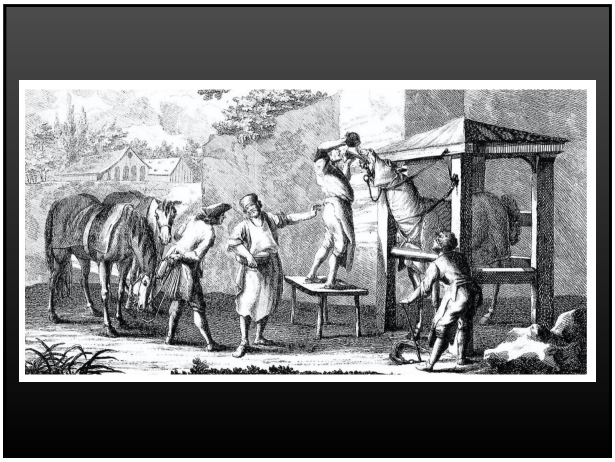

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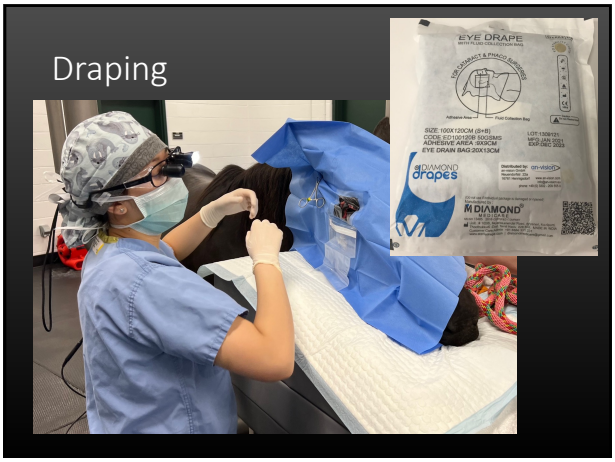

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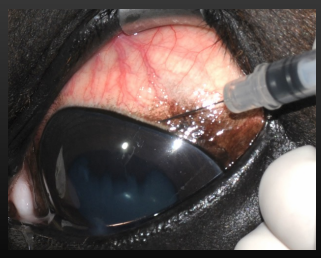
Draping

- Quick & minimally invasive procedures
  - NO drape



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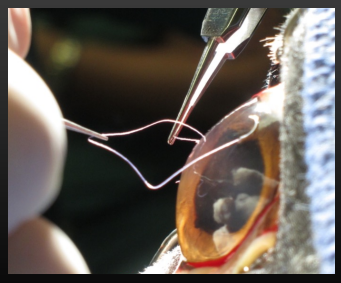
Draping

- When using suture
  - DRAPE



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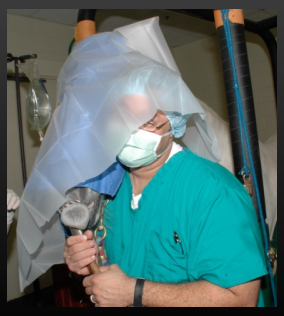
Considerations

- Do not cover contralateral eye
- Absorbent > plastic
  - Noise
- Self-adhesive
  - Ioban
- Fixate drape to halter



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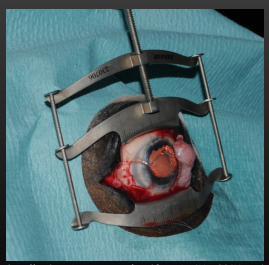
Microsurgical instrumentation

29

Eyelid speculum

- Blades open parallel
  - Uniform palpebral fissure
- No pressure on globe
- Fixation points for stay sutures



https://northamerica.covetrus.com/search?q=equine%20eyelid%20speculum

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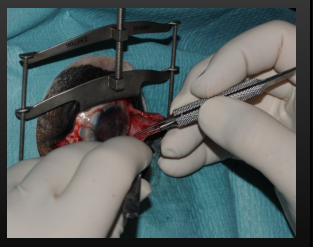
Forceps & needle holders

- Colibri forceps & needle holders with longer grip
  - Facilitate better hand support
  - Increase field of view
  - Tissue fixation w/o hands over LOI



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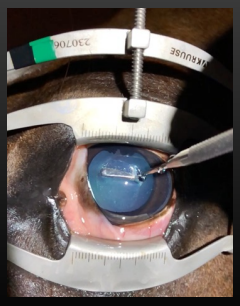
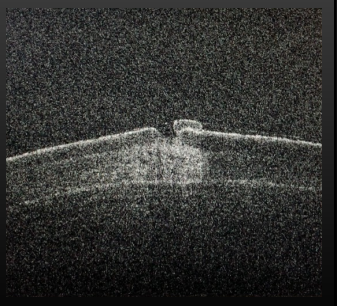
Martinez corneal dissector





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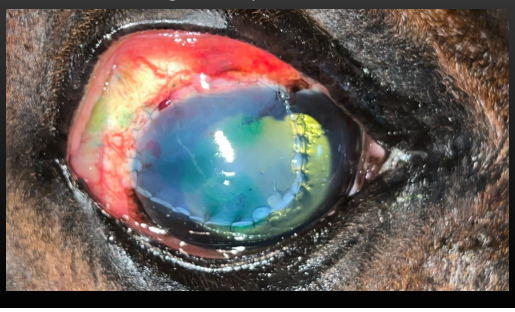
Conjunctival & amnion grafts

- Ford interlocking suture pattern



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Magnification & illumination

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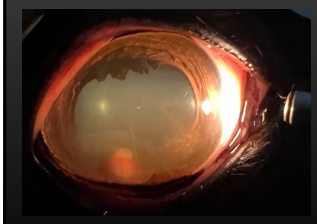
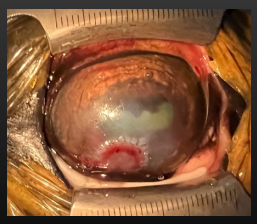
Standing ophthalmic surgery





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Categories of surgery

- Category I: Minimally invasive
- Category II: Simple
- Category III: Advanced
- Category IV: Complicated

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Categories of surgery

- Category I: MINIMALLY INVASIVE
  - Quick – No RB, profound sedation & LA
  - Examples:
    - Aqueous paracentesis, intravitreal and suprachoroidal injections, episcleral cyclosporine implant placement, diamond burr keratotomy

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Categories of surgery

- Category II: SIMPLE
  - More advanced instrumentation
  - More time consuming, RB & LA
  - Examples:
    - Enucleation, nictitans excision, eyelid neoplasia, laser ablation iris/uveal cysts, transscleral cyclophotocoagulation (TSCP)

38

Categories of surgery

- Category III: ADVANCED
  - Sutures required, precise tissue dissection
  - Microsurgical skills
  - Examples:
    - Superficial lamellar keratectomy (SLK), grafting procedures (conjunctiva, amniotic membrane, BioSiSt, A-cell), intrastromal corneal injections, glaucoma shunt bleb revision ("deroofinig")

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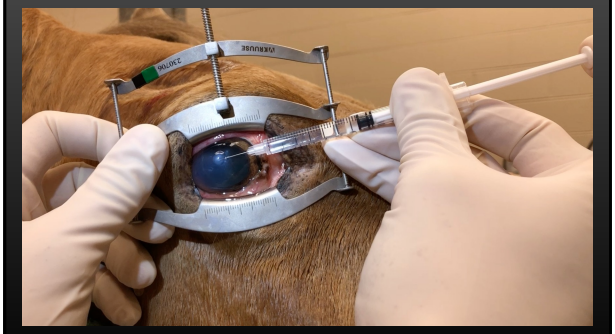
Categories of surgery

- Category IV: COMPLICATED
  - Highly specialized procedures
  - Require advanced microsurgical skills/experience, patience and intuition
  - Examples:
    - Suprachoroidal cyclosporine implant placement (CSI), deep lamellar endothelial keratoplasty (DLEK), posterior lamellar keratoplasty (PLK), corneoconjunctival transposition (CCT), gonio-shunt placement

40



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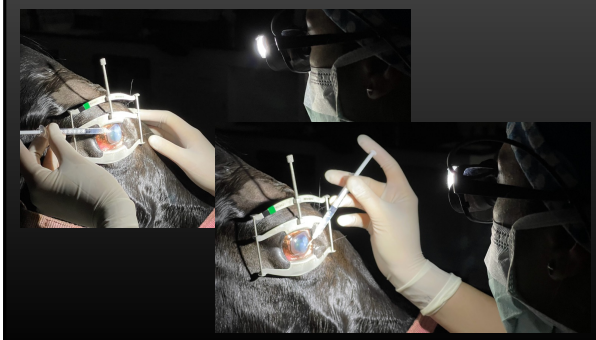
Be a little ambidextrous



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Take home points

- Use pads instead of people for stands
- Embrace the retrobulbar block
- Keep horse's eye at shoulder/eye level whenever possible
- 30G/12mm length needles or microneedles
- Ford interlocking suture pattern

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Acknowledgements

- AU Equine Ophthalmology Students & Service
  - Allie Ng, Kim Lam, Shenise Howard, Milena Sanchez, Roxy Rodriguez, Alessandra Keenan, Britta Fischer, Ethan Hefner, Lauren Charnock, Teresa Barros, Hannah Bostick, and Stephanie Mitchell

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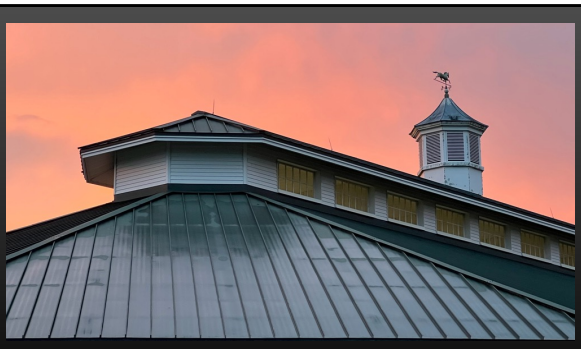

Thank you!

45

EPM in Horses:
Causes, Diagnosis, Treatment and Management

Alfredo Sanchez-Londoño, DVM, MS, DACVIM (Large Animal)
Associate Clinical Professor, Equine Field Service Clinician

Equine Protozoal Myeloencephalitis (EPM) is a focal or multifocal central nervous system (CNS) disease that can affect the brain and spinal cord. It can be caused by either *Sarcocytis neurona* or *Neospora hughesi*, but most cases are due to infection with *S. neurona*.

Etiology:
S. neurona has a 2-host life cycle and multiple intermediate hosts, which include skunks, raccoons, armadillos and cats. The opossum has been identified as the definitive host. The parasite reproduced in the intestinal epithelium of the opossum resulting in production of sporozoites, which contain the sporocysts that are passed in the feces. Sporozoites are infectious to the intermediate hosts. Latent sarcocysts are developed in the muscle tissue of the intermediate host, which is the source of infection for the opossum. Opossums will contaminate the environment through passage of contaminated feces. Horses will get infected by ingestion of contaminated food or water sources with opossum fecal material. It is important to recognize that there is no horizontal transmission between horses, and it cannot be transmitted to non-equine intermediate hosts. Even though vertical transmission of the organism is uncommon there have been a few reports of infected foals prior to suckling. [1,2]. The exact mechanism through which the organism enters the CNS is poorly understood, but it is suspected to be through infection of endothelial cells or leukocytes.

The complete life cycle of *N. hughesi* is not completely known. Canids are the definitive host for *Neospora caninum,* but it is still not confirmed that dogs or wild canids are the definitive host for *N. hughesi*. *N. caninum* can be transmitted vertically in cattle and there have been several reports showing that the organism can be transmitted transplacentally in horses.[3,4.]

All horses and equids are susceptible to being infected with EPM, but not all horses will develop disease, which has been demonstrated by multiple studies in mice and horses which have shown the importance of the immune response in preventing development of disease. It is not completely clear what factors are involved in progression to neurologic disease, as studies looking at stress and administration of immunosuppressive doses of steroids did not consistently cause an increase in severity of neurologic disease. [5,6].

Epidemiology and Risk Factors:
Thoroughbreds, Standardbreds and Quarter Horses have been most commonly reported, but the disease can happen in any breed of horse.[5] Seroprevalence of *S. neurona* can have a very large variability depending on geographical location[7-11], while *N. hughesi* usually has a low seroprevalence.
EPM is typically an individual horse disease, but there have been clusters of cases identified.[12,13]. Most studies have found that young horse (1-5 years) and older horses (>13 years) have a higher risk of development of the disease. The least common season for occurrence of EPM is winter, while the risk in spring and summer is 3x higher and 6x higher in the fall. Other risk factors associated with development of EPM are the presence of opossums, previous diagnosis of EPM, and presence of wooded areas.

Stressful events such as transportation[14], heavy exercise, trauma, surgery or parturition have been associated with high risk of development of EPM[15]. Race and show horses have been demonstrated to be at higher risk of development of EPM compared to pleasure and breeding horses.

Clinical Signs:

There is a large amount of variability in clinical signs, which can be acute or chronic, local, or multifocal and involving the brain, brainstem, or spinal cord. Dysphagia, abnormal upper airway function, unusual or non-specific lameness, or even seizures can be signs of EPM. Horses that are severely affected can present with difficulty rising, walking, or swallowing and the clinical signs will rapidly progress. The main reason why there is so much variability in clinical signs is because it will depend on if white or grey matter are affected and on the affected site. Grey matter signs involve focal muscle atrophy and severe muscle weakness, while white matter lesions usually cause ataxia and weakness in the limbs caudal to the site of infection. Initial clinical signs include stumbling or interference, which can be easily confused with a subtle lameness. Affected horses can have a gradual onset that will rapidly progress to severe clinical disease and recumbency. Neurologic evaluation of affected horses usually reveals asymmetric ataxia, weakness, and spasticity. Common clinical signs of brain or brainstem disease are obtundation, head tilt, facial nerve paralysis and difficulty swallowing amongst others.

Differential Diagnosis:

EPM affected horses can have very similar clinical signs to a lot of neurologic diseases. It is imperative to perform a complete and thorough neurologic examination to differentiate between these neurologic diseases. Common differentials include cervical vertebral myelopathy (CVM), trauma, EHV-1, WNV encephalomyelitis, equine degenerative myeloencephalopathy (EDM), equine motor neuron disease (EMND), spinal cord tumors, toxicities, temporohyoid osteoarthropathy, metabolic derangements and hepatic encephalopathies amongst others[11].

Diagnosis:

For antemortem diagnosis it is important to perform a thorough neurologic evaluation and to rule out other potential causes for the presence of neurologic signs. Cervical radiography could be of value to rule out the presence of other conditions that could affect the nervous system. Immunodiagnostic tests in serum and CSF can aid in the diagnosis of the disease.[16] Detection of serum antibodies in horses infected with *S. neurona* does not confirm the presence of disease, just exposure to the organism. Testing for serum antibodies against *S. neurona* has minimal diagnostic value unless the results are negative, but on the other hand detection of serum antibodies for *N. hughesi* in a neurologic horse has a much higher positive predictive value due to the low seroprevalence of the organism. It is important to remember that a negative serum test in an early infected neurologic horse does not rule out the possibility of EPM, and it is recommended to retest in 10-14 days. Detection of antibodies in the CSF can provide more valuable information, but it is important to remember that by itself it is not a positive indicator of disease, as there is the possibility of antibodies to cross a healthy blood brain barrier or have blood contamination form sample collection. It is for this reason that a serum:CSF ratio should be performed when infection with *S. neurona* is suspected. Unfortunately, a cutoff ratio for infection with *N. hughesi* has not been established at this time.

Available tests for *S. neurona*:

- Western blot (WB)
    - Qualitative test – detects antibodies against merozoite lysate.
    - High negative predictive value
- Indirect fluorescent antibody testing (IFAT)
    - Quantitative test – detects antibodies against culture-derived whole merozoites.
    - Poor predictor of EPM when used alone.
- Surface Antigen Enzyme-linked immunosorbent assay (SAG ELISA)
    - SnSAG2 ELISA and SnSAG 4/3 ELISA
    - Quantitative test – detects *S. neurona* surface antigens.
    - Used on both serum and CSF samples.

Available test for *N. hughesi*:

- Surface Antigen Enzyme-linked immunosorbent assay (SAG ELISA)
    - NhSAG1 – detects surface antigens.
        - 94% sensitivity, 95% specificity
    - IFAT – detects antibodies against whole *N. hughesi* tachyzoites.
        - 100% sensitivity, 71.4% specificity

Postmortem diagnosis with H&E staining, can in a small percentage (10-36%) of cases show CNS lesions caused by protozoa [17,18]. Significant inflammatory changes are usually present, and there is experimentally a PCR test to detect parasites in CNS tissue.

Treatment:

- Ponazuril (Marquis®)
- Diclazuril (Protazil®)
- Sulfadiazine/Pyrimethamine (ReBalance®)

Supportive medical treatment:

- NSAID's
- Corticosteroids
- DMSO
- Vitamin E

Immunomodulators

- Levamisole
- Killed Propionibacterium agnes (EqStim™)
- Mycobacterial wall extract (Equimune ®)
- Inactivated Parapox ovis virus (Zylexis)
- Transfer Factor (4Life® Transfer Factor)

Prevention:

The main preventative approach to EPM is decreasing stress and reduction of exposure to opossum feces, which can be achieved by not feeding horses off the ground, provide separate sources of fresh water to horses and preventing wildlife from entering the paddocks and stalls of horses will help minimize the incidence of infection.

There are reports of intermittent use of coccidiostatic and coccidiocidal drugs to prevent EPM. [19,20.] A study looking at a dose of 2.5 or 5mg/kg PO q 24 hrs. for 7 days before experimental challenge and then continued for 28 days showed decreased clinical signs and delayed seroconversion. In another study, intermittent administration of ponazuril paste at a dose of 20mg/kg PO every 7 days showed decreased intrathecal *S. neurona* antibody response in experimentally infected horses. Neither of these studies eliminate the risk of infection. Another study, looking at low dose Diclazuril (0.5 mg/kg PO, q 24 hrs.) administered to foals in a farm with high exposure rate to *S. neurona* showed a significant reduction in seroprevalence in treated versus untreated foals[21].

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EQUINE ON-FARM FLUID THERAPY

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Auburn University College of Veterinary Medicine, Auburn, AL, USA

Keywords: horse; fluids; dehydration; intravenous; enteral

INTRODUCTION

Fluid therapy in horses is a critical therapeutic component for many clinical diseases that veterinarians face daily. Administering fluid therapy in a field setting can be a challenge for patient, client, financial, and logistical reasons; however, it can be a valuable service that can significantly improve clinical outcome. Whether you identify enteral or intravenous fluid therapy (IVFT), or a combination of both, as the most clinically appropriate delivery method for the patient, performing on-farm fluid therapy is worth overcoming the challenges.

Fluid therapy on the farm is frequently met with a number of roadblocks that include cost (particularly for IVFT), equipment (e.g., for IVFT, having an adequate amount of fluids in your vehicle, catheter supplies delivery lines, ability to hang bags), personnel to monitor the horse and to ensure safe delivery of either enteral fluid therapy (EFT) or IVFT, time in the day for the veterinarian to be reassessing the horse appropriately, and others. Overcoming these roadblocks is not always easy, but some can be eliminated through thoughtful planning of the fluid therapy to maximize the clinical outcome while simultaneously meeting the needs of the patient, client, and veterinarian's time. Ultimately, it is the author's opinion that knowing your options and

developing a thoughtful fluid therapy plan with the patient, client, and your time in mind, makes on-farm fluid possible and effective.

DEVELOPING A FLUID THERAPY PLAN

Common indications for administration of fluids on the farm include dehydration, heat exhaustion, esophageal obstruction, any gastrointestinal disease, hemorrhage, dysphagia, and many others. Of course, there are many other indications for fluid therapy that may be associated with referral to a hospital; however, the reality of ambulatory practice-life is that referral is not always an option for clients, so more aggressive or prolonged therapy may need to be delivered to the horse on the farm.

The goals of fluid administration include restoration and maintenance of hydration (this is far and away the most common reason for fluid therapy in the field setting), correction of electrolyte and acid/base abnormalities, diuresis and minimizing adverse effects of nephrotoxic drugs/toxic metabolic by-products, improvement of cardiovascular parameters, *et cetera*. In practice, the author considers this list of goals, identifies the primary goal of fluid therapy in the patient and then assesses the following steps to solidify a fluid treatment plan: volume, type, route, rate, and reassessment. Lastly, after creating the plan, modifications are considered to account for the owner's budget, patient compliance, ability of personnel to monitor, duration that therapy is needed, and logistics to ensure it is feasible.

Volume

The author considers the first step in creating a plan to be identifying the volume needed to meet

the goal (e.g., restore and/or maintain hydration) as the volume to be delivered will impact the type given, the route of administration, and whether or not it can be accomplished in a reasonable time frame. When determining the volume, the veterinarian must consider the volume to restore hydration, to account of maintenance needs, and to account of ongoing losses. Performing the calculations is critical to ensure that the patient is not fluid overloaded (particularly in a foal) or given an inadequate amount. In the author's experience, fluid overloading an adult horse that has normal cardiopulmonary and renal function is difficult to do; however, fluid overloading a foal is valid concern as it is much easier to give too much. Similarly, when considering a sick, dehydrated patient, being able to give any amount of fluids in the field is likely better than giving none; however, the author finds this to be a common area where fluid therapy protocols could be improved to ensure that the horse is receiving a significant amount to meet the calculated, clinical goal. For example, if a 500 kg, 5% dehydrated horse needs 55 liters of intravenous fluid therapy to ensure restoration and maintenance of hydration, giving 5 liters is better than no fluid, but giving at least the deficit of 25 liters is going to make a much more significant clinical impact.

The maintenance fluid requirement for adult horses is approximately 60 mL/kg/day. This accounts for intake and urinary, fecal, and metabolic water loss. NOTE: this maintenance requirement reflects what the horse needs to drink each day to stay euhydrated, so it is the same rate used when developing a plan for IVFT or EFT. Maintenance rates are increased for neonatal patients, mares that are lactating, or horses in heavy work in hot/humid weather conditions. Calculating the maintenance rate for a 500 kg horse: (60 mL) x (500 kg) = 30,000 mL or 30 L per day. Dehydration is a reflection of the percentage of body weight lost due to fluid loss. This

loss of fluid needs to be replaced if the horse will not or cannot replace it on its own. Dehydration is assessed by the physical examination/patient's perfusion parameters (Table 1). Dehydration of less than 5% is not clinically detectable and dehydration of greater than 15% is not compatible with life. Calculating the volume for restoration of 10% dehydration in a 500 kg horse is based on multiplying the body weight in kilograms times the % dehydration: (500 kg) x (10 %) = 50 L. Estimating/assessing ongoing losses is centered on considering the clinical conditions rather than the inconsequential losses (feces, urine, sweat, and condensation of breathing). NOTE: these losses from normal biological processes are accounted for by the animal's daily maintenance fluid needs. SO, these insensible losses are not factored into the fluid plan IF the animal has normal consistency to the feces, normal volume of urine, or is not sweating profusely. Most commonly, ongoing losses that need to be factored into the fluid plan are associated with the presence of large volumes of diarrhea or enterogastric reflux, loss of fluid into a third space as with peritoneal or pleural effusion, or loss of fluid in the form of hemorrhage or polyuria. Volumes of enterogastric reflux can be quantified and replaced (e.g., if a horse is losing 4 liters of reflux every 3 hours, then 32 L of fluid would need to be accounted for in the daily fluid plan). Volumes of diarrhea must be observed and estimated. If pleural or peritoneal fluid is drained from the body cavity, that volume can also be accounted for in the daily fluid plan.

Once you have assessed the patient and calculated the volume required for maintenance, restoration of hydration, and ongoing losses, these volumes are added together and used during a 24-hour treatment period typically; however, this can be modified for the period you plan to be on the farm. In the example of a 500 kg horse that is 10% dehydrated and is losing

approximately 4 liters of reflux every 3 hours, the horse would require 112 L over 24 hours. This is unlikely to be a feasible endeavor in the field and may require referral to a hospital; however if the client is willing to pay for your time, even that high volume of fluid can be delivered.

Type

Determining the type of fluid to be administered in the field is usually uncomplicated: give what you have available, which is frequently isotonic crystalloids for IVT and tap water for EFT. However, the fluid can certainly be modified as needed for each clinical situation by adjusting the electrolyte composition or providing dextrose, for example. Polyionic fluids labeled as 'replacement or resuscitation' fluids (Lactated Ringer's solution, Normosol-R®, Vetivex®, or Plasma-Lyte-A® for example) are generally the safest fluids for IV administration and are appropriate for many clinical conditions faced by veterinarians on the farm. In severely poorly perfused horses, hypertonic saline (7% NaCl) can be given to promote fluid shifts into the vasculature from the tissues; however, it's practicality in the field setting should be assessed since large-volume administration of isotonic, polyionic fluids must follow hypertonic saline administration and this can't always be achieved in the field.

Route

The primary routes of fluid administration in the field setting include either the intravenous or enteral route. Determining the route of fluid administration is directly tied to the horse's clinical condition and whether or not the gastrointestinal (GI) tract is functioning normally, as well as the volume that needs to be delivered. If the GI tract is not functioning, enteral administration of fluids is not safe/appropriate. Similarly, if the GI tract is functioning but the horse is in

hypovolemic shock, intravenous fluid administration will be more effective/appropriate. The route of administration is also profoundly impacted by cost of administration. Intravenous fluid therapy is considerably more expensive than enteral fluid therapy, so the client's budget must certainly be considered.

Enteral fluid therapy is an excellent option for the field setting, particularly if large volumes are not needed. The primary consideration for fluid delivered by the enteral route is ensuring it can be tolerated (i.e., the horse must have a functional GI tract…the horse cannot be refluxing and the colon must be capable of absorbing the fluid). Fluids can be administered by slow, continuous rate infusion through a narrow bore, indwelling nasoesophageal tube or intermittently through a large-bore nasogastric (NG) tube by pump or funnel. Nasogastric tubes can be indwelling or intermittently passed/removed; however, if indwelling, monitoring of the tube placement/location is necessary to ensure safe delivery of fluids to the horse. Additionally, the volume administered should be closely monitored. The volume is limited based on the size of the horse's stomach. The stomach volume of an average-sized horse is approximately 12-16 liters. The amount of fluid administered at one time should not exceed 8-10 L in a 500 kg horse; the administration may be repeated every 30 minutes to few hours, after checking the stomach for reflux. Most horses will not tolerate large volumes too frequently and will develop enterogastric reflux. A recipe for isotonic enteral fluid therapy is available in Table 2.

Rate

Determining the rate of administration depends on the following: the severity of the fluid loss and the disease for which the horse is being treated, the type of fluid being administered (e.g.,

many severe electrolyte derangements have to be corrected at specific rates for safety), the route may dictate the rate, and the amount of time you have available on the farm. For the intravenous route, a safe average rate of fluid administration is 20 mL/kg/hr, increasing to 40-80 mL/kg/hr for horses in hypovolemic shock and decreasing to 2-3 mL/kg/hr for maintenance. Ultimately, the rate can be adjusted to meet the horse's clinical needs and your period on the farm, as long as the clinical conditions are considered. Remember that the rate is important in smaller patients, or patients with renal disease or cardiopulmonary disease, because they can be fluid overloaded. For enteral fluid therapy, the rate of administration is dictated by the stomach size and the horse's ability to tolerate the volume delivered to the stomach. As mentioned, the capacity of an average-sized adult stomach for safe administration of fluids is 8-10L; however, if the enteral route is to be intermittently utilized, the ideal volume/rate is 2-4 liters every 2-3 hours.

Reassessment

Reassessing the fluid plan and the patient's needs is another critical step in achieving a successful response to fluid administration. Patient monitoring should be done frequently to ensure that the fluids, by whichever route, are being delivered safely. Additionally, the patient's clinical response should be monitored to determine if adjustments need to be made in the volume, route, rate, or type of fluid. If the horse's clinical condition is changing rapidly, the fluid plan may need to change rapidly. If the horse is deteriorating and needs more than can be accomplished on the farm, referral may need to be considered. The horse should be monitored for adequate urine production/decreased ongoing losses in proportion to the hydration and volume of fluid administered, the perfusion parameters should be assessed frequently to ensure improvement, and clinicopathological data can be evaluated if available.

SUMMARY

Administering fluids to horses in the field setting is feasible and a clinically valuable endeavor when the logistics for the patient, client, and veterinarian are all considered. When approached in a step-by-step fashion, the delivery of fluids on the farm can provide a strong clinical benefit to the horse.

References upon request.

Table 1: Clinical findings used to assess perfusion:

Dehydration	% water loss	Clinical Signs
Mild	5-7%	Lethargy, dry mucous membranes, prolonged CRT, decreased urine production
Moderate	8-10%	As above; weak pulse, prolonged jugular filling, decreased skin turgor (prolonged skin tent), tachycardia
Severe	>10%	As above; cold extremities, +/- recumbency, depressed, sunken eyes

Table 2. Isotonic, enteral fluid recipe:

Supplement:	Amount:	Conversion:	Product:
Sodium chloride	5.27 g/L or 5.6 g/L	5 tbsp./15 L	Morton Salt®
Potassium chloride	0.37 g/L or 0.6 g/L	1.5 tsp./15 L	Morton Lite Salt®
Sodium bicarbonate	3.78 g/L or 3.4 g/L	3 tbsp./15 L	Arm & Hammer Baking Soda®

Colic: When Surgery/Referral Isn't an Option

Claudia Reyner, DVM, DACVS-LA

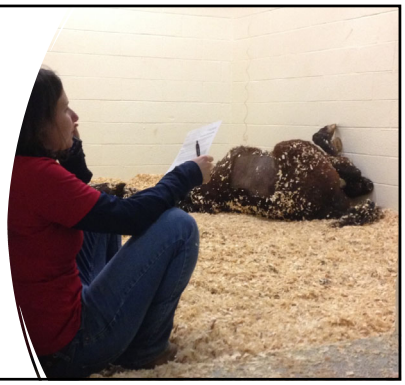
October 5, 2023

JT Vaughan Equine Conference

1

Outline

- Treatment vs. Euthanasia
- Tools/Techniques
  - Trocarization
  - Rectal Fluids
  - Analgesics – Beyond Banamine



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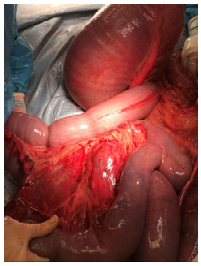
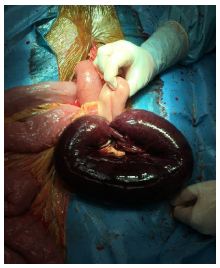
Treatment vs. Euthanasia

Sometimes treatment should not be an option without referral





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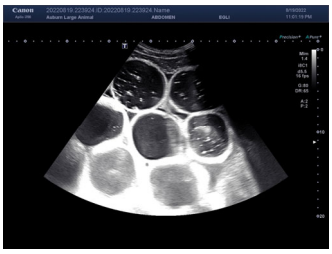
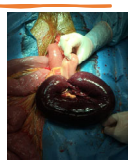
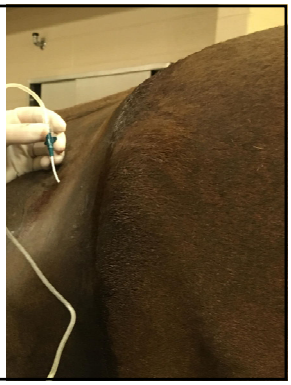
Treatment vs. Euthanasia

Sometimes treatment should not be an option without referral

4

Large Intestinal Trocarization



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Trocarization

- Trocarization in horses - use of a needle or trocar to decompress gas from the cecum or large colon.
- Large intestinal tympany can be primary or secondary
  - Primary: Abnormal bacterial fermentation leads to accumulation of gas
  - Secondary: Tympany is secondary to another condition (impaction, displacement, volvulus).

6

Trocarization

- Trocarization of the large colon or cecum may resolve primary gas tympany of these structures.
- Trocarization of the large colon or cecum may resolve/reduce gas distension enough to promote resolution of a displaced colon.
- Trocarization may decrease morbidity and mortality associated with severe intra-abdominal hypertension.

7

Trocarization – Case Selection

- Usually this is performed on horses with moderate to severe large intestinal gas distension that is not resolving with routine medical management (and do not have a surgical option).
- Patients need to have gas distended bowel that is adjacent to the flank.
  - If the gas distended bowel is not accessible trocarization will not be useful
- Sometimes I will perform this procedure prior to surgery in cases where I worry their respiratory function is severely compromised from the distension.

8

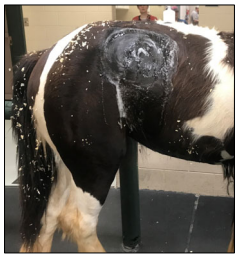
Trocarization -Supplies

Supplies
- Clippers
- Sedation (alpha-2 agonist + opiod)
- Materials for sterile scrub (chlorohexidine and alcohol-soaked gauze sponges)
- Local Anesthetic
- 14-gauge catheter
- Extension set
- Aminoglycoside (3-5 mL of Gentamicin or Amikacin)
- Cup of water

9

Trocarization - Technique

1. **Patient Restraint**
   - Sedation, +/- restraint in stocks, +/- twitch
2. **Site Selection**
   - Usually on right side, but may also be performed on left
   - Site selection determined by percussion, rectal palpation, abdominal ultrasound or a combination of these techniques.
   - Site is usually approximately halfway between last rib and tuber coxae within paralumbar fossa.
3. **Preparation of the site**
   - Clip, aseptic preparation, local block



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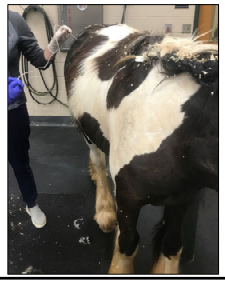
Trocarization - Technique

4. **Insertion of catheter**
   - Catheter (including stylet), is inserted through bleb and directed approximately 10-15 degrees cranioventrally until a rush of gas is appreciated.
   - The stylet is partially or completely withdrawn (to prevent inadvertent trauma to bowel wall) and an extension set is attached.
   - The free end of the extension set is placed in a cup of water. The position is maintained until gas ceases to escape (the bubbles stop).
5. **Removal of Catheter**
   - Extension set is removed
   - Catheter is flushed with 3-7mL of an Aminoglycoside during removal.



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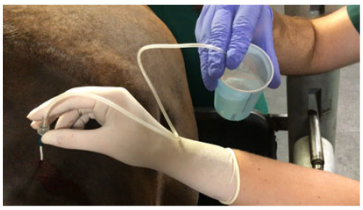
Trocarization - Technique



12

Trocarization – Other Considerations

- Extension set can be attached to suction (which may significantly shorten length of procedure).
- The procedure may be repeated if needed (though increasing number of trocarization procedures is associated with non-survival).
- Consider placing the patient on broad spectrum antibiotics following procedure.

13

Trocarization Literature

Outcome and complications following transrectal and transabdominal large intestinal trocarization in equids with colic: 228 cases (2004–2015)

Angelika Schoster PD, Dr Med Vet, PhD, DVSc
Nicole Altermatt Med Vet
Paul R. Torgerson PhD, VetMB
Andrea S. Bischofberger Dr Med Vet, PhD

JAVMA | JULY 2020

- Retrospective study evaluating 228 equids with colic that underwent large intestinal trocarisation
- No patients died or were euthanized from complications of large intestinal trocarisation.
  - 20% of equids that received medical treatment only had had clinically relevant peritonitis following trocarization.
- Non-survival associated with increasing number of trocarizations.

14

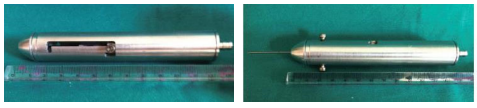
Trocarization Literature

Equine Veterinary Education
184
EQUINE VETERINARY EDUCATION
Equine vet. Educ. (2013) **25** (4) 184–188
doi: 10.1111/j.2042-3292.2012.00445.x

Original Article

Transrectal decompression as a new approach for treatment of large intestinal tympany in horses with colic: Preliminary results

G. B. Scotti, S. S. Lazzaretti, D. D. Zani† and M. Magri‡*



Transrectal decompression device (TDD) used by authors to perform transrectal decompression.

15

Trocarization Literature

Equine Veterinary Education

184

EQUINE VETERINARY EDUCATION
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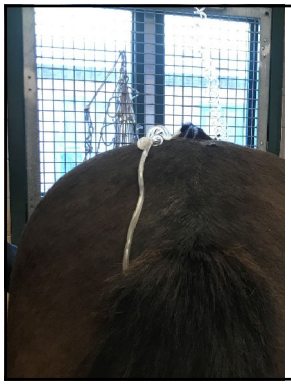
G. B. Scotti, S. S. Lazzaretti, D. D. Zani† and M. Magri‡*

- A total of 33 transrectal decompressions were performed on 17 different horses for treatment of tympany.
- The authors report that no horses developed short-term or long-term complications from the procedure.

16



Transrectal Fluids

Tap water administered per rectum may be an inexpensive and safe alternative to I.V. or nasogastric fluid administration

17

Transrectal Fluids Literature

Equine Veterinary Journal

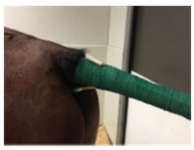
Equine Veterinary Journal ISSN 0425-1644
DOI: 10.1111/evj.13113

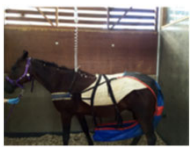
Continuous fluid infusion per rectum compared with intravenous and nasogastric fluid administration in horses

A. KHAN[†], G. D. HALLOWELL[‡], C. UNDERWOOD[†] and A. W. VAN EPS[†]*

[†]School of Veterinary Science, the University of Queensland, Gatton, Queensland, Australia
[‡]School of Veterinary Medicine and Science, the University of Nottingham, Leicestershire, UK.

*Correspondence email: vaneps@upenn.edu. Dr A. Khan's present address: Faculty of Veterinary and Agricultural Sciences, the University of Melbourne, Werribee, Victoria, Australia. Dr A. Van Eps's present address: Department of Clinical Studies, New Bolton Center, School of Veterinary Medicine, University of Pennsylvania, Kennett Square, Pennsylvania, USA. Received: 05.06.18; Accepted: 15.03.19





Images of transrectal fluid setup from paper (Khan et al.)

18

Transrectal Fluids Literature

Equine Veterinary Journal

Equine Veterinary Journal ISSN 0425-1644
DOI: 10.1111/evj.13113

Continuous fluid infusion per rectum compared with intravenous and nasogastric fluid administration in horses

A. KHAN[†], G. D. HALLOWELL[‡], C. UNDERWOOD[†] and A. W. VAN EPS[†]*

Randomized controlled experimental trial involving six clinically normal Standardbred geldings in a 4-way cross over study (control, IV fluids, nasogastric fluids, transrectal fluids).

Hemodilution achieved with tap water administered transrectally at a rate of approximately twice maintenance was comparable to that achieved by both IV and nasogastric tube.

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Transrectal Fluids – Case Selection

- Transrectal fluid administration is not appropriate by itself for patients that need rapid volume resuscitation.
- Transrectal fluid administration is not an effective administration route for electrolyte supplementation.
- The major benefit of transrectal fluid administration is a reduction in cost compared to IV fluid therapy. It may also be a better alternative to fluids via nasogastric tube in cases of simple small intestinal obstruction where enteral fluid therapy may not be tolerated.
- Authors of paper have administered tap water per rectum as a CRI for up to 3 days without apparent complication.

20

Transrectal Fluids –Set up

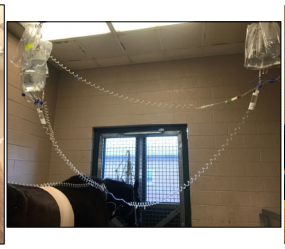
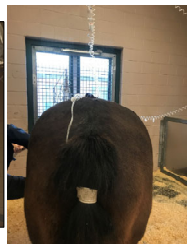
Enema Catheter (~24 Fr)

Adapter

Regular Fluid Administration Set

21

Transrectal Fluids –Set up

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Analgesia

23

Analgesia and Colic

Banamine: 1.1 mg/kg IV

Alpha-2 Agonist in combination with opiod.

- Detomidine: 0.01-0.03 mg/kg IV or IM
- Butorphanol: 0.01-0.03 mg/kg IV or IM
- *Effect of this therapy must be considered in subsequent evaluations*

24

Analgesia and Colic

Dipyrone: 30 mg/kg IV or IM
- *Modest analgesic effects*

Buscopan: 0.3 mg/kg IV

25

Analgesia and Colic Constant Rate Infusions (CRIs)

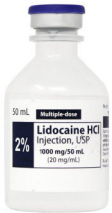
Lidocaine
- 1.3 mg/kg loading dose
- 0.05 mg/kg/min

Butorphanol
- 0.013 mg/kg/h

26

Lidocaine CRIs

- Intravenous lidocaine as a CRI has potential for analgesic, anti-inflammatory, and prokinetic effects.
- Clinical studies on its use have resulted in conflicting results.
- In our clinic it is most commonly used for the management of post-operative colic cases or in horses with inflammatory gastrointestinal lesions (i.e. enteritis).



27

Butorphanol CRIs

J Vet Intern Med 2004;18:555–563

Effects of Continuous Rate Intravenous Infusion of Butorphanol on Physiologic and Outcome Variables in Horses after Celiotomy

Debra C. Sellon, Malcolm C. Roberts, Anthony T. Blikslager, Catherine Ulibarri, and Mark G. Papich

Butorphanol CRIs in the immediate post-operative period resulted in lower plasma cortisol concentrations and improved behavioral scores.

28

Analgesia and Colic Ketamine Stun

Adding small doses of ketamine to injectable cocktails can dramatically improve systemic analgesia

29

Ketamine

- NMDA Receptor Antagonist
- Can be a potent analgesic at sub-anesthetic doses
- Ketamine boluses (“Stun”) at 0.22 mg/kg IV or IM (approximately 100 mg/450 kg) can be given “to effect”
  - More conservative doses should be used if patient must remain standing.

30

Ketamine
Additional considerations

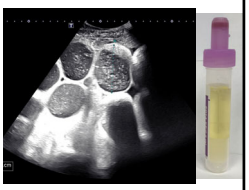
Use in combination with other sedative
- I personally only use it in combination with alpha-2 agonist and opiod (detomidine and butorphanol).

Even at sub-anesthetic doses it can induce recumbency

31

Case Example

14 Year Old Quarter Horse Gelding (~1000 pounds) presented for colic signs of ~6 hrs duration. No improvement after full dose Banamine
- PE: Pulse 60 bpm. Gums WNL. – actively colicing (pawing) admission
- Nasogastric Intubation: No reflux
- Ultrasound: Multiple distended loops of small intestines – 6 cm diameter
- Rectal: Multiple distended loops of small intestines
- Abdominocentesis: Grossly normal



32

Case Example - Continued

Assessment: Suspect ileal impaction. Recommend medical management

Initial Treatment
- IV Fluid Therapy
- NPO - Regular gastric decompression
- Analgesia – **5 mg Detomidine and 5 mg Butorphanol IV**

Case Progress
- Patient develops moderate signs (pawing/flank watching) of colic **2 hours** later. Pulse is 56 bpm, gums WNL, no reflux.
- Administer another **5 mg Detomidine and 5 mg Butorphanol IV**

33

Case Example - Continued

1.5 hours after second round of sedation patient is down and rolling and profusely sweating. Pulse is 84 bpm and 4 liters of reflux is obtained.

Repeat Colic work up

- Ultrasound: Distended loops of small intestines – 7.5 cm diameter
- Abdominocentesis: Unchanged, grossly normal

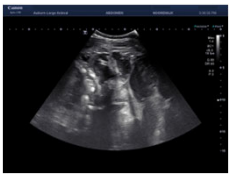
Recommended Surgery. Declined by owner.

34

Case Example - Continued

Treatment (back in patient's stall):

- 5 mg Detomidine and 5 mg Butorphanol IV
- 5 mg Detomidine and 5 mg Butorphanol IM
- 100 mg (1mL) Ketamine IM



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Questions

36

Hematuria and Pigmenturia in the Horse

Mariano Mora-Pereira DVM, MS, PhD, DACVIM-LA

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Hematuria and Pigmenturia

- Hematuria: Blood in the urine
- Pigmenturia: Presence of a component that gives an abnormal color to urine
- Color of urine → associated with excretion of urochrome
  - Product of the degradation of hemoglobin

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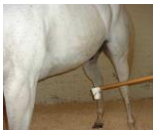
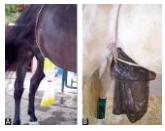
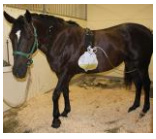
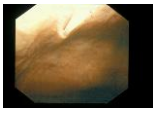
Urine collection

- Free catch
- Catheterization
- Endoscopy
  - Ureter









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Hematuria

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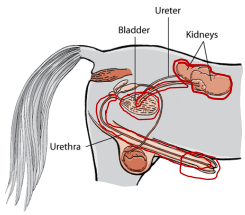
Hematuria

Origin of blood

a) Kidney
b) Bladder
c) Ureter
d) Urethra
e) Reproductive tract



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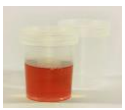
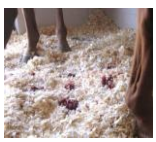
Hematuria

- Macroscopic or microscopic
- Severe cases → voiding of blood clots



History

- Drugs administered
- Type of pasture
- Geographical location
- Recent exercise, abnormal gait



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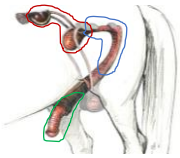
Hematuria

- **Timing of micturition**
  - Beginning to end → renal, ureteral or bladder
  - End → proximal urethra or bladder neck
  - Beginning → distal urethra



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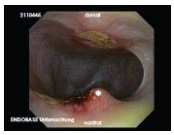
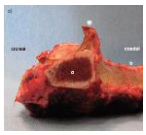
Exercise-induced hematuria

- First void after exercise

a) Cystoliths
b) Bladder trauma against pelvic rim (Concussion)
c) Osteochondroma of the *os pubis*





Hematuria caused by osteochondroma of the os pubis. EVE 24:30-37, 2012

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Urolithiasis

- More often in males
- Hematuria after exercise
- Near the end of urination
- Pollakiuria
- Dysuria
- Dribbling urine
- Prolonged periods of penile protrusion
- Blood-stained pelvic limbs

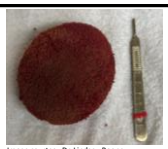
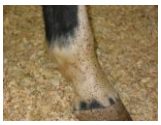


Image courtesy Dr. Lindsey Boone



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Urolithiasis

Nephroliths and ureteroliths

- Partial or complete obstruction
  - If bilateral → chronic renal failure
- Mild recurrent colic
- Microscopic hematuria

Saetra, T., et al. (2018). Equine Vet Educ, 30: 635-639.

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Urolithiasis

Diagnosis

- Rectal palpation
- Ultrasound
- Cystoscopy
- Type 1- yellow to green, spiculated, friable (mainly $CaCO_3$)
  - 90% cases
- Type 2- Smooth, hard and white ($CaCO_3$+phosphate+Mg)

Image courtesy Dr. Lindsey Boone

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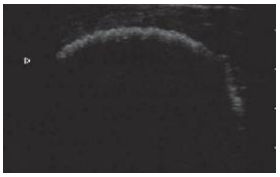
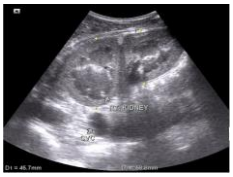
Urolithiasis



Cystolith



Nephrolith

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Cystoscopy

Video courtesy Dr. Erin Groover

Image courtesy Dr. Lindsey Boone

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Urolithiasis - treatment

- Surgical/manual removal
- Laser and shock wave
- Recurrence
  - 46.6%
    - Fragments acting as a nidus remained
    - Undetected calculi
    - Propensity toward stone formation (Ca crystal aggregation)

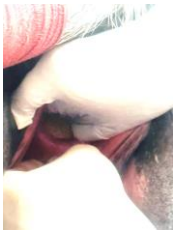

Image courtesy Dr. Lindsey Boone

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Urolithiasis - treatment

- No studies to prove that urine acidification prevents formation
  - Below pH 6.5 calcium carbonate uroliths do not form
  - Prevented new calculi formation in a single case of a horse with recurrent cystic calculi

ment was achieved by feeding a 0.2% calcium oat hay ration and administering 175 mg ammonium sulfate per kg body weight orally twice daily for 7 months which produced a urine pH of 5.0. There was no evidence of metabolic acid/base

Remillard et al. 1984

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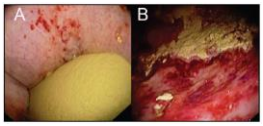
Sabulous cystitis

- Secondary to ventral accumulation of urine sediment
- Associated with bladder dysfunction
- Urinary incontinence
  - Most common presenting complain
- Treatment
  - Bladder lavage
  - Antimicrobials
  - Anti-inflammatories
  - Bethanechol
  - Phenazopyridine



Zakia et al. 2022. JVIM

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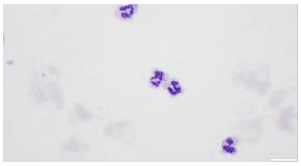
Urinary tract infection and pyelonephritis

- Primary (rare)
- Secondary
  - Paresis or paralysis of the bladder
  - Urocystoliths
- Urinalysis
  - ↑ WBCs
  - Intracellular bacteria
  - Quantitative urine culture (>10,000 CFU/mL)



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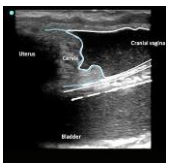
Urinary tract infection and pyelonephritis

- Lower urinary tract → Bladder, urethra
  - Multiparous mares
  - Chronic atonic bladders
- Upper urinary tract → kidneys, ureters
  - Pyelonephritis → renal pelvis and parenchyma
    - Associated with nephroliths or ureteroliths
    - Microscopic or macroscopic hematuria
    - Unilateral or bilateral renal hemorrhage



Linton, 2022

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Clinical case

- 12 YO AQH gelding
- Acute hematuria of 3-day duration
- Lethargic 2 weeks prior
- HR 48 bpm, RR 16 brpm, T 100.2F
- Hematuria (frank blood) in the mid-late stream

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Clinical case

RBC	6.37		x 10^6/uL
HGB	10.9		g/dL
HCT	30.9	L	%
MCV	48.4		fL
MCH	17.1		pg
MCHC	35.4		g/dL
RDW	18.9		%
PLATELET COUNT	48	L	x 10^3/uL
MPV	7.6		fL
WBC	10.43		x 10^3/uL

Test	Diff %	Result		Units
SEG	(82%)	8.553	H	x 10^3/uL
BANDS	(0%)	0.000		x 10^3/uL
LYMPH	(13%)	1.356	L	x 10^3/uL
MONO	(3%)	0.313		/uL
EOS	(0%)	0.000		x 10^3/uL
NRBC		0		/100 WBC
PLT EST	BELOW REFERENCE INTERVAL			
Plasma T/S	7.7 g/dL			
Fibrinogen T/S		200		mg/dl

RBC MORPHOLOGY
FEW ECHINOCYTES, MODERATE ROULEAUX

PLATELET MORPHOLOGY
38-50(x10^3/uL)= PLATELET EST

CREATININE	3.4	H	mg/dL	0.0 - 2.0
CALCIUM	12.8		mg/dL	10.5 - 12.9
MAGNESIUM	1.6	L	mg/dL	1.7 - 2.1
BICARBONATE	28.1		mmol/L	21.0 - 30.0
SODIUM	132	L	mmol/L	134 - 150
POTASSIUM	4.3		mmol/L	3.5 - 4.5
CHLORIDE	93	L	mmol/L	97 - 111
ANION GAP	15.2			9.0 - 25.0

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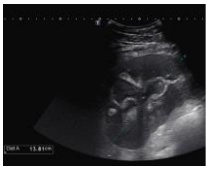
Clinical case

- Diagnosis based on ultrasonographic findings
  - ↑ renal echogenicity
  - Abnormal outline
  - ↓ corticomedullary distinction
  - Debris in the renal pelvis
  - Dilated renal pelvis (pyelectasia)
  - Renal biopsy?



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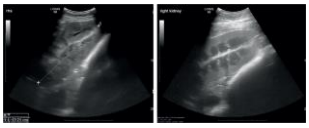
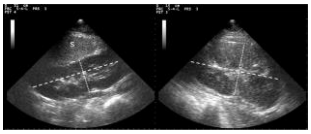
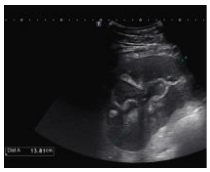


Jocelyn N. Kidney disease in the horse. *Equine Health*. 2020;2020:20-23.





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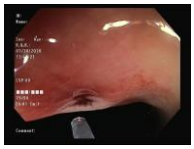
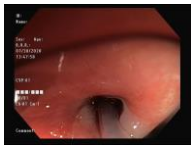
Haboshon-Butcher, J., Bowen, M. and Hallowell, G. (2014), VALIDATION OF A NOVEL TRANSLUMBAR ULTRASOUND TECHNIQUE FOR MEASURING RENAL DIMENSIONS IN HORSES. Journal of Equine Ultrasound, 55: 323-330.

Clinical case





- Unilateral kidney hemorrhage
- Collection of samples for urinalysis, bacterial culture, leptospirosis

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Clinical case

Urine Volume	50.0 ML
Urine Source	VOIDED(FREE-CATCH)
Urine Color	BROWN
Urine Turbidity	CLOUDY
Specific Gravity	1.021
Urine pH	8.5
Urine Protein	97.7 mg/dL
Urine Glucose	NEGATIVE
Urine Ketone	NEGATIVE
Urine Blood	3+
Urine Bilirubin	1+

URINE SEDIMENT EXAM
0-3/hpf WBC, TOO NUMEROUS TO COUNT RBC

CRYSTAL EXAM
MANY CALCIUM CARBONATE CRYSTALS

- IV fluid therapy
- Enrofloxacin IV

- Bacterial culture – No bacterial growth
- Idiopathic renal hematuria?

- Necropsy
  - Bilateral chronic interstitial nephritis and pyelonephritis

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Treatment

- Antibiotic based on culture and sensitivity
- Use an antibiotic eliminated in urine
  - Penicillin (unchanged)
  - Aminoglycosides (unchanged) (nephrotoxic)
  - TMS (mostly—some through the liver)

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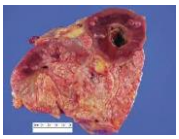
Neoplasia

- Clinical signs similar to those of horses with cystic calculi
- Rectal palpation
  - Mass in bladder
  - Enlarged kidney
- Ultrasound
- Cystoscopy
- Urinalysis and cytology
- Nephrectomy → search for metastasis first



Wise et al. 2009. JVIM

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Verminous nephritis

- Halocephalobus gingivalis
  - 1. Brain (mimics EPM)
  - 2. Spinal cord
  - 3. kidney
- Renal granulomas
- Diagnosis
  - Renal ultrasound
  - Nematode in urine sediment
- Treatment
  - Larvicidal antihelmintic
  - No successful medical treatment reported
  - Nephrectomy

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Clinical case

- 13 YO AQH gelding
- Intermittent hematuria of 1 month duration, fever
- Evaluated few weeks prior → unknown origin of hematuria

Physical exam

- HR 74 bpm, RR 20 brpm, T 104.4F
- CRT 3.5 s
- Yellow/cloudy urine with blood at end of urination
- Sabulous material on hind limbs

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Clinical case

- Abdominal ultrasound → Normal kidneys, slightly hypomotile SI
- Rectal → enlarged bladder, normal left kidney
- Abdominocentesis → pale yellow, clear
- Normal coagulation profile
- Urinalysis by catheterization
- CBC and chem

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Clinical case

RBC	7.62	x 10^6/uL	6.00 - 12.00
HGB	13.8	g/dL	10.0 - 18.0
HCT	37.0	%	32.0 - 48.0
MCV	48.5	fL	34.0 - 58.0
MCH	18.1	pg	14.0 - 19.0
MCHC	37.4 H	g/dL	31.0 - 37.0
RDW	18.0	%	17.0 - 20.0
PLATELET COUNT	106	x 10^3/uL	100 - 230
MPV	6.4	fL	5.8 - 11.5
WBC	14.38 H	x 10^3/uL	6.00 - 12.00
Test	Diff % Result	Units	Ref Interval
SEG	(79%) 11.360 H	x 10^3/uL	3.000 - 6.000
BANDS	(3%) 0.431 H	x 10^3/uL	0.000 - 0.100
LYMPH	(16%) 2.301	x 10^3/uL	1.500 - 5.000
MONO	(2%) 0.288	nL	0.000 - 0.600
EOS	(0%) 0.000	x 10^3/uL	0.000 - 0.600
BASO	(0%) 0.000	x 10^3/uL	0.000 - 0.100
OTHER	(0%) 0.000	x 10^3/uL	0.000 - 0.000
NRBC	0	/100 WBC	No Ref Interval
PLT EST	WITHIN REFERENCE INTERVAL		
Plasma T/S	7.2 g/dL		
Fibrinogen T/S	300	mg/dl	100 - 400
RBC MORPHOLOGY			
SLIGHT ROULEAUX			

TOTAL PROTEIN	6.53	g/dL	6.00 - 8.60
ALBUMIN	2.95	g/dL	2.70 - 4.10
GLOBULIN	3.58	g/dL	2.80 - 4.40
ALBUMIN/GLOBULIN RATIO	0.82		0.70 - 1.00
SDH	7.3	U/L	0.5 - 10.0
AST	328	U/L	144 - 350
GGT	17	U/L	2 - 29
TOTAL BILIRUBIN	4.46 H	mg/dL	0.70 - 3.60
CK2	340	U/L	103 - 402
BUN	12.9	mg/dL	9.0 - 24.0
CREATININE	1.1	mg/dL	0.0 - 2.0
CALCIUM	10.3 L	mg/dL	10.5 - 12.9
PHOSPHORUS	1.8 L	mg/dL	2.1 - 4.6
MAGNESIUM	1.2 L	mg/dL	1.7 - 2.1
GLUCOSE	120	mg/dL	81 - 127
BICARBONATE	22.9	mmol/L	21.0 - 30.0
SODIUM	139	mmol/L	134 - 150
POTASSIUM	3.0 L	mmol/L	3.5 - 4.5
CHLORIDE	104	mmol/L	97 - 111
ANION GAP	15.1		9.0 - 25.0
OSMOL(CALC)	275	mOsm/kg	276 - 288
S.IRON	31 L	ug/dL	129 - 173
UIBC	320	ug/dL	123 - 430
TIBC	351	ug/dL	243 - 553

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Clinical case

Urine Volume	23.0 ML
Urine Source	CATHETERIZED
Urine Color	YELLOW
Urine Turbidity	CLEAR
Specific Gravity	1.022
→ Urine pH	>= 9.0
Urine Protein	29.8 mg/dL
Urine Glucose	NEGATIVE
Urine Ketone	NEGATIVE
Urine Blood	NEGATIVE
Urine Bilirubin	NEGATIVE

URINE SEDIMENT EXAM

MANY BACTERIA, 1-5/hpf WBC

CRYSTAL EXAM

→ MANY CALCIUM CARBONATE CRYSTALS

Smear Result: GRAM STAIN - MANY GRAM POSITIVE COCCI IN CHAINS

Culture Description: HEAVY GROWTH

Organism

→ Organism: GROUP D NON-ENTEROCOCCUS

Antibiotic susceptibility Pattern

	GROUP D NON-ENTEROCOCCUS		
	Interpretation	MIC	Test
AMIKACIN	R	>=	
AZITHROMYCIN	R	*	
CEFAZOLIN	R	>=	
CEFPODOXIME	S	>=	
CEFTIOFUR	S		
CHLORAMPHENICOL	S	*	
CLARITHROMYCIN	R	*	
ENROFLOXACIN	S	>=	
GENTAMICIN	S	>=	
PENICILLIN	R	*	
RIFAMPIN	R	>=	
TETRACYCLINE	S	*	
→ TRIMETHOPRIM/SULFA	S	*	

- Treatment with TMS 25 mg/kg q12h
- Flunixin meglumine 1.1 mg/kg q12h

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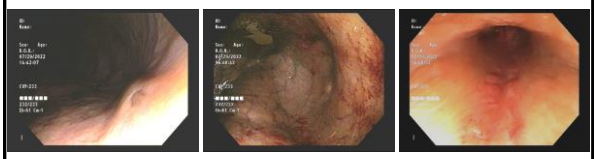
Clinical case

- Cystoscopy



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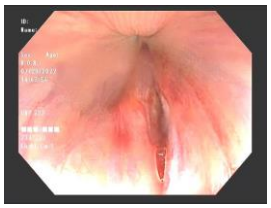
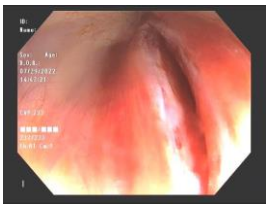
Clinical case





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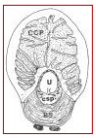
Urethral rents

- Linear defect of the urethral mucosa
- Convex surface of the urethra at the level of the ischial arch
- Communicate with the corpus spongiosum penis (CSP)
- Bulbospongiosus muscle contracts to expel urine from the urethra at the end of urination
  - Increase in pressure within the CSP



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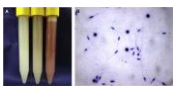
Urethral rents

- Terminal hematuria in geldings
- Hemospermia in stallions
- Baseline pressure within the CSP was not significantly different between geldings and stallions
- Peak urination pressure within the CSP of geldings was significantly increased when compared to stallions (25 vs 14.5 mmHg)



Taintor et al. EVJ. 2004

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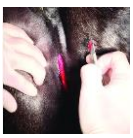
Urethral rents

Diagnosis
- Timing of hematuria
- Urinalysis might be normal if caught at the beginning
- +/- mild anemia

Treatment
- Often self resolves
- Perineal urethrotomy or corpus spongiotomy



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Pigmenturia

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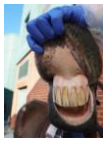
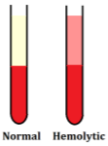
Hemoglobinuria

- Intravascular hemolysis → RBCs release hemoglobin
- Pink/red serum
- Signs of primary disease
- Sample not clear after centrifugation





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Clinical case

- 16 YO AQH mare
- 2-day history of lethargy
- Anemia and urine discoloration
- HR 60 bpm, RR 20 brpm, T 98.8F
- MM: dry, cyanotic, CRT 2 sec
- Dark urine
  - Remained dark after centrifugation

Images courtesy Dr. Lascola and Dr. Ceriotti

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Clinical case

RBC	3.42	L	x 10^6/uL	6.00 - 12.00
HGB	9.4	L	g/dL	10.0 - 18.0
HCT	15.3	L	%	32.0 - 48.0
MCV	44.8		fL	34.0 - 58.0
MCH	27.4	H	pg	14.0 - 19.0
MCHC	61.1	H	g/dL	31.0 - 37.0
RDW	20.0		%	17.0 - 20.0
PLATELET COUNT	624	H	x 10^3/uL	100 - 230
MPV	21.0	H	fL	5.8 - 11.5
WBC	6.68		x 10^3/uL	6.00 - 12.00

Test	Diff %	Result	Units	Ref. Interval
SEG	(77%)	5.144	x 10^3/uL	3.000 - 6.000
BANDS	(0%)	0.000	x 10^3/uL	0.000 - 0.100
LYMPH	(21%)	1.403	L x 10^3/uL	1.500 - 5.000
MONO	(2%)	0.134	/uL	0.000 - 0.600
EOS	(0%)	0.000	x 10^3/uL	0.000 - 0.600
BASO	(0%)	0.000	x 10^3/uL	0.000 - 0.100
OTHER	(0%)	0.000	x 10^3/uL	0.000 - 0.000
NRBC		0	/100 WBC	No Ref Interval
PLT EST	ABOVE REFERENCE INTERVAL			
Plasma T/S	9.5	g/dL		
Fibrinogen T/S		200	mg/dl	100 - 400

TOTAL PROTEIN	7.55		g/dL	6.00 - 8.60
ALBUMIN	2.32	L	g/dL	2.70 - 4.10
GLOBULIN	5.23	H	g/dL	2.60 - 4.40
ALBUMIN/GLOBULIN RATIO	0.44	L		0.70 - 1.00
AST	406	H	U/L	144 - 350
GGT	3		U/L	2 - 29
TOTAL BILIRUBIN	7.97	H	mg/dL	0.70 - 3.60
CK2	851	H	U/L	103 - 402
BUN	32.9	H	mg/dL	9.0 - 24.0
CREATININE	7.9	H	mg/dL	0.0 - 2.0
CALCIUM	10.4	L	mg/dL	10.5 - 12.9
PHOSPHORUS	4.1		mg/dL	2.1 - 4.6
MAGNESIUM	1.6	L	mg/dL	1.7 - 2.1
GLUCOSE	115		mg/dL	81 - 127
BICARBONATE	22.7		mmol/L	21.0 - 30.0
SODIUM	130	L	mmol/L	134 - 150
POTASSIUM	3.6		mmol/L	3.5 - 4.5
CHLORIDE	93	L	mmol/L	97 - 111
ANION GAP	17.9			9.0 - 25.0
OSMOL(CALC)	267	L	mOsm/kg	276 - 288
S.IRON	699	H	ug/dL	129 - 173
UIBC	797		ug/dL	123 - 430
TIBC	1496		ug/dL	243 - 553
LIPEMIA_INDEX	272	H		0 - 14

Marked anemia. Ghost cells indicate intravascular hemolysis. Eccentrocytes are caused by oxidative injury to the erythrocyte membrane. Increased MCHC (hyperchromasia) is likely due to intravascular hemolysis, but can also be seen with lipemia, excess of EDTA, and heinz bodies. Taken together, these findings indicate intravascular hemolysis owing to oxidative damage. Oxidative damage can be caused by toxins (Red Maple toxicosis), drugs, and infectious organisms.

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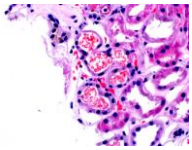
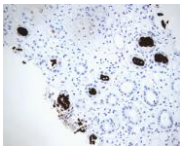
Clinical case

The gross and histological findings of dark red urine, dark red kidneys, and hemoglobin casts are consistent with hemoglobinuria. These findings are supportive of red maple toxicosis, as clinically suspected. The gross and histologic changes observed in the liver are consistent with parasite granulomas. Although no parasites were histologically observed, potential differential diagnoses include *Strongylus* sp. migration, and *Heterobilharzia americana* infection.





Caza T. AJKD. 2022

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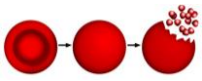
Red maple toxicosis

- Anemia caused by oxidative damage to the erythrocyte cell membrane and hemoglobin
- Summer-fall
- ~60% fatality rate
- Signs observed 12-48 hrs
- Renal failure secondary to hemoglobin deposition in the kidney



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Red maple toxicosis

Management

- Prevent toxic absorption → activated charcoal 1-3 g/kg BW
- Nasal oxygen
- Blood transfusion
- IV fluids
- Judicious use of NSAIDs
- Avoid corticosteroids and DMSO

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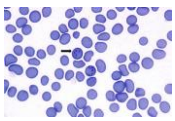
Hemoglobinuria

Common causes of intravascular hemolysis

- Parasitic – piroplasmosis
- Viral – EIA
- Bacterial – C. perfringens type A
- Immune mediated

Toxins
Red maple leaf*
Phenothiazine
Copper
Wild onion



Wise *et al.*, 2013. JVIM

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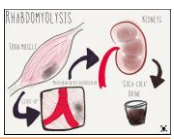
Myoglobinuria

- Secondary to severe muscle injury
  - Exertional rhabdomyolysis
- Leakage of myoglobin from myocytes
- Brown-to-red discolored urine
- Clinical signs of rhabdomyolysis
- Urine discolored after centrifugation



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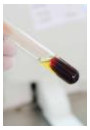
Myoglobinuria

- CK > 2,000 IU
- Serum will be clear
  - Myoglobin has no carrier protein → rapidly cleared
  - Hemoglobin is bound to haptoglobin → not rapidly cleared



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Myoglobinuria

Seasonal pasture/Atypical myopathy

- Non-exertional rhabdomyolisis
- Ingestion of hypoglycin A → disruption of mitochondrial fatty acid metabolism in myocyte
- HGA in seeds of Acer tree
- Onset 12-24 hrs after ingestion
- > fall

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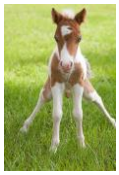
Drugs

- Doxycycline → dark brown or black-colored urine
- Rifampin → red- or orange-colored urine
- Phenazopyridine → red- or orange-colored urine

Plant pigments

- Red clovers → porphyrins → red urine
- Alsike clover → brown urine



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Urinalysis

- Hemorrhage → more than 5-8 RBCs
- Differentiate between hematuria, hemoglobinuria or myoglobinuria
- False results → diluted (<1.006), pH > 8, delayed analysis
  - RBC lysis

	Urine	RBCs
Hematuria	Clear	Precipitated
Hemoglobinuria	Red	
Myoglobinuria	Red	

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Differentiating hemo- and myoglobinuria

- Ammonium sulfate precipitation
  - Hemoglobin precipitates at 80% saturation
  - Myoglobin precipitates at full saturation
- Electrophoresis
- Spectroscopy
- Biochemical results
  - Hemoglobinuria → intravascular hemolysis → Pink serum
- Discoloration with negative strip → plant or drug pigmenturia

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Summary

- Thorough clinical examination
  - Systemic disease
  - Need for blood transfusion
- Differentiate hematuria, hemoglobinuria and myoglobinuria
  - History, bloodwork, serum color, urine color, ultrasound, etc
  - Direct treatment and prognosis
- Acknowledge the risk for renal failure

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Questions

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FROM VEIN TO VICTORIES: MASTERING EQUINE BLOOD TRANSFUSIONS IN THE FIELD

Serena Ceriotti

ANNUAL CONFERENCE 2023

1

Objectives

- Review of blood transfusion fundamental principles and indications (**adult horses**, foals, donkeys)
- Summary of practical tools, tips, and formulary for safe and efficient blood transfusion (in the field)

2

Contents

- **Preparing for a blood transfusion**
  - When is a blood transfusion needed?
  - Blood donor selection
- **Performing a blood transfusion**
  - Transfusion kit
  - Blood collection
  - Blood processing and storage
  - Blood administration
- **Monitoring after a blood transfusion**
  - Transfusion effectiveness
  - Transfusion reactions
  - Management of the donor

3

Preparing for a blood transfusion

- **When is a blood transfusion needed?**

In theory…

" Clinically significant decrease in oxygen tissue delivery due to reduced oxygen carrying capacity"

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Preparing for a blood transfusion

- **When is a blood transfusion needed?**

In practice…

*" **Clinically significant** decrease in oxygen tissue delivery due to reduced oxygen carrying capacity"*

- Blood loss > 30% **(> 12 liters for 1,100 pounds horse)**

AND/OR

- Visible clinical (and clinicopathological) signs

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Preparing for a blood transfusion

- **When is a blood transfusion needed?**

In practice…

*" Clinically significant **decrease in oxygen tissue delivery** due to reduced oxygen carrying capacity"*

Transfusion triggers = signs of hypoperfusion & tissue hypoxia

Clinical signs

- Tachycardia > 60 bpm
- Tachypnea > 30 brpm
- Pale mucous membranes
- CRT > 3 seconds
- Delayed jugular refill
- Lethargy, inappetence
- Cold extremities

Clinicopathological signs
(venous blood gas/pulse oximeter)

- Peripheral lactate > 4 mmol/L
- Azotemia (creatinine > 2 mg/dL)
- Metabolic acidosis (bicarbonate < 20 mmol/l)
- PvO_2 <30 mmHg
- Oxygen extraction ratio ($SpaO_2$ - $SpvO_2$/ $SpaO_2$) > 40-50%

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Preparing for a blood transfusion

- **When is a blood transfusion needed?**

In practice…

" Clinically significant decrease in oxygen tissue delivery ***due to reduced oxygen carrying capacity"***

- **Consider and treat (if possible) other concurrent causes of hypoperfusion/tissue hypoxia**
  - Concurrent respiratory disease (reduced oxygen absorption)
  - Concurrent cardiocirculatory disease (hypovolemia, SIRS, cardiac failure)
  - Inability to utilize oxygen (cyanide and carbon monoxide toxicity, smoke inhalation)
- **Evidence of anemia**
  - Sudden PCV drop (10%)
  - PCV < 20% within 12 hours
  - PCV < 12% for 1-2 days or longer
  - Hemoglobin < 5-7 g/dL

In equids:
- **Hemorrhage (+++ acute)**
- **Hemolysis**
- Bone marrow disease

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Preparing for a blood transfusion

- **When is a blood transfusion needed?**

Common scenarios in equine practice:

- Life threatening hemorrhage
- Acute hemorrhage/hemolysis
- Chronic anemia
- Planned surgery/procedure with high risk of hemorrhage

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Preparing for a blood transfusion

- **When is a blood transfusion needed?**

Common scenarios in equine practice:

- **Life threatening hemorrhage**
  - **Ex: Internal carotid, uterine artery ruptures**
- Acute hemorrhage/hemolysis
- Subacute-chronic anemia
- Planned surgery/procedure with high risk of hemorrhage

➡

- Known blood loss > 30-40% **(12-16 liters)**
- Signs of hemorrhagic/hypovolemic shock
  - Lethargy
  - Profuse sweating
  - HR>80 bpm
  - RR>40 brpm
  - Absent jugular refill
  - Pale mucous membranes
  - Non-detectable CRT
  - Cold extremities

TRANSFUSE!!!!

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Preparing for a blood transfusion

- **When is a blood transfusion needed?**

Common scenarios in equine practice:

- Life threatening hemorrhage
- **Acute hemorrhage/hemolysis**
  - **Ex: lacerations, ethmoidal hemorrhage, red maple toxicosis, (acute piroplasmosis)**
- Chronic anemia
- Planned surgery/procedure with high risk of hemorrhage

- Is there known blood loss (15-20%, 6-8 liters)?

AND/OR

- Is there acute anemia (PCV<20% within 12 hours, PCV suddenly dropped 10%)?
- Are transfusion triggers present?

*Correct concurrent causes of tissue hypoxia: **+++ IV fluid resuscitation,** (oxygen therapy)*

Treat primary condition (if possible): ex. stop hemorrhage

- Are transfusion triggers STILL present?

TRANSFUSE!!!!

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Preparing for a blood transfusion

- **When is a blood transfusion needed?**

Common scenarios in equine practice:

- Life threatening hemorrhage
- Acute hemorrhage/hemolysis
- **Chronic anemia**
  - **Ex: repeated intermittent hemorrhage, immune-mediated anemia, bone marrow neoplasia/aplasia**
- Planned surgery/procedure with high risk of hemorrhage

- Is there PCV<12% for more than 1-2 days?

AND/OR

- Are transfusion triggers present?
  - Clinical transfusion triggers (+++ inappetence)
  - PvO_2 <30 mmHg
  - Oxygen extraction ratio ($SpaO_2$ - $SpvO_2$/ $SpaO_2$) > 40-50%

TRANSFUSE!!!!

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Preparing for a blood transfusion

- **When is a blood transfusion needed?**

Common scenarios in equine practice:

- Life threatening hemorrhage
- Acute hemorrhage/hemolysis
- Chronic anemia
- **Planned surgery/procedure with high risk of hemorrhage**
  - **Ex: sinus surgery, lung biopsy**

Consider planning for **autologous blood transfusion**

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Preparing for a blood transfusion

- **Blood donor selection**
- Minimize negative impact on donor health
- Minimize negative impact on recipient health
- Minimize risk of blood incompatibility

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13

Preparing for a blood transfusion

- **Blood donor selection**
- **Minimize negative impact on donor health** ➡
  - Large size (>1,000 pounds at least)
  - Young adult (3-16 years old)
  - Good demeanor
  - Healthy
    - Physical exam
    - CBC, chemistry
    - Up to date in preventative care
  - PCV>35%, TS> 6 g/dL
- Minimize negative impact on recipient health
- Minimize risk of blood incompatibility

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14

Preparing for a blood transfusion

- **Blood donor selection**
- Minimize negative impact on donor health
  - Healthy
    - Physical exam
    - CBC, chemistry
    - Up to date in preventative care
- **Minimize negative impact on recipient health** ➡
  - Screened for blood-borne pathogens
    - EIA (negative Coggins test)
    - Hepatic viruses (Equine Hepatitis PCR panel, Cornell University)
    - Equine Viral Arteritis
    - Brucellosis
    - Glanders
    - Dourine
    - Anaplasmosis
    - Piroplasmosis
- Minimize risk of blood incompatibility

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Preparing for a blood transfusion

- **Blood donor selection**

- Minimize negative impact on donor health
- Minimize negative impact on recipient health

- **Minimize risk of blood incompatibility** ➡
  - Transfusion reactions
  - Transfusion effectiveness

- Choosing a "likely compatible" donor
- Crossmatch

16

Preparing for a blood transfusion

- **Blood donor selection – minimize risk of blood incompatibility**
- *Choosing a "likely compatible" donor* … IN THEORY

- Blood types
  - No universal donor
  - Aa, Qa highly immunogenic
- Alloantibodies
  - Acquired
  - Natural
    - Up to 10% anti-Ca, anti-Aa

Blood Group Systems, Factors, and Alleles of the Horse Recognized by the International Society for Animal Genetics

System	Factors	Recognized Alleles
A	a,[a] b,[b] c, d, e, f, g	Aa, Aadf, Aadg, Aabdf, Aabdg, Ab, Abc, Abce, Abe, Ac, Ace, Ae, A–
C	a	Ca, C–
D	a, b,[b] c,[b] d, e, f, g,[b] h, i, k, l, m, n, o, p, q, r	Dadl, Dadlnr, Dadlr, Dbcmq, Dcefgmq, Dcegimnq, Dcfgkm, Dcfmqr, Dcgm, Dcdmp, Dcgmq, Dcgmqr, Ddeklqr, DeIno, Ddeloq, Ddelq, Ddfkir, Ddghmp, Ddghmq, Ddghmqr, Ddkl, Ddlnq, Ddlnqr, Ddlqr, Ddno, Dq,(D–)
K	a	Ka, K–
P	a,[b] b, c, d	Pa, Pac Pacd, Pad, Pb, Pbd, Pd, P–
Q	a,[a] b, c[b]	Qa, Qab, Qabc, Qac, Qb, Qbc, Qc, Q–
U	a[b]	Ua, U–

[a]Most common factors involved in neonatal isoerythrolysis (NI).
[b]Previously reported to cause NI in at least one case.
From Cothran G: Personal communication, University of Kentucky, Lexington, Ky., 1996.

From: Smith, Large Animal Internal Medicine, 6th edition

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Preparing for a blood transfusion

- **Blood donor selection – minimize risk of blood incompatibility**
- *Choosing a "likely compatible" donor* … IN PRACTICE

- Blood types
  - No universal donor
  - Aa, Qa highly immunogenic

  ➡ Blood typing: Aa, Qa, Ca negative
- Alloantibodies
  - Acquired

  ➡ Screen for alloantibodies yearly
  - Natural
    - Up to 10% anti-Ca, anti-Aa

  ➡ Screen for alloantibodies

Journal of Veterinary Internal Medicine — ACVIM — Open Access
Standard Article
J Vet Intern Med 2016;30:1864–1871
Comparison of Tube, Gel, and Immunochromatographic Strip Methods for Evaluation of Blood Transfusion Compatibility in Horses
D. Luethy, S.D. Owens, D. Stefanovski, R. Nolen-Walston, and U. Giger

https://www.alvedia.com/quick-test-bt-equine/

Box 1
Equine blood typing laboratories

Central Laboratory Receiving
Room 1033, Veterinary Medical Teaching Hospital
One Garrod Drive
University of California, Davis
Davis, CA 95616
Phone: 530-752-8684
http://www.vetmed.ucdavis.edu/vmth/small_animal/laboratory/local-assets/pdfs/UC_Davis_VMTH_EQUINE_BLOOD_TYPING-NI_Submission_Form.pdf

University of Kentucky
Animal Genetic Testing & Research Laboratory
108 Gluck Equine Research Center
Lexington, KY 40546-0000
Phone: 859-218-1212
http://www2.ca.uky.edu/gluck/AGTRL.asp

Rood and Riddle Veterinary Laboratory
2150 Georgetown Road
Lexington, KY 40511
Phone: 859-233-0331
http://www.roodandriddle.com/laboratory.html

Hagyard Equine Medical Institute
4250 Iron Works Pike
Lexington, KY 40511-8412
Phone: 859-259-3685
http://www.hagyard.com/Hagyard-Laboratory.html

From: Mudge, Vet Clin N America Eq Practice 2014

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Preparing for a blood transfusion

- **Blood donor selection – minimize risk of blood incompatibility**
- *Choosing a "likely compatible" donor* … IN PRACTICE

- Blood types
  - No universal donor
  - Aa, Qa highly immunogenic

  → Blood typing: Aa Qa negative
  - Same breed of recipient
  - Quarter Horse (99% Qa -), Saddlebred
- Alloantibodies
  - Acquired

  → Screen for alloantibodies
  - Avoid mares, prefer geldings
  - Avoid horses with previous known exposure heterologous blood products
  - Natural
    - Up to 10% anti-Ca, anti-Aa

  → Screen for alloantibodies
  - Avoid Thoroughbreds (85% Qa +)
  - Be careful when transfusing a Thoroughbred

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Preparing for a blood transfusion

- **Blood donor selection**

- Minimize negative impact on donor health
- Minimize negative impact on recipient health

- **Minimize risk of blood incompatibility** →
  - Transfusion reactions
  - Transfusion effectiveness

  - Choosing a "likely compatible" donor
  - Crossmatch

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Preparing for a blood transfusion

- **Blood donor selection – minimize risk of blood incompatibility**
- *Crossmatch … theory*

Type of incompatibility

- Major *(makes the transfusion useless)* → **Clinically significant!!!**
  - Donor RBC + recipient serum
- Minor
  - Donor serum + recipient RBC

Type of reaction

- Agglutination
  - Macroagglutination → **Field cross match (grossly visible!)**
  - Microagglutination → Only laboratory crossmatch (microscopic examination)
- Hemolysis → Only laboratory crossmatch (add source of complement)
- Both

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Preparing for a blood transfusion

- **Blood donor selection – minimize risk of blood incompatibility**
- *Crossmatch … in the field*
  - "Standard" and "quick field" cross matching
    - Centrifugation or gravity sedimentation
    - ONLY agglutination
  - Gel Test Equine CrossMatch® (Alvedia Veterinary Diagnostics)
    - Centrifugation
    - ONLY agglutination
    - Similar performances to laboratory crossmatch

https://www.alvedia.com/gel_test_xm_equine/


STANDARD ARTICLE

Journal of Veterinary Internal Medicine ACVIM

Agreement of stall-side and laboratory major crossmatch tests with the reference standard method in horses

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Preparing for a blood transfusion

- **Blood donor selection – minimize risk of blood incompatibility**
- *Crossmatch … interpretation*
  - Positive agglutination at major crossmatch ➡ Transfusion reaction LIKELY to occur and likely to be CLINICALLY SIGNIFICANT
  - Negative crossmatch ➡ Possible false negatives
    - Hemolysis without agglutination
    - Natural alloantibodies in low titers
  - Crossmatch performances affected by factors (and their prevalence, ex. breed)

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Preparing for a blood transfusion

- **Blood donor selection – FOALS**
- Neonatal isoerythrolysis (NI), (1% foals)
  - Dam (Aa-/Qa-) with Aa/Qa alloantibodies (++ multiparous)
  - Sire (Aa+/Qa+)

  ➡ Foal (Aa+/Qa+) + Maternal colostrum (Aa/Qa) alloantibodies ➡ Hemolysis
- *IF PREGNANT MARE HAS KNOWN RISK…*
  - Screen for alloantibodies/crossmatch with sire (within 30 days foaling)
  - Avoid foal nursing for 24 hours/hyperimmune commercial plasma
  - Jaundiced foal agglutination test (colostrum + foal RBC)
- *IF NI IS HAPPENING AND TRANSFUSION IS NEEDED*
  - Ideally: use washed maternal RBCs
  - If not possible: Aa-/Qa- donor screened for alloantibodies + crossmatch

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Preparing for a blood transfusion

- **Blood donor selection – DONKEY AND MULES**
- Donkey Factor
  - RBC antigen
  - Donkeys and mules
  - Very immunogenic
- Additional implications:
  - Mule foals: high incidence (10%) NI
  - Care when transfusing mules/donkeys with equine plasma

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Performing a blood transfusion

- **Transfusion kit/box**
  - Field blood typing/crossmatch
  - Blood collection kit & anticoagulant
  - Blood (short-term) storage
  - Blood administration
  - Transfusion monitoring

- Blood tubes (EDTA, serum)
- Syringes/needles
- Pipettes
- NaCl 0.9%
- Slides
- (Centrifuge)
- Stall side commercial blood typing/crossmatch kits

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Performing a blood transfusion

- **Transfusion kit/box**
  - Field blood typing/crossmatch
  - Blood collection kit & anticoagulant
  - Blood (short-term) storage
  - Blood administration
  - Transfusion monitoring

- CLOSED KIT (commercially available)
  - Bags (up to 4 liters)/(Bottles)
  - Dry/with pre-measured anticoagulants
- OPEN KIT (“home-made”)
  - Empty IV fluid bags
  - Large bore IV catheter (10-14 Ga)
  - Male-male adapting IV line
  - Needle
- Hemostatic clamps

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Performing a blood transfusion

- **Transfusion kit/box**
  - Field blood typing/crossmatch
  - Blood collection kit & anticoagulant
  - Blood (short-term) storage
  - Blood administration
  - Transfusion monitoring

Anticoagulant – preservative	Storage/ Viability
Tri sodium citrate	Rapid deterioration, only 50% cells viable after 1 week.
Heparin	Rapid deterioration. Added disadvantage of being progressively neutralized by plasma. Therefore, most unsuitable for storage.
ACD-A	Storage/viability for 21 days, 24 hrs survival 77%, DPG level better maintained maximum for 1 week
CPD	Storage/viability for 28 days. 24 hrs survival 80%, DPG level better maintained for 10-14 days because of the favourable effect of higher pH.
CPDA-1/2	Storage/viability 35 days - improved storage due to adenine which maintains high ATP level in the RBC

Preservative-free

With storage preservatives

- Preservative free ok for "immediate" transfusion
  - Preferably avoid heparin

Comparison of 4 Blood Storage Methods in a Protocol for Equine Pre-operative Autologous Donation

MARGARET C. MUDGE, DVM, MELINDA H. MACDONALD, DVM, PhD, Diplomate ACVS, PhD, SEAN D. OWENS, DVM, and FERN TABLIN, PhD, DSc

- Storage preservatives for autologous blood transfusion
  - **BEST** : commercial 450 mL plastic bag with premeasured CPDA-1

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Performing a blood transfusion

- **Transfusion kit/box**
  - Field blood typing/crossmatch
  - Blood collection kit & anticoagulant
  - Blood (short-term) storage
  - Blood administration
  - Transfusion monitoring

Anticoagulant	Proportion anticoagulant/blood	Volume anticoagulant/ 1L bag
Citrate anticoagulants	1/7	140-150 mL
Heparin	1 (unit):1 mL	1000 Units

- SHELF-LIFE
  - Three years
  - Protect from light
  - Temperatures: 59-86 F

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Performing a blood transfusion

- **Transfusion kit/box**
  - Field blood typing/crossmatch
  - Blood collection kit & anticoagulant
  - Blood (short-term) storage
  - Blood administration
  - Transfusion monitoring

- Coolers/insulated containers
- Ice-packs

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Performing a blood transfusion

- **Transfusion kit/box**
  - Field blood typing/crossmatch
  - Blood collection kit & anticoagulant
  - Blood (short-term) storage
  - Blood administration
    - IV catheter
    - Filtered IV line (at least 2 or 3)
  - Transfusion monitoring

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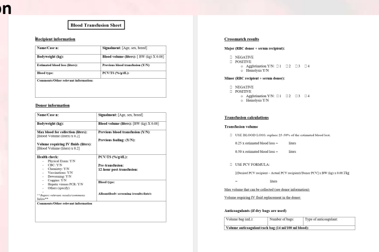
Performing a blood transfusion

- **Transfusion kit/box**
  - Field blood typing/crossmatch
  - Blood collection kit & anticoagulant
  - Blood (short-term) storage
  - Blood administration
  - Transfusion monitoring


Blood Transfusion Sheet

Transfusion sheet
- Recipient/donor information
- Volume calculations
- Monitored parameters
- Emergency drugs and dosages

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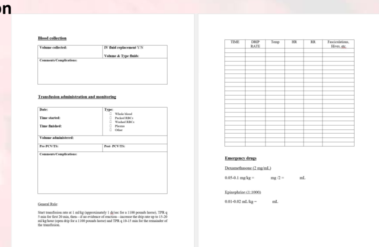
Performing a blood transfusion

- **Transfusion kit/box**
  - Field blood typing/crossmatch
  - Blood collection kit & anticoagulant
  - Blood (short-term) storage
  - Blood administration
  - Transfusion monitoring



Transfusion sheet
- Recipient/donor information
- Volume calculations
- Monitored parameters
- Emergency drugs and dosages

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Performing a blood transfusion

- **Blood collection**
  - Volume calculation
  - Collection procedure

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Performing a blood transfusion

- **Blood collection**
  - Volume calculation
  - Collection procedure

General rules:

- NEVER MORE THAN 20% of DONOR BLOOD VOLUME (8 liters in 1100 pounds horse)
- IF MORE THAN 15% OF DONOR BLOOD VOLUME COLLECTED: REPLACE WITH IV FLUIDS

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Performing a blood transfusion

- **Blood collection**
  - Volume calculation
  - Collection procedure

- Acute hemorrhage: *(PCV does not reflect real blood loss…)*

  Replace 25-50% of the estimated blood lost

- Chronic anemia

  Volume (liters) =

  [(Desired PCV – Actual PCV)/Donor PCV] x 0.08L/kg X bodyweight (kg)

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Performing a blood transfusion

- **Blood collection**
  - Volume calculation
  - Collection procedure
    - IV catheter placed aseptically, and directed rostrally
    - Connect the male-male line aseptically (open systems)
    - One person gently mixing the blood while collecting by gravity
    - Clamp bag once filled

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Performing a blood transfusion

- **Blood collection**
  - Autologous blood transfusion
    - Advantages
      - Lower risk of reactions
      - Longer hatflife transfused RBCs
    - Planned surgery/procedure with high risk of hemorrhage
      - Blood collection 2-3 weeks prior to surgery
    - Body cavitary blood effusion (hemothorax, hemoabdomen)
      - Teat-cannula + filtered line (change q2hrs)
      - Less anticoagulant needed
      - NO IF SEPSIS/NEOPLASIA SUSPECTED!!!!

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Performing a blood transfusion

- **Blood processing and storage**
  - Processing
    - Whole blood
    - Separation (sedimentation/centrifugation)
      - Plasma
      - Packed RBCs → Washed RBC
        Wash 2X
        (Centrifugation)

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Performing a blood transfusion

- **Blood processing and storage**
  - Processing

Product	Clinical benefit	Indications	Limitations
Whole blood	*Volume* *Oxygen carrying capacity* *Oncotic pressure and proteins* *Clotting factors & platelets*	*Blood loss*	*Transfusion reactions, volume overload (foals)*
Plasma	*Volume (+/-)* *Oncotic pressure and proteins* *Clotting factors*	*SIRS, protein losing diseases, failure of passive transfer (foals)*	*Transfusion reactions*
Packed RBCs	*Oxygen carrying capacity*	*Euvolemic anemia (i.e. hemolysis, bone marrow neoplasia)*	Transfusion reactions, dilution required for administration
Washed RBCs	*Oxygen carrying capacity*	*Neonatal isoerythrolysis*	*Dilution required for administration, required centrifugation*

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Performing a blood transfusion

- **Blood processing and storage**
  - Storage
    - Negative effects
      - Risk of bacterial growth (+++ open systems)
      - Decreased RBC viability, increased lactate, potassium
      - Decreased cross match compatibility (1 week)
      - Increased inflammatory transfusion reactions (leukoreduction)

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Performing a blood transfusion

- **Blood processing and storage**
  - Storage
    - Room temperature – whole heterologous blood
      - Administer **within 4 hours** (++ open systems)

    } **MOST COMMON IN THE FIELD!**

    - Blood bank refrigerator (4°C, 39 F)
      - Heterologous blood: administer **within 24 hours**
      - Autologous blood (with CPDA-1): **max storage 2-3 weeks**

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Performing a blood transfusion

- **Blood administration**
  - Administration
    - Aseptic IV catheter placement
    - Warm up bags to room/(body) temperature
    - Filtered IV line (replaced every 3-4 liters)
  - Rate
    - 1 ml/kg first 20 minutes
      - 1 drop/sec 1,100 lbs horse
      - 1 drop/2-3 sec foal
    - 15-20 ml/kg/hour (< 4 hours total)
      - Fully open drip 1,100 lbs horse
      - 2 drop/sec foal
  - Monitoring (transfusion sheet)
    - Baseline TPR
    - TPR every 5 min (first 20 min)
    - TPR every 15 min (after 20 min)

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Monitoring after a blood transfusion

- **Transfusion effectiveness**
- Improvement in clinical and clinicopathological perfusion variables
  - Post-hemorrhage anemia: 58% horses show improvement in HR, RR but not PCV
  - PCV increase takes time (2-3 weeks at least, 10-28 days erythropoiesis)
- Effectiveness depends on transfused RBCs halflife (fresh whole blood)
  - Autologous blood: 45 days
  - Heterologous blood (compatible crossmatch): 20-35 days
  - Heterologous blood (not compatible crossmatch): 3-5 days

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Monitoring after a blood transfusion

- **Transfusion reactions**

TABLE 1: Timing and mechanisms of common types of adverse reactions and complications associated with whole blood transfusion (Leo and Pedal 2010; Tocci 2010)

	Immune-mediated	Nonimmune-mediated
Immediate (Minutes-hours)	• Haemolysis • Febrile nonhaemolytic reactions • Allergic reactions • Post transfusion purpura (alloantibody-mediated thrombocytopaenia) • Transfusion-related acute lung injury (TRALI)	• Transfusion-associated sepsis • Transfusion-associated circulatory overload • Haemolysis (due to mishandling) • Metabolic and haemostatic complications with large volume transfusion ○ hypocalcaemia due to citrate toxicity ○ hyperkalaemia with RBC lysis ○ hypothermia if cold blood is administered ○ coagulopathies due to excess anticoagulant administration
Delayed	• Haemolysis	• Transmission of other blood-borne infections • Haemosiderosis, with repeat or large volume transfusions

- Incidence 16% in equine practice
- Not always predicted by crossmatch/compatibility EVEN IF IMMUNE MEDIATED

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Monitoring after a blood transfusion

- **Transfusion reactions**

TABLE 1: Timing and mechanisms of common types of adverse reactions and complications associated with whole blood transfusion (Leo and Pedal 2010; Tocci 2010)

	Immune-mediated	Nonimmune-mediated
Immediate	• Haemolysis • Febrile nonhaemolytic reactions • Allergic reactions • Post transfusion purpura (alloantibody-mediated thrombocytopaenia) • Transfusion-related acute lung injury (TRALI)	• Transfusion-associated sepsis • Transfusion-associated circulatory overload • Haemolysis (due to mishandling) • Metabolic and haemostatic complications with large volume transfusion ○ hypocalcaemia due to citrate toxicity ○ hyperkalaemia with RBC lysis ○ hypothermia if cold blood is administered ○ coagulopathies due to excess anticoagulant administration
Delayed	• Haemolysis	• Transmission of other blood-borne infections • Haemosiderosis, with repeat or large volume transfusions

(Minutes-hours)

- Incidence 16% in equine practice
- Not always predicted by crossmatch/compatibility EVEN IF IMMUNE MEDIATED

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Monitoring after a blood transfusion

- **Transfusion reactions**

TABLE 1: Timing and mechanisms of common types of adverse reactions and complications associated with whole blood transfusion (Leo and Pedal 2010; Tocci 2010)

	Immune-mediated	Nonimmune-mediated
Immediate	• Haemolysis • Febrile nonhaemolytic reactions • Allergic reactions • Post transfusion purpura (alloantibody-mediated thrombocytopaenia) • Transfusion-related acute lung injury (TRALI)	• Transfusion-associated sepsis • Transfusion-associated circulatory overload • Haemolysis (due to mishandling) • Metabolic and haemostatic complications with large volume transfusion ○ hypocalcaemia due to citrate toxicity ○ hyperkalaemia with RBC lysis ○ hypothermia if cold blood is administered ○ coagulopathies due to excess anticoagulant administration
Delayed	• Haemolysis	• Transmission of other blood-borne infections • Haemosiderosis, with repeat or large volume transfusions

(Days)

- Incidence 16% in equine practice
- Not always predicted by crossmatch/compatibility EVEN IF IMMUNE MEDIATED

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Monitoring after a blood transfusion

- **Transfusion reactions**

	Immune-mediated
Immediate	• Haemolysis • Febrile nonhaemolytic reactions • Allergic reactions • Post transfusion purpura (alloantibody-mediated thrombocytopaenia) • Transfusion-related acute lung injury (TRALI)
Delayed	• Haemolysis

Most common in equine practice

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Monitoring after a blood transfusion

- **Transfusion reactions**

	Immune-mediated
Immediate	• Haemolysis • Febrile nonhaemolytic reactions • Allergic reactions • Post transfusion purpura (alloantibody-mediated thrombocytopaenia) • Transfusion-related acute lung injury (TRALI)
Delayed	• Haemolysis

TYPE 2 hypersensitivity reaction:

- Fever
- Intravascular/Extravascular hemolysis
- Icterus

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Monitoring after a blood transfusion

- **Transfusion reactions**

	Immune-mediated	
Immediate	• Haemolysis • Febrile nonhaemolytic reactions • Allergic reactions • Post transfusion purpura (alloantibody-mediated thrombocytopaenia) • Transfusion-related acute lung injury (TRALI)	→ +++ acquired alloantibodies, predicted by MAJOR CROSSMATCH
Delayed	• Haemolysis	→ +++ low titer natural antibodies, usually crossmatch is not sensitive enough!

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Monitoring after a blood transfusion

- **Transfusion reactions**

	Immune-mediated	
Immediate	• Haemolysis • Febrile nonhaemolytic reactions • Allergic reactions • Post transfusion purpura (alloantibody-mediated thrombocytopaenia) • Transfusion-related acute lung injury (TRALI)	→ • Common, +++ fever • NOT predicted by crossmatch • Increased risk with storage • Minimized by leukoreduction
Delayed	• Haemolysis	

Cytokines, inflammatory mediators, type 2 hypersensitivity against donor WBC

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Monitoring after a blood transfusion

- **Transfusion reactions**

Immune-mediated	
Immediate	• Haemolysis • Febrile nonhaemolytic reactions • Allergic reactions • Post transfusion purpura (alloantibody-mediated thrombocytopaenia) • Transfusion-related acute lung injury (TRALI)
Delayed	• Haemolysis

TYPE 1 HYPERSENSITIVITY (IgE-mast cells)

- Triggered by plasma proteins
- Not predicted by crossmatch

(… can happen also with plasma transfusion)

- Local allergy
  - Urticaria, pruritus, rhinitis
- Anaphylaxis (respiratory + GI)
  - Respiratory distress, colic, diarrhea
  - Shock, sudden collapse

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Monitoring after a blood transfusion

- **Transfusion reactions**

Immune-mediated	
Immediate	• Haemolysis • Febrile nonhaemolytic reactions • Allergic reactions • Post transfusion purpura (alloantibody-mediated thrombocytopaenia) • Transfusion-related acute lung injury (TRALI)
Delayed	• Haemolysis

TYPE 1 HYPERSENSITIVITY (IgE-mast cells)

- Triggered by plasma proteins
- Not predicted by crossmatch

(… can happen also with plasma transfusion)

- Local allergy
  - Urticaria, pruritus, rhinitis
- Anaphylaxis (respiratory + GI)
  - Respiratory distress, colic, diarrhea
  - Shock, sudden collapse

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Monitoring after a blood transfusion

- **Transfusion reactions**

Nonimmune-mediated	
• Transfusion-associated sepsis	Contamination during collection, prolonged storage
• Transfusion-associated circulatory overload	
• Haemolysis (due to mishandling)	
• Metabolic and haemostatic complications with large volume transfusion ○ hypocalcaemia due to citrate toxicity ○ hyperkalaemia with RBC lysis ○ hypothermia if cold blood is administered ○ coagulopathies due to excess anticoagulant administration	
• Transmisison of other blood-borne infections	EIA, Serum hepatitis (Theiler disease)
• Haemosiderosis. with repeat or large volume transfusions	

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Monitoring after a blood transfusion

- **Transfusion reactions**

Nonimmune-mediated
• Transfusion-associated sepsis
• Transfusion-associated circulatory overload
• Haemolysis (due to mishandling)
• Metabolic and haemostatic complications with large volume transfusion
○ hypocalcaemia due to citrate toxicity
○ hyperkalaemia with RBC lysis
○ hypothermia if cold blood is administered
○ coagulopathies due to excess anticoagulant administration
• Transmisison of other blood-borne infections
• Haemosiderosis, with repeat or large volume transfusions

FOALS!!!!

>4 liters of blood, 20 times higher risk of liver failure

Monitoring after a blood transfusion

- **Transfusion reactions**

Nonimmune-mediated
• Transfusion-associated sepsis
• Transfusion-associated circulatory overload
• Haemolysis (due to mishandling)
• Metabolic and haemostatic complications with large volume transfusion
○ hypocalcaemia due to citrate toxicity
○ hyperkalaemia with RBC lysis
○ hypothermia if cold blood is administered
○ coagulopathies due to excess anticoagulant administration
• Transmisison of other blood-borne infections
• Haemosiderosis, with repeat or large volume transfusions

- Inappropriate handling/storage

Monitoring after a blood transfusion

- **Transfusion reactions**

Nonimmune-mediated
• Transfusion-associated sepsis
• Transfusion-associated circulatory overload
• Haemolysis (due to mishandling)
• Metabolic and haemostatic complications with large volume transfusion
○ hypocalcaemia due to citrate toxicity
○ hyperkalaemia with RBC lysis
○ hypothermia if cold blood is administered
○ coagulopathies due to excess anticoagulant administration
• Transmisison of other blood-borne infections
• Haemosiderosis, with repeat or large volume transfusions

- Side effects of anticoagulants

Monitoring after a blood transfusion

- **Transfusion reactions**
  - If reaction occurs while administering transfusion
    - Don't panic!
    - STOP TRANSFUSION
    - Monitor closely/provide supportive care
    - Administer ER drugs, if needed (pre-calculated!)

Emergency drugs

Dexamethasone (2 mg/mL)

0.05-0.1 mg/kg = mg /2 = mL

Epinephrine (1:1000)

0.01-0.02 mL/kg = mL

  - Don't forget DELAYED and NON-IMMUNOMEDIATE reactions
    - Re-evaluation within 24 hours (PE, PCV, TS, blood gas)
    - Re-evaluation after 3-5 days (PE, PCV, TS)

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Monitoring after a blood transfusion

- **Clinical case**

9 year-old Thoroughbred gelding
Repeated severe hemorrhage hind fetlock wound (in 48 hours)

Severe subacute anemia (PCV=10%), azotemia
Persistent tachycardia (66 bpm), lethargy, weakness

Blood transfusion

Donor blood type Ab Ca Ka Ua
Compatible crossmatch (major & minor)
Theoretical volume (PCV formula): 12 liters

8 liters administered overnight (15 hours)

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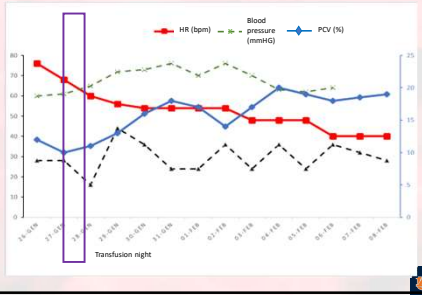
Monitoring after a blood transfusion

- **Clinical case**



Transfusion was effective

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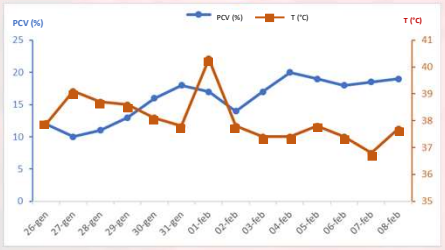
Monitoring after a blood transfusion

- Clinical case



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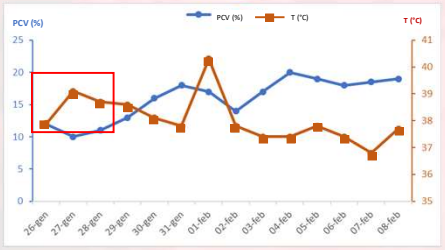
Monitoring after a blood transfusion

- Clinical case



Time	T° (F)
Before transfusion	100.5
1 h	100.9
5 h	101.3
7 h	101.8
11h	102.3
13h	101.6
15h	101.4
2 h after the end	101.6
6 h after the end	100.9
10h after the end	100.5

Febrile non-hemolytic transfusion reaction

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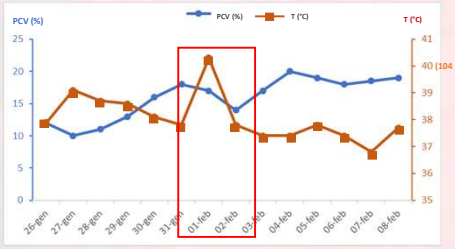
Monitoring after a blood transfusion

- Clinical case



Febrile delayed hemolytic transfusion reaction

Donor blood type: Ab **Ca** Ka Ua

Recipient: Thoroughbred

Natural low titer anti-Ca alloantibodies??

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Monitoring after a blood transfusion

- **Management of the donor**
  - Unused blood can be re-administered to the donor (if properly stored)
  - Ensure availability of feed/water:
    - Feed 1-3 pounds complete feed & free choice hay
    - Free choice, clean water
  - Monitor during following 24 hours
    - PE, PCV, TS
    - Catheter site

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Take home messages

- Clinical more than clinicopathological parameters to define if transfusion is necessary and useful
- Large, healthy gelding, same breed of the recipient, EIA negative is best ER donor
- Crossmatch!!!!(Field crossmatch better than nothing)
- Have a "ready to go" transfusion kit, a checklist, and calculations/procedure/transfusion sheet in the truck/clinic (see proceedings)
- Monitor the recipient until 5-7 days after transfusion
- Don't forget the donor!

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FORMULARY – EQUINE TRANSFUSIONS

Is transfusion necessary?

Normal horse blood volume (liters): 8% bodyweight (kg)

- Adult horse (approx. 1100 lbs, 500 kg): 40 liters
- Foal (approx. 110 lbs, 50 kg): 4 liters

Transfusion triggers

- Blood loss >30% (12 liters in 1100 lbs horse)
- Clinical parameters
- Clinicopathological parameters

Clinical			**Clinicopathological**	
Parameter	Trigger	Shock	Parameter	Trigger
HR (bpm)	>60	>80	Peripheral lactate (mmol/l)	>4
RR (brpm)	>30	>40	Creatinine (mg/dL)	>2
CRT (sec)	>3	absent	Bicarbonate HCO3- (mmol/l)	<20
Mucous membranes	Pale	Pale	PvO2 (mmHg)	<30
Jugular refill	Delayed	absent	Oxygen Extraction Ratio (%)*	>40-50
Extremities	Cold	Cold	*($SpaO_2$ - $SpvO_2$/ $SpaO_2$)	
Attitude	Lethargy Inappetence	Obtunded Sweating		

Anemia thresholds:

- Acute
  - Known blood loss 15-20% of blood volume (6-8 liters, 1100 lbs horse)
  - PCV < 20% in less than 12 hours
  - Sudden PCV drop of 10%
- Subacute/Chronic
  - PCV <12% for more than 1-2 days

Blood donor selection

Laboratory resources

- Hepatitis Viruses PCR screening (Cornell University)
  - https://app.vet.cornell.edu/ahdc-portal/test-fee
  - Look for "Equine Hepatitis Virus PCR Panel 2 | (EQHEPPCRPNL2)"

- Blood typing and alloantibodies screening

Box 1
Equine blood typing laboratories

Central Laboratory Receiving

Room 1033, Veterinary Medical Teaching Hospital

One Garrod Drive

University of California, Davis

Davis, CA 95616

Phone: 530-752-8684

http://www.vetmed.ucdavis.edu/vmth/small_animal/laboratory/local-assets/pdfs/UC_Davis_VMTH_EQUINE_BLOOD_TYPING-NI_Submission_Form.pdf

University of Kentucky

Animal Genetic Testing & Research Laboratory

108 Gluck Equine Research Center

Lexington, KY 40546-0000

Phone: 859-218-1212

http://www2.ca.uky.edu/gluck/AGTRL.asp

Rood and Riddle Veterinary Laboratory

2150 Georgetown Road

Lexington, KY 40511

Phone: 859-233-0331

http://www.roodandriddle.com/laboratory.html

Hagyard Equine Medical Institute

4250 Iron Works Pike

Lexington, KY 40511-8412

Phone: 859-259-3685

http://www.hagyard.com/Hagyard-Laboratory.html

- Rapid stall side commercial Ca blood typing kit
  - https://www.alvedia.com/quick-test-bt-equine/

- Stall side commercial crossmatch kit
  - https://www.alvedia.com/gel_test_xm_equine/

Crossmatch procedures

Standard crossmatch

1. Collect an EDTA and red top (clot tube) blood sample from both donor and recipient.
2. Centrifuge the EDTA and clot tubes from both donor and recipient. Remove the plasma from both EDTA tubes and save the pRBCs. Extract and save the serum from both clot tubes.
3. For a major crossmatch, take 1-2 drops of donor pRBCs (EDTA tube) and wash several times with sterile saline.
    1. Add 3-4 drops of sterile saline to the pRBCs, centrifuge, and decant the saline. Repeat 3 times.
4. After the third wash, add 10-20 drops of saline to the washed RBCs to give a 2-4% suspension.
5. Add 2 drops of recipient serum (clot tube) to 1 drop 2-4% donor RBC solution.
6. For minor cross-match: repeat steps 3-5 with recipient RBCs and donor serum.
7. Include negative controls (donor serum and donor washed RBCs, recipient serum and recipient washed RBCs).
8. Incubate all reactions for 20 minutes at 37°C.
9. Centrifuge for 15 seconds and evaluate for macroscopic and microscopic agglutination or hemolysis (rarely seen without adding complement).

Agglutination is scored 0-4.

0. No clumps seen
1. 3-5 small microscopic clumps
2. Multiple small and large microscopic clumps, but individual cell still seen
3. Many large and small microscopic clumps
4. Clumps seen macroscopically

Saline dilution can be used to distinguish Rouleaux formations from agglutination. When assessing for hemolysins, rabbit complement is added to each mixture of washed RBC suspension and serum. The major, minor, and 2 negative controls are agitated on a vibrating plate mixer. Hemolysis is read at 30 minutes and again at 3 hours and is graded 1-4. This is only done by select veterinary clinical pathology laboratories (see Laboratory Resources).

1. Partial hemolysis
2. Intermediate hemolysis
3. Strong, almost complete hemolysis
4. Complete hemolysis[29]

Quick Field Cross-match

1. Collect EDTA and red top (clot tube) blood samples from both donor and recipient.
2. Gravity-sediment or centrifuge (preferred) EDTA tubes and remove plasma to give pRBCs.
3. Combine 1 drop of donor pRBCs to 2 drops of recipient serum (centrifuged) or plasma (gravity separated) for a major cross-match, or vice versa for a minor cross-match (recipient RBCs and donor plasma or serum).
4. Evaluate for macroscopic agglutination.

Jaundiced foal agglutination test

1. Do not allow the neonate to nurse immediately after foaling. Collect colostrum.
2. Collect an EDTA blood sample from the foal.
3. Add 1 ml of saline to 6 test tubes.
4. Add 1 ml of colostrum to 1 of the 6 saline tubes. Label this tube "1:2 Dilution" and mix.
5. Take 1 ml of the "1:2 Dilution" mixture and add it to the second saline tube. Label this tube "1:4 Dilution" and mix. Repeat for all 6 tubes. There should be 1:2, 1:4, 1:8, 1:16, and 1:32 dilutions produced.
6. Add 1 drop of the foal's whole blood to each tube and mix. Centrifuge for 2-3 minutes.
7. Remove the supernatant of the tubes. Macroscopically and microscopically observe for agglutination.

If a there is any agglutination, the mare's RBC should be tested as a control. A positive result at a dilution of 1:16 or higher is considered significant; the foal should not be allowed to consume the mare's colostrum, and plasma or donor colostrum should be given. This test does not allow for detection of hemolytic and non-agglutinating antibodies; however, it is well-correlated with standard hemolysis assays.

Blood transfusion kit – checklist

- ☐ COOLER/INSULATED CONTAINER (LIGHT PROTECTED)
- ☐ ICE-PACKS
- ☐ NECESSARY FOR CROSSMATCH
  - 10 mL syringes/needles
  - EDTA (purple top) tubes
  - Serum (red top, dry) tubes
  - Pipettes
  - NaCl 0.9% (20-50 mL)
  - Centrifuge
  - Slides or commercial crossmatch kit
- ☐ IV CATHETER PLACEMENT KIT (DONOR/RECIPIENT)
  - Razor or clippers
  - Chlorhexidine gauzes
  - Alcohol gauzes
  - Non-sterile gloves
  - Sterile gloves
  - Suture material
  - NaCl 0.9% or heparinized flush
  - Infusion plug
  - IV catheters (10-12 ga for collection/14 ga for administration)
- ☐ BLOOD COLLECTION
  - Closed blood collection kit: bag+line+catheter/needle
  - Open system:
    - IV fluid bag
    - Male to male IV line
    - Large needle
  - Hemostatic clamps
  - Double bag/transfer set (if separate plasma is needed)
- ☐ BLOOD ADMINISTRATION
  - Filtered IV line
- ☐ MONITORING
  - Stethoscope
  - Thermometer
  - Transfusion formulary/sheet

Blood processing and storage

Packed RBCs (centrifuge not necessary)

1. Allow RBCs to sediment by gravity (30 min) or centrifuge at 3000 rpm for 20 minutes.
2. Remove the supernatant plasma.
3. Dilute with isotonic crystalloid fluid until viscosity allows flowing through the filtered IV line.

Washed RBCs (centrifuge necessary)

1. Centrifuge at 3000 rpm for 20 minutes.
2. Remove the supernatant plasma.
3. Add a volume of isotonic crystalloid fluid (sterile NaCl 0.9%) similar to removed plasma volume and gently mix
4. Centrifuge at 3000 rpm for 20 minutes
5. Repeat step 3 and 4 other two times (total of three washing cycles)
6. Replace the last wash isotonic with "new" isotonic crystalloid (until viscosity allows flowing through the filtered IV line)

Blood Transfusion Sheet

Recipient information

Name/Case n:	**Signalment:** [Age, sex, breed]
Bodyweight (kg):	**Blood volume (liters):** [BW (kg) X 0.08]
Estimated blood loss (liters):	**Previous blood transfusion (Y/N)**:
Blood type:	**PCV/TS (%/g/dL):**
Comments/Other relevant information:	

Donor information

Name/Case n:	**Signalment:** [Age, sex, breed]
Bodyweight (kg):	**Blood volume (liters):** [BW (kg) X 0.08]
Max blood for collection (liters): [Blood Volume (liters) x 0.2] **Volume requiring IV fluids (liters)**: [Blood Volume (liters) x 0.2]	**Previous blood transfusion (Y/N)**: **Previous foaling: (Y/N):**
Health check: - Physical Exam: Y/N - CBC: Y/N - Chemistry: Y/N - Vaccinations: Y/N - Deworming: Y/N - Coggins: Y/N - Hepatic viruses PCR: Y/N - Others (specify) - ***Report relevant results/comments below***	**PCV/TS (%/g/dL):** **Pre-transfusion:** **12-hour post-transfusion:** **Blood type:** **Alloantibody screening (results/date):**
Comments/Other relevant information	

Crossmatch results

Major (RBC donor + serum recipient):

- □ NEGATIVE
- □ POSITIVE
  - Agglutination Y/N: □ 1 □ 2 □ 3 □ 4
  - Hemolysis Y/N

Minor (RBC recipient + serum donor):

- □ NEGATIVE
- □ POSITIVE
  - Agglutination Y/N: □ 1 □ 2 □ 3 □ 4
  - Hemolysis Y/N

Transfusion calculations

Transfusion volume

□ USE BLOOD LOSS: replace 25-50% of the estimated blood lost.

0.25 x estimated blood loss = liters

0.50 x estimated blood loss = liters

□ USE PCV FORMULA:

[(Desired PCV recipient – Actual PCV recipient)/Donor PCV] x BW (kg) x 0.08 l/kg

= liters

Max volume that can be collected (see donor information):

Volume requiring IV fluid replacement in the donor:

Anticoagulants (if dry bags are used)

Volume bag (mL):	Number of bags:	Type of anticoagulant:
Volume anticoagulant/each bag (14 ml/100 ml blood):		

Blood collection

Volume collected:	**IV fluid replacement** Y/N **Volume & Type fluids**:
Comments/Complications:	

Transfusion administration and monitoring

Date: **Time started:** **Time finished:**	**Type:** □ Whole blood □ Packed RBCs □ Washed RBCs □ Plasma □ Other
Volume administered:	
Pre-PCV/TS:	**Post- PCV/TS:**
Comments/Complications:	

General Rule:

Start transfusion rate at 1 ml/kg (approximately 1 dr/sec for a 1100 pounds horse), TPR q 5 min for first 20 min, then—if no evidence of reaction—increase the drip rate up to 15-20 ml/kg/hour (open drip for a 1100 pounds horse) and TPR q 10-15 min for the remainder of the transfusion.

TIME	DRIP RATE	Temp	HR	RR	Fasciculations, Hives, etc

Emergency drugs

Dexamethasone (2 mg/mL)

0.05-0.1 mg/kg = mg /2 = mL

Epinephrine (1:1000)

0.01-0.02 mL/kg = mL

Common immune mediated blood transfusion reactions

Reaction	Type	Clinical signs	Treatment
Febrile hemolysis	Type 2 hypersensitivity Immediate (hours) Delayed (3-7 days)	Fever, icterus, (hemoglobinemia, hemoglobinuria if intravascular)	d/c transfusion, fluid therapy, steroids
Febrile non-hemolytic reaction	Type 2 hypersensitivity, Inflammatory Immediate (hours)	Fever	d/c transfusion, antiinflammatories
Allergic reactions	Type 1 hypersensitivity, Immediate (minutes)	Local: urticaria, pruritus, rhinitis Anaphylaxis: respiratory distress, colic, diarrhea, collapse	d/c transfusion, steroids d/c transfusion, steroids, epinephrine, IV fluid resuscitation

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Liver Disease in Horses

Kara Lascola DVM, MS, DACVIM
Auburn University

1

Hepatic Disease in Horses

- Common, progression to liver failure is rare
- **~60-70% of liver must be affected for function to be impaired**
  - ***Hepatic disease can be present without hepatic failure***
- **Causes:**
  - Toxic
  - Infectious (bacterial, viral)
  - Metabolic/vascular
  - Neoplastic
  - Hypoxic

2

The story of "Holly" and "Roxy"

ACUTE ONSET HEPATIC DISEASE & HEPATOENCEPHALOPATHY IN TWO MARES

3

Holly: Signalment

- 5-year-old previously healthy QH mare
- 2-month-old foal by her side
- Presented for evaluation of acute lethargy and anorexia

4

Holly: History

- Normal foaling two months ago
- Mare and foal administered tetanus toxoid and antitoxin at foaling and mare up-to-date on vaccinations
- Maintained on pasture with other horses
- All other horses and foal are healthy
- Owners believe mare has lost weight acutely over the previous week

5

Holly: Initial Evaluation

- Recumbent and minimally responsive on trailer
- HR 20 BPM
- Mucous membranes hyperemic with prolonged CRT
- Poor jugular fill
- **Venous blood gas:** ***Glucose 19 mg/dL***
  lactate 8.3 mmol/L
  pH 7.33 HCO_3 15 mmol/L
  iCa^{++} 1.2 mmol/L
  PCV 52%

6

Holly: Immediate therapy

- 1L Hypertonic saline; LRS with 2.5% dextrose and calcium supplementation
- HR 60, RR 20, T 102.3
- Mare stood with assistance on trailer
- Menace response absent & PLRs present bilaterally
- The mare appeared mildly ataxic and very depressed but was able to exit the trailer
- CBC & chemistry submitted

7

Holly Additional Diagnostics

- **CBC w/ Fibrinogen**
  - Hypofibrinogenemia (91 mg/dL); neutrophilic leukocytosis (21.9 X 10^3)
- **Serum Biochemistry**
  - **GGT** 145 U/L (4-20); **GLDH** 47.7 (1-5); **Tbili** 24.3 (0.5-2.3);
  - AST 2394 (150-294); Alk Phos 1027 (41-137)
- **Abdominal Ultrasound**
  - Hepatomegaly, decreased echogenicity
- **Ammonia**
  - 274 (15-45)
- **Serum bile acids**
  - 111.4 (0-20)
- **PT & PTT**
  - 25 (8-15); 56.7 (33-47)

8

Holly Additional Therapy

- Anti-inflammatory therapy: flunixin meglumine
- Maintenance intravenous fluid therapy with electrolyte supplementation, dextrose and antioxidants (thiamine and vitamin C)
- Lactulose 120ml PO every 6 hours for hyperammonemia

9

Roxy: Signalment

- 5-year-old previously healthy QH mare
- 2-month-old foal by her side
- Presented for evaluation of acute lethargy, anorexia, and ataxia of 48 hours duration

10

Roxy: History

- Normal foaling two months ago
- Mare and foal administered tetanus toxoid and antitoxin at foaling and mare up-to-date on vaccinations
- Mare has previously been healthy

11

12

Roxy: evaluation prior to referral

- Physical Examination:
  - Icterus
  - Ataxia
  - Pyrexia (102.3F)
- Biochemistry:
  - GGT 157 U/L;
  - TBIL 15.2 mg/dL;
  - ALK Phos 453 U/L

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Roxy: Initial evaluation

- HR 60; RR 24
- Mucous membranes: icteric/dark red; CRT >3 sec; prolonged jugular fill time; petechia
- Marked ataxia, head pressing and compulsive circling
- Appeared nonvisual; + PLR & menace bilaterally
- Abrasions, lacerations and diffuse edema over face and muzzle

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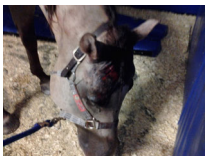
Roxy Initial Evaluation

- **Venous Blood Gas:**
  - **pH** 7.298
  - **LAC** 18.1 mmol/L
  - **HCO_3** 15 mmol/L
  - ***iCa^{++} 0.9 mmol/L***
  - **Mg^{++}** 1.26 mmol/L
- **PCV** 55% and **TP** 7.6 g/dL



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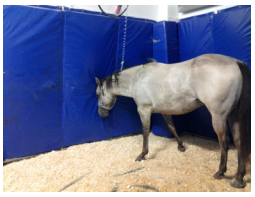
Roxy: Treatment

- Hypertonic saline
- LRS: dextrose, CMPK, Vit C, thiamine
- TMS & lactulose via small bore NGT

Over next 18 hours mare's condition worsened with episodes of unpredictable aggression



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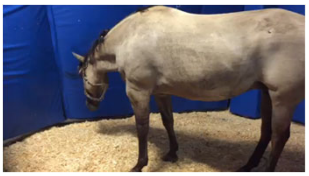

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18

- Clinical Signs
- Diagnostic Testing:
  - Biochemical testing: liver specific enzymes, tests of liver function, nonspecific hematological abnormalities
- Histopathology

RECOGNIZING AND DIAGNOSING HEPATIC DISEASE

19

Indicators of hepatic disease

- Variable and often non-specific
- Depend upon: duration; type (hepatocellular, biliary) and extent of hepatic damage; specific cause
- Holly & Roxy
  - Clinical signs:
    - CNS (blindness, circling, mentation, ataxia); icterus; pyrexia; anorexia; petechia
  - Biochemical abnormalities
    - Increased specific (GLDH, GGT) and nonspecific (AST, ALP) liver enzymes
    - Altered liver function (bile acids, ammonia, bilirubin)
    - Other: coagulopathy, hypoproteinemia, hyperlactatemia, hypoglycemia

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Clinical Signs of Hepatic Insufficiency

- **Common**
  - *Icterus*
  - Weight Loss*
  - Anorexia
  - Colic
  - *Pyrexia*

- **Less Common**
  - *Hepatic encephalopathy**
  - Photosensitization *
- **Uncommon**
  - Epistaxis (coagulopathy)
  - Ascites, edema
  - Diarrhea

**more common chronic*
***more common acute*

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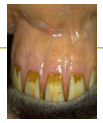
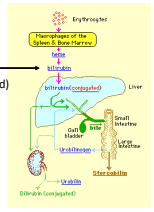
Icterus



- **Hyperbilirubinemia** with deposition of pigment in tissues
- *Total serum bilirubin = **Indirect** (unconjugated) > **Direct** (conjugated)*
  - DIRECT and INDIRECT both increased with hepatic disease
  - DIRECT more specific
    - Biliary outflow obstruction: direct bilirubin > 30% of total bilirubin

Increases
Liver disease
Hemolysis
GI disease
Anorexia

Indirect (unconjugated)



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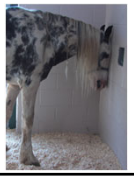
Hepatic Encephalopathy

- Abnormal mentation & hepatic disease
- Clinical signs - often progressive
  - Depression, yawning, behavior changes
  - Proprioceptive deficits, ataxia
  - Head-pressing, circling/pacing, central blindness
  - Episodes of aggression and/or somnolence
- Presumptive diagnosis:
  - Neurologic signs of cerebral dysfunction
  - Clinical findings of hepatic disease
  - Increased serum ammonia



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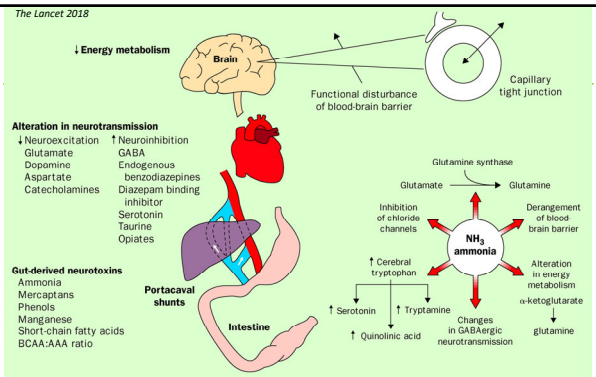
Hepatic Encephalopathy

- Severity correlates with degree of hepatocellular damage
- Exact pathophysiology is complex and elusive
  - ***Characteristically associated with hyperammonemia (CSF, blood)***
    - Gut-derived neurotoxin (NH_3)
  - Other contributors:
    - Additional neurotoxins, cerebral and systemic inflammation, cerebral vascular dysfunction, neuroendocrine abnormalities
- Alzheimer Type II astrocytes may be identified in brain

24



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Diagnosis of hepatic disease: biochemical testing

- **Liver specific enzymes**
  - Sorbitol dehydrogenase (SDH), Glutamate dehydrogenase (GLDH); Gamma-glutamyl transferase (GGT)
- **Nonspecific indicators of liver disease**
  - Alkaline phosphatase (ALP), aspartate aminotransferase (AST), lactate dehydrogenase (LDH)
  - Plasma proteins, metabolic indicators
- **Tests of liver function**
  - Bile acids, bilirubin (direct and indirect), ammonia, coagulation tests

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Liver Specific Enzymes

- Glutamate dehydrogenase (GLDH):
  - Hepatocellular (mitochondrial); $T_{1/2}$ ~14h
- Sorbitol dehydrogenase (SDH)
  - Hepatocellular (cytosolic); $T_{1/2}$ <12h
- Gamma-glutamyl transferase (GGT):
  - Biliary epithelium; $T_{1/2}$ ~3D
    - Cholangiohepatitis; biliary disease

Severe and/or long-standing liver disease may result in a similar increases in both hepatocellular and biliary enzymes

magnitude of increase in enzymes may not correspond to the functional status of the liver or with prognosis

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Diagnosis: tests of liver function

Bile Acids (most common)
Indicator of functional reserve of liver
Excellent screen of liver failure (> 20 µmol/L)
Not specific for type of disease
Better indicator of prognosis with chronic disease

Bilirubin (especially Direct)
Magnitude of increase corresponds to failure
Indirect – hepatocellular
Direct – biliary disease (>25% total)

Ammonia
Neurotoxic by-product of metabolism of nitrogen containing compounds (urea cycle)
Inconsistently increased with liver disease
Increased also with GI disease

Coagulation (Clotting) Factors
Increased PT and APTT
Decreased Factor 7 (+/- other factors)
Clinical bleeding uncommon

28

Diagnosis: nonspecific laboratory abnormalities

Enzymes
- Aspartate aminotransferase (AST):
  - Hepatocellular damage; half-life 7d
- Alkaline phosphatase (ALP):
  - Biliary disease ; half-life 3d
- Lactate dehydrogenase (LDH):
  - Isoenzyme 5 – hepatocellular disease

Protein
- Hypoalbuminemia:
  - Severe/chronic disease
- Hyperglobulinemia:
  - Liver failure
- Fibrinogen:
  - Variable; decreased in liver failure

Metabolic
- Hypoglycemia in liver failure
  - Impaired gluconeogenesis
- Hypertriglyceridemia is nonspecific

Hyperlactatemia
- Liver failure
  - Reduced clearance, increased production

29

Most useful diagnostics for liver disease

- Laboratory
  - SDH (or GLDH)
  - GGT
  - Bile acids
  - Total and direct bilirubin
- Liver US and biopsy
- ***Prognosis for liver disease is best determined by:***
  - ***(1) Persistent abnormalities in tests of liver function, (2) etiology, (3) extent of fibrosis, and (4) hepatic encephalopathy***


Journal of Equine Veterinary Science

Bile Acids, Direct Bilirubin and Gamma-glutamyltransferase as Prognostic Indicators for Horses with Liver Disease in the Eastern United States: 82 Cases (1997-2019)

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Systemic disease and hepatic enzymes

- Inflammation, vascular, hypoxic, toxic insults from non-hepatic primary diseases
- Intestinal disorders
  - E.g. LC displacement, GGT, direct bilirubin
  - E.g. reduced prognosis with increased bile acids
- Maladjustment to training
  - Thoroughbred racehorses and GGT

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Outcome: Holly & Roxy

- Rapid clinical deterioration:
  - Euthanized within 18-24 hours
- Necropsy Liver:
  - severe to massive hepatocellular degeneration and necrosis
  - Hemorrhage, stromal collapse & fibroplasia
  - Gross and microscopic findings consistent with **serum hepatitis (Theiler's disease)** → **Tetanus antitoxin**
- Necropsy Brain (gray matter):
  - Alzheimer Type II astrocytosis (hepatoencephalopathy)

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Serum Hepatitis

- 1918: Africa Horse Sickness vaccine
  - Theiler's Disease
- Epidemiology
  - Administration of biologic product of equine origin
    - ***Tetanus antitoxin*** (post 1960's), botulism antitoxin, pregnant mare serum, *Strep equi* antiserum
    - Plasma for colloid support (Aleman 2005)
    - Allogenic stem cells
  - Non-biologic cases
    - In-contact (infectious)
    - Isolated case clusters
- Cause elusive historically

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Serum Hepatitis – Theiler's Disease

- Clinical signs observed 4-10 weeks post exposure:
  - Acute onset, rapidly progressive, fulminant liver failure
  - Lethargy, anorexia, icterus, fever, encephalopathy
  - Marked increase in liver enzymes & B.A., hypoglycemia, hemoconcentration
- Mortality 50-90% in clinically affected horses
  - Morbidity in outbreak < 10%
  - ***Subclinical cases only increased liver enzymes***
- Diagnosis
  - Histopathology: lymphocytic hepatitis, severe centrilobular necrosis, hepatocyte loss and damage
  - Recently: antemortem hepatic viral testing

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Journal of Veterinary Internal Medicine ACVIM

STANDARD ARTICLE

Viral testing of 18 consecutive cases of equine serum hepatitis: A prospective study (2014-2018)

Joy E. Tomlinson[1] | Amit Kapoor[2] | Arvind Kumar[2] | Bud C. Tennant[3] | 2019

- 18 cases: 12 TAT, 3 plasma, 3 allogenic stem cells
- Equine Parvovirus EqPV-H
  - serum and/or liver tissue (10/10 TAT)
- Other viruses identified but inconclusive:
  - Equine Hepacivirus (EqHV); Equine Pegivirus 1 (EqPgV1), Theiler's Disease Associated Virus (TDAV; EqPV2),
- Roxy & Holly:
  - Serum & liver positive
  - TAT from same lot EqPV-H positive

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Equine Parvovirus Hepatitis (EqPV-H)

- Hepatotropic DNA virus
  - Consistently identified - experimental & biologic exposure, outbreaks
- Unknown why causes disease – possible immune response to virus
  - Increased viremia associated with acute disease
  - Most infections subclinical
- Seroprevalence 15-30% (multiple countries)
  - >60% seroprevalence during outbreaks
- Spread
  - Biologics: virus resistant to many preservatives
  - Insect spread proposed in outbreaks

EqPV-H and EqHV PCR testing through Cornell Animal Health Diagnostic Center

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Other Viruses

- Equine Hepacivirus (EqHV)
  - Hepatotropic, RNA virus *very* closely related to Hepatitis C virus
    - **Peak viremia:** mild/transient increase in hepatic enzymes, lymphocytic portal inflammation with mild & diffuse hepatocyte necrosis
      - Viral clearance approximately 6 months post viremia
  - USA: 2-7% infection rate & 30% seropositivity in adult horses
- Equine Pegivirus 1 (EqPV1) and Equine Pegivirus 2 (EqPV2)
  - RNA viruses, NO hepatotropism, NO liver disease
  - EqPV1: relatively common nonclinical infection in horses
  - EqPV2: Uncommon; formerly Theiler's Disease Associated Virus (TDAV)

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Hepatic Disease in Horses

- **Causes:**
  - Toxic
  - Infectious
  - Metabolic/vascular
  - Neoplastic
  - Hypoxic

→ **HEPATITIS (acute or chronic)**
Primary viral
Ascending bacterial
Toxicosis
Other: idiopathic, EIA, mycotoxin, fungal

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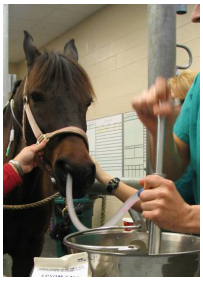
Ascending Bacterial Hepatitis - Cholangiohepatitis

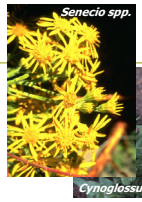
- Cause
  - Primary gastrointestinal disease
    - duodenitis, colonic displacement, Ileus
- Pathology
  - Portal tract and bile duct inflammation
- Clinical signs
  - Fever, colic, icterus, increased GGT, bilirubin
- Treatment
  - May resolve if correct underlying cause
  - Antimicrobials, anti-inflammatory



39

Toxicosis Associated Hepatitis

- **Pyrrolizidine alkaloid-containing plants**
  - Potent hepatotoxins
  - Chronic exposure (4 weeks - 6 months)
  - Hepatic necrosis, megalocytosis, biliary hyperplasia, portal fibrosis
- Other toxin sources
  - Alsike clover
  - Panicum grasses



40

Less Common Causes of Hepatitis

- Mycotoxicosis
  - Fumonisin
- Fungal
- EIA
- Idiopathic

JAVMA AVMA

A seasonal idiopathic hepatitis syndrome in horses presented to a Midwestern veterinary teaching hospital

Sandra D. Taylor, DVM, PhD[1*]; Janice E. Kritchevsky, VMD, MS[2]; Patrick Huang, DVM[2]; Carla Olave, DVM, PhD[2]; Sarah J. Waxman, DVM, MS[2]; Margaret A. Miller, DVM, PhD[2]

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The Impact of Pain Pathophysiology on Analgesic Treatment Decisions: Large Animal Focus

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Abstract: In all species, acute pain has a protective role but pain in excess of that needed for protection and pathologic pain, like chronic pain, have no purpose. Pain causes numerous adverse health, behavior and welfare effects and prevention/treatment of pain is a critical component of medical care in all species.

Key words: pain, adaptive, maladaptive, analgesia, horse, equine

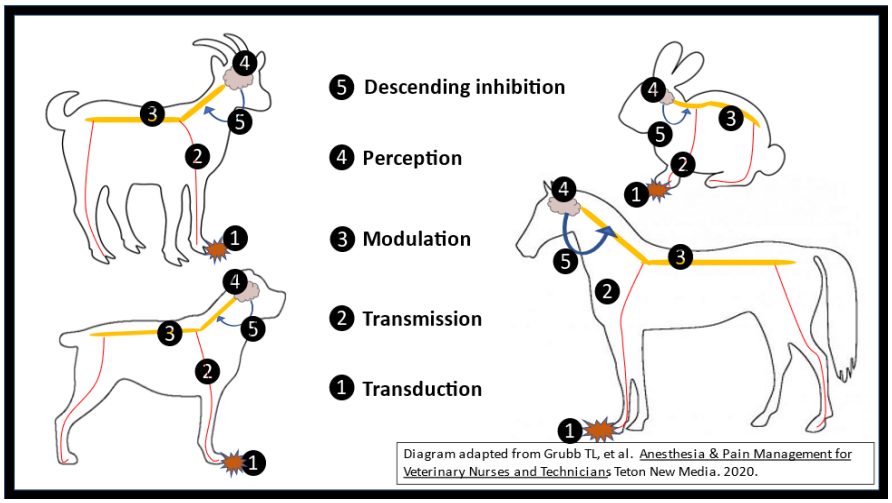
Although there may be individuals who still believe the myth that 'animals don't feel pain', this is actually scientifically impossible. The processes involved in the initiation, propagation and sensation of pain are highly conserved, meaning very similar, across mammalian (and other) species (Broom, 2001, Smith and Lewan, 2009). This means that a stimulus causing pain in a human is scientifically evidenced to cause pain in an animal. Thus, veterinary patients should receive analgesics for the same painful conditions that are treated in humans. Failure to control pain is both an ethical and medical issue, causing a myriad of negative effects on the patient's health, welfare (or 'quality of life') and behavior (Muir and Woolf, 2001, Muir, 2009).

Effective analgesia is best provided using knowledge of the pain process/pathway and administration of drugs/techniques that are most selective for the source or type of pain experienced by the patient. Drugs/techniques with different mechanisms or sites of action in the pain process can be used together to maximize analgesic efficacy. This technique, multimodal analgesia (MMA), is particularly crucial for effective control of moderate to severe pain in humans and in animals (Kazakos & Savvas, 2017, Lamont, 2008; Berry, 2015; Beverly, et al. 2017, Helander et al., 2017). The following is a brief overview of the pain process as related to effective pain management. More in-depth reviews are available (Muir and Anderson, 2005 [cattle], Muir, 2010 [horses], Fox, 2010, Shilo and Pascoe, 2014, Bell, 2018, Self and Grubb, 2019).

Understanding the Pain Process/Pathway and Maximizing Analgesic Efficacy

Pain is defined by the International Association for the Study of Pain (IASP; 2017) as 'an

unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage'. This rather awkward-sounding definition is actually useful because it describes the value of pain in protection from injury. A paw placed on a sharp rock causes activation of the pain pathway, the paw is reflexively withdrawn and tissue damage is prevented, or at least reduced. Thus, pain can be a normal physiologic response which is called 'physiologic' or 'protective' pain. Pain can also be an abnormal response causing a state of intense and/or prolonged pain that is not protective from tissue damage, which is called 'pathologic' or 'maladaptive' pain (Fox, 2010, Shilo and Pascoe, 2014, Adrian et al., 2017, Bell, 2018, Self and Grubb, 2019). Pathologic pain can occur due to a variety of reasons, including severe tissue trauma, prolonged inflammation, direct damage to the nervous system (eg, nerve root tumors, herniated intervertebral disc, etc…), and untreated or under-treated pain, especially if the pain is moderate to severe.



The Pain Pathway

The initiation, propagation and sensation of pain is a very dynamic and complex event that involves integration of a variety of physiologic processes, receptors, neurotransmitters, neural fibers, neural pathways and both discrete and diffuse anatomic locations from the periphery to the central nervous system (CNS). These components are dynamic or 'plastic' and often change their structure, function or activity according to the pain source, intensity and/or duration. Although they are not discrete entities, the components of the pain process can be loosely divided into a series of continuous and overlapping 'steps' that is called the 'pain pathway'. The

steps include transmission, transduction, modulation and perception. Because of its role in analgesia, descending inhibition, which is technically a component of modulation, is listed as a separate step in this discussion.

Transduction: The prefix 'noci' means 'injury' or 'pain' and the pain pathway is initiated when a specialized, peripheral sensory receptor, or 'nociceptor', is depolarized by a noxious, or 'nociceptive', stimulus. Depolarization of the nociceptors *transduces* the mechanical information from the stimulus into an electrical impulse. The density and exact distribution of nociceptors may vary by species and can be impacted by age and disease but are commonly highly represented in the skin and located throughout most structures in the body including the muscles, tendons, bone, viscera, peritoneum, pleura, periosteum, meninges, joint capsules, blood vessels, etc…. (Woolf and Ma, 2007; Smith and Lewan, 2009)

The nociceptors are not traditional 'receptors' but are the free endings of A-delta and C nerve fibers that will transmit the stimulus to the CNS (Woolf & Ma, 2007). Most of the nociceptors, especially those from C fibers, are 'polymodal', meaning that they can be depolarized by a variety of noxious stimuli from mechanical, thermal and chemical sources. Thus, as examples, noxious stimuli from surgery, trauma, burns and skin contact with acids are all recognized as pain. In physiologic pain, the nociceptors require a noxious stimulus to depolarize, there is no spontaneous nociceptor depolarization. In addition, the nociceptors are high threshold, meaning that they respond only to noxious stimuli and not non-noxious stimuli like touch (Woolf & Ma, 2007). With tissue injury, damage from structural and inflammatory cells (eg, neutrophils, mast cells, macrophages, and lymphocytes) causes a release of intracellular compounds and recruitment of other compounds (eg, H+, K+, histamine, prostaglandins, etc…) that accumulate in the area of the injury, potentially damaging adjacent cells, and thus expanding the area of cellular damage and inflammation. If the original insult causes minimal tissue damage and inflammation and/or if analgesic treatment specific for this inflammatory process is administered, the expanding tissue damage can be minimized, and pain maintained as physiologic. However, if the tissue injury is moderate to severe and/or inadequate analgesia is administered, the area of inflammation may continue to enlarge. Within the area of inflammation more nociceptors depolarize, nociceptor threshold is reduced so non-noxious stimuli can cause them to depolarize, and some may depolarize spontaneously. This expanded and exaggerated

pain response is ‘pathologic pain’, or pain in excess of that needed for protection, and the process just described is termed *peripheral sensitization.* Peripheral sensitization increases the number of pain signals that are sent to the CNS, thereby increasing the level of pain experienced by the patient. Peripheral sensitization is a major component of hyperalgesia, which is moderate to severe pain elicited by what should be a mildly painful stimulus. The clinical impact of hyperalgesia is the need for more aggressive analgesia for the patient, even if the patient is admitted for something considered to be low-level pain. For instance, a dog or cat with osteoarthritis is expected to be more painful after a minor surgery than a dog or cat with no preexisting pain.

Prevention or suppression of the pathologic pain response at transduction is an integral component of effective analgesia. Because the physiologic pain process (and the pathologic process at least in part) at transduction is primarily driven by inflammation, the most effective currently-available drug class at this pain pathway step is the anti-inflammatory drug (NSAID) class. When inflammation is predicted, the timing of anti-inflammatory drugs is important as NSAIDs are generally more effective when administered preoperatively versus postoperatively (example: Lascelles et al., 1998). NSAIDs are more effective when combined with drugs that work in other parts of the pain pathway like opioids (example: Mwangi et al., 2018)

A novel drug class, the anti-nerve growth factor monoclonal antibody (anti-NGF mAb) class, has also shown to be very effective at transduction, at least for the treatment of chronic pain (Enomoto et al., 2019). Local anesthetics, the application of ice (cryotherapy), acupuncture, photobiomodulation (ie, laser therapy) and capsaicin are examples of other drugs/treatments that have some degree of efficacy at transduction.

Transmission: In the transmission step of the pathway, each depolarized nociceptor *transmits* a stimulus, or action potential, from the A-delta and C fibers to the CNS, primarily through opening of sodium channels (Levinson et al., 2012). In pathologic pain, additional A-delta and C fibers can be recruited, A-beta fibers (which normally transmit touch) can be altered to transmit noxious stimuli, and some Na+ channels can become hyperexcitable and exhibit spontaneous electrical activity (Levinson et al., 2012). These processes increase the number and frequency of nociceptive impulses transmitted to the CNS, thus amplifying the pain signal.

The local anesthetic drugs, which block sodium channels, are an integral part of pain control at transmission. This is a unique and powerful mechanism in the pain pathway and local/regional blockade is recommended for all patients, if possible (Mathews et al., 2014, Grubb & Lobprise 2020). As with NSAIDs, administration of local anesthetics prior to - versus after - the initiation of pain is generally more effective (example: Savvas et al., 2008) and inclusion of local blocks with other analgesic drugs improves analgesic efficacy (examples: Ko et al., 2009, Warrit et al., 2019).

Examples of other analgesic drugs/treatments with some efficacy at transmission include opioids and alpha-2 agonists combined with local anesthetics, cryotherapy, acupuncture, and anti-NGF mAbs.

> NOTE: Transmission as an ascending *analgesic* pathway: A-beta receptors and fibers, which are located with the A-delta and C fibers, generally conduct non-noxious (non-nociceptive) stimuli such as touch and movement. Stimulation of the A-beta fibers can also recruit inhibitory neurons in the dorsal horn of the spinal cord. This appears to be a component of the explanation of why gently rubbing a painful site may temporarily decrease the level of pain ('gate control'; Melzak and Wall, 1965).

Modulation: This step of the pathway, which occurs at the dorsal horn of the spinal cord, is very complex, with numerous possible scenarios, including changing or '*modulation'* of the intensity of the pain stimulus (D'Mello and Dickenson, 2008). The A-delta and C fibers terminate in various lamina in the dorsal horn of the spinal cord where neurotransmitters (primarily glutamate and substance P) are released. In the simplest form of physiologic pain, the impulses are sent to the contralateral side of the spinal cord and then transmitted directly to the brain via ascending (or 'projecting') tracts without modulation.

Modulation is often excitatory (numerous processes) but, as just previously described, can be inhibitory (eg, ascending A-beta fiber input or input from the descending inhibition). Inhibitory input can be a component of physiologic pain or activated in an endogenous attempt to control pathologic pain. In pathologic pain, excitatory modulation is often pronounced because the pain signal can be amplified by processes that are numerous, complex and dynamic. The initiation of excitatory modulation is often driven by peripheral sensitization but can also be due to direct nervous system injury. Increased excitatory activity in the spinal cord, or *central sensitization* or

central plasticity, means an increased number of pain stimuli sent to the brain, and greater pain for the patient. This can cause hyperalgesia and/or allodynia, which is a pain response to a nonpainful stimulus. This is often seen as an exaggerated behavioral response, like a rapid withdrawal from, or aggressive move towards, the perceived source of the stimulus. The clinical impact is the critical need for multimodal analgesia, potentially aggressive multimodal analgesia, since central sensitization is multifaceted and results in extreme pain.

A major contribution to central sensitization is activation of N-methyl-D-aspartate (NMDA) receptors, which are normally dormant. This leads to numerous avenues of pain amplification, including recruitment of additional pain receptors, lowered threshold of pain receptors and downregulation of opioid receptors (ie, 'opioid resistance'). Ketamine, administered as a sub-anesthetic infusion (but potentially also delivered by other routes), is an important therapeutic choice because it prevents/reverses central sensitization by 'plugging' the NMDA-receptors. Although research in ketamine infusion-mediated analgesia is in its infancy in veterinary medicine, evidence from human medicine supports the use of ketamine in both acute and chronic pain (Cohen et al., 2018, Schwenk et al., 2018).

Examples of other drugs/treatments that have some efficacy at modulation include opioids, alpha-2 agonists, systemic lidocaine, neurokinin-1 receptor antagonists, etc… Drugs/treatments that work in the transduction and transmission phase of the pathway have an impact on modulation by decreasing the number of pain signals that reach the dorsal horn of the spinal cord.

Perception: The perception of pain by the patient is also a very complex process mediated by the number of pain signals reaching the brain and impacted by a variety of other factors, like age, health status, level of stress/fear and previous pain experience. Perception is not completely understood in humans, who can communicate what they are perceiving, and is even less-understood in animals, who generally don't communicate in a way that humans understand. It is known that there is no specific pain center in the brain, and nociceptive impulses from the spinal cord arrive at a variety of anatomical sites (eg, the thalamus, hypothalamus) where they synapse and transmit signals to various cortical and subcortical regions (eg, the somatosensory cortex, periaqueductal gray region (PAG)). This diverse pattern of distribution results in a variety of

outcomes, which includes pain perception along with arousal/wakefulness (which contributes to insomnia in painful patients), behavior changes and emotional responses.

Many of the drugs/treatments that work in the spinal cord also work in the brain, including the opioids, alpha-2 agonists, NMDA-receptor antagonists, tricyclic antidepressants, norepinephrine and serotonin (5-HT) reuptake inhibitors, etc.

> *Definition clarification and role of inhalant anesthetics:* An understanding of 'nociception,' versus 'pain' is based on what happens, or doesn't happen, in the brain. *Nociception* describes strictly the neural process that occurs beginning with transduction of a painful stimulus but without ending in a cognitive processing of that stimulus. This definition is often used for phyla (eg, invertebrates) that don't seem to have a central processing center (although this may be incorrect). *Pain* is defined as a cognitive or emotional response to nociception that occurs in the higher centers of the CNS, such as the cerebral cortex. Thus, our patients experience pain. However, inhalant anesthetics block perception, thus pain technically doesn't occur in anesthetized patients since the cognitive or emotional response would be prevented by the anesthetic. However, with noxious stimulation, the other components of the pain pathway are activated, causing adverse effects from the noxious stimulus during anesthesia (eg, tachycardia, neuroendocrine responses, etc…). The patient will experience pain, along with the adverse effects of pain, on emergence from anesthesia if pain is un- or under-treated during anesthesia.

Descending inhibition: Descending inhibition of pain impulses can be activated in various central sites and its main effective site is the dorsal horn of the spinal cord through release of inhibitory neurotransmitters (eg, endogenous opioids [endorphins, enkephalins, dynorphins], serotonin, etc…). The major importance of descending inhibition is that decreased efficacy of descending inhibition may play a large role in pathologic pain, central sensitization and allodynia (Ren and Ruda, 2002). Exogenous stimulation of descending inhibition has only minor contributions to pain control in physiologic pain but could potentially play a larger role in pathologic pain. Drugs/treatments with some efficacy at descending inhibition include

exogenously administered opioids, treatments that cause the release of endogenous opioids (eg, acupuncture), serotonin and norepinephrine reuptake inhibitors (Moore, 2016) and drugs that increase the inhibitory neurotransmitter gamma aminobutyric acid (GABA).

Conclusion

Perhaps the myth that animals don't feel pain stems from the fact that animals don't convey pain in ways that humans readily recognize. This is eloquently described by the IASP (2017), 'inability to communicate does not negate the possibility that a human or a nonhuman animal experiences pain'. With a basic understanding of the pain pathway, 1) the fact that animals do feel pain can be scientifically supported and 2) effective analgesic protocols based on the site/mechanism of action of the drug/treatment can be developed.

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Sedative & Analgesic Infusions in Horses

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Abstract: Sedation and analgesia provided by infusion rather than boluses provides flexibility in both duration and depth of sedation/analgesia. Traditional drugs like xylazine can be used but other alpha-2 agonists, opioids, ketamine, lidocaine and combinations of drugs are all options.
Key Words: equine, horse, sedation, analgesia, infusion

Analgesic infusions (Table 1)

Alpha-2 agonists

Alpha-2 agonists are commonly used to provide sedation in horses. The fact that the alpha-2 agonists also provide moderate analgesia makes them excellent drugs to incorporate into pain management protocols. The effects of alpha-2 agonists are reversible, although they are rarely reversed in horses. Detomidine is the alpha-2 agonist most commonly used for CRIs in horses. Adding butorphanol, either as a bolus or as an infusion, greatly augments the analgesia provided by the alpha-2 agonist. Because they have a higher alpha-2:alpha-1 receptor binding ratio, medetomidine and dexmedetomidine are more potent analgesic drugs than detomidine and have been used to provide analgesia and anesthetic stability in anesthetized horses (Bettschart-Wofensberger et al. Vet Rec 2001 and Ringer et al. Vet Anaesth Analg 2007; Marcilla et al. Vet Anaesth Analg 2010, respectively). In this situation, the dose is very low, thus offsetting the increased price of these drugs when compared to alpha-2 agonists traditionally used in horses. Romifidine, which may not be currently available, has been used as an analgesic CRI in anesthetized horses (Devisscher et al. Vet Anaesth Analg 2010).

Lidocaine

Lidocaine can be administered systemically to provide analgesia, although the mechanism of analgesia following systemic administration is not entirely clear. Proposed mechanisms include, but are not limited to, blockade of sodium channels or potassium currents in the dorsal horn of the spinal cord and direct inhibition of abnormal electrical charges from injured or inflamed peripheral nerves. In horses, lidocaine CRIs are commonly used to treat GI pain (Doherty Vet Clin NA Equine 2009), have been suggested for treatment of the pain of laminitis (Doherty &

Seddighi Vet Clin NA Equine 2010) and are effective against somatic pain (Robertson et al. Eq Vet J 2005). In addition to the analgesic effects, lidocaine ameliorates the inflammatory response in endotoxemic horses (Peiro et al. J Vet Intern Med 2010), the inflammatory response in horses with ischemic bowel (Cook et al. Am J Vet Res 2009) and improves GI motility following abdominal surgery (Doherty Vet Clin NA Equine 2009). IV lidocaine significantly decreased the amount of reflux and improved the clinical course in refluxing horses (Malone et al. Vet Surg 2006). IV lidocaine has been used to decrease the MAC in anesthetized horses (Doherty & Frazier Eq Vet J 1998). Mild ataxia in recovery has been reported in horses receiving lidocaine CRIs during general anesthesia but the problem is eliminated if the CRI is discontinued 20-30 minutes prior to the end of the procedure (Valverde et al. Eq Vet J 2005). Ataxia in conscious horses has not been reported at the clinically used rate of 50 microg/kg/min. A review article on the use of lidocaine CRIs in horses was published in 2010 by Doherty & Seddighi (Vet Clin NA Equine).

Opioids

The opioid class of drugs includes some of the most potent analgesic drugs available and opioids should be considered for any patient experiencing moderate to severe pain. Opioids can cause excitement in horses but this response is uncommon in painful horses and the low dose of opioids delivered in a CRI rarely results in agitation or excitement, even in non-painful horses. However, if excitement does occur, a light dose of a sedative (eg, detomidine) can be administered to the horse and the CRI rate maintained (if excitement is mild) or reduced (if excitement is moderate). If sedation occurs, the dose of the CRI can be decreased. Butorphanol, an opioid agonist-antagonist is the opioid most commonly used in horses. As an agonist-antagonist, butorphanol provides only moderate analgesia and has a ceiling effect for pain relief (ie, a point is reached where higher dosages result in more sedation but not more analgesia) but is also less likely than full agonist opioids to cause excitement in horses. Butorphanol CRIs have been used to control post-operative pain (Sellon et al. J Vet Intern Med 2004) and horses receiving butorphanol CRIs had less weight loss and lower pain scores and plasma cortisol concentrations than control horses. Also, non-painful horses receiving butorphanol CRIs had minimal to no behavior changes (eg, excitement or ataxia) whereas horses receiving a butorphanol bolus did exhibit some negative behavior (Sellon et al. Am J Vet Res 2001). Morphine and methadone are potent full agonist opioids that provide profound dose-related

analgesia. The full agonists are more likely to cause adverse effects than the partial agonists but the incidence of opioid-induced side effects, while present, has been overstated. Morphine CRIs are being used more commonly in horses (Clarke et al. Vet Anaesth & Analg 2005; Clarke et al. Vet Anaesth & Analg 2008). The potential for excitement in recovery is a concern of opponents of morphine CRIs, however, recoveries from anesthesia for elective surgical procedures was characterized by fewer attempts to attain sternal recumbency and standing, and a shorter time from the first recovery movement to the time of standing, in horses receiving an intra-operative CRI of morphine compared to horses not receiving a CRI (Clarke et al. Vet Anaesth & Analg 2008). The potent full agonist opioid fentanyl has also been safely and effectively used as a CRI in anesthetized horses (Ohta et al. J Vet Med Sci 2010). Methadone is commonly used in horses at the same dose that morphine is used, however, there are no publications on this technique.

Ketamine

Painful impulses cause N-methyl-D-aspartate (NMDA) receptors (among others) in the dorsal horn of the spinal cord to depolarize and prolonged depolarization of these receptors can lead to an amplification of the pain stimulus, resulting in what we commonly refer to as 'wind-up' or 'hypersensitization' or ‘central sensitization’. When this occurs, the patient may feel more pain than expected (hyperalgesia) or even feel pain in response to a non-painful stimulus (allodynia). By administering drugs that antagonize these receptors (like ketamine), we are able to alleviate this exaggerated response and make the pain easier to control. Ketamine is the NMDA-receptor antagonist most commonly used in veterinary medicine and NMDA receptor antagonist effects are achieved when ketamine is used as a low-dose CRI. A single low-dose bolus of ketamine or the high-dose bolus used for anesthetic induction can serve as a loading dose for a CRI but is unlikely to provide analgesia when used alone. Furthermore, the NMDA receptor antagonists strictly mediate sensitization and do not provide true analgesia, thus, these drugs must be administered in conjunction with true analgesic drugs (eg, opioids or NSAIDs). Ketamine has been used as a CRI to treat acute pain in anesthetized horses (Levionnois et al. Vet J 2010) and in conscious ponies (Peterbauer et al. Vet Anaesth Analg 2008). Ketamine administered at the most commonly reported dosages of 0.4-0.8 mg/kg/hr (6-12 microg/kg/min; Fielding et al. Am J Vet Res 2006) and even as high as 1.5 mg/kg/hr (25 microg/kg/min; Lankveld et al. J Vet Pharmacol Therap 2006) to horses does not result in sedation or excitement.

Combinations

CRIs that include multiple drugs are often more effective than CRIs of single drugs because the effects of analgesic agents from different drug classes are generally additive or synergistic. Any of the drugs listed above can be used in combination. Morphine-lidocaine-ketamine (MLK) is a popular combination used in small animals and MLK use has been used in anesthetized horses to decrease the inhalant gas requirement (Lerche & Muir ACVA Proceedings 2008). Morphine has been used in combination with medetomidine to provide 'reliable sedation and stable cardiorespiratory function in conscious, standing horses undergoing exploratory laparoscopy' (Solano et al. Eq Vet J 2009). Methadone can be used in place of morphine in all of these combinations. Lidocaine and ketamine have been used in combination to 'improve anesthetic and cardiovascular stability during isoflurane anesthesia' with no adverse effect on quality of recovery (Enderle Vet Anaesth Analg 2008). A combination of lidocaine, morphine, ketamine, detomidine and acepromazine ('pentafusion') appears to be a very potent analgesic (Abrahamsen ACVS Proceedings 2011). Many other combinations have been reported and/or used anecdotally.

Calculations of CRI dosages

Generally, dosing tables or individualized spread sheets (eg, there are very useful spreadsheets available at multiple websites, including one of my favorites at www. vasg.org) should be used for constant rate infusions. These sheets greatly improve the speed at which CRIs can be initiated and greatly decrease the chance of mathematical errors. However, CRI dosages can also be easily calculated using the formula:

- A = desired dose in microg/kg/min
- B = body wt in kg
- C = Diluent volume in mls
- D = Desired fluid rate in mls/hr
- E = Drug concentration in mg/ml

(A x B x C x 60)/(D x E x 1000) = mls of drug to add to diluent

Table 1: Analgesic infusions for horses. Some infusions can be administered either to the conscious or the anesthetized horse while some are better administered only under general anesthesia. The latter category is indicated in the comments column.

Drug(s)	Dosage	Comment or Tip
OPIOIDS		
Butorphanol	Loading dose: 18 mic/kg IV CRI: 23-25 mic/kg/hr	QUICK TIP: add 1 ml of 10 mg/ml butorphanol to 1-L LRS and administer at 1 L per hour per 450 kg. May need to administer an alpha-2 agonist to some horses. (Sellon et al. J Vet InternMed. 2004)
Morphine or methadone	Loading dose 0.15 mg/kg IV CRI: 0.1 mg/kg/hr	Improved recovery in horses anesthetized for elective surgical procedures. (Clarke et al. Vet Anaesth & Analg 2005 and 2008). No reference for methadone although clinical use is common.
ALPHA-2 AGONISTS: See tips for using alpha-2 infusions in STANDING horses in Table 2		
Dexmedetomidine	Loading dose 1-3.5 mic/kg IV CRI 0.5-1.5 (up to 3) mic/kg/hr	Analgesia + decreased inhalant dose = better blood pressure, usually contributes to better recoveries QUICK TIP: Mix 8 mls saline + 2 mls 0.5 mg/ml dexmedetomidine in 10 cc syringe. Final concentration is 100 mic/ml. Administer at 1 mic/kg/hr. Example: A 500 kg horse will get 5 mls/hr.
OTHER DRUGS		
Lidocaine	Loading dose: 1-1.5 mg/kg IV delivered over 10-20 mins CRI: 40-50 mic/kg/min	QUICK TIP: Add 150 mls 2% lidocaine per liter of fluids (generally 750 mls is added to a 5-L bag) and administer the fluids at 1 ml/kg/hr for a dose of 50 mic/kg/min.
Ketamine	Loading dose: 0.2-0.6 mg/kg 2-10 mic/kg/min (0.12-0.6 mg/kg/hr)	QUICK TIP: Add 3-6 mls to 1-L fluids, administer at 1 ml/kg/hr for 0.3-0.6ml/kg/hr. Intraop: 0.6mg/kg/hr x 450kg=0.27ml/hr dilute in 10 ml saline & use syringe pump 0.4-0.8 mg/kg/hr (6-13 mic/kg/min) has been used in either conscious or anesthetized horses (Fielding et al. AJVR 2006).
COMBINATIONS (Any of the drugs listed in this chart can be used in combination)		
Morphine (M), Lidocaine (L), Ketamine (K)	See next column	'Following a bolus of L 1.2mg/kg IV given over 20 minutes, an infusion of MLK was administered with the following rates: M at 0.1mg/kg/hour, L at 45µg/kg/minute and K at 17µg/kg/minute. (Lerche et

		al. ACVA 2008; ketamine was used as induction drug (2.2 mg/kg), which serves as bolus. This infusion is used most commonly during general anesthesia.
Medetomidine & morphine	See next column	Medetomidine (5 mic/kg IV) followed in 10 min by morphine (50 mic/kg IV) and 10 min later by a CRI of medetomidine and morphine (5 and 30 microg/kg/hr, respectively) (Solano et al. EVJ 2009). Most commonly for general anesthesia.
Lidocaine & ketamine	See next column	Lidocaine 1.5 mg/kg bolus over 10 minutes, followed by 40 mic/kg/min and ketamine 60 mic/kg/min, both reduced to 65% of the initial dose after 50 minutes, and stopped 15 minutes before the end of anesthesia. Either conscious or anesthetized horses. (Enderle VAA 2008)
Pentafusion	See next column & Table 3	Dosages: Lidocaine 3 mg/kg/hr; Ketamine 0.6 mg/kg/hr; Morphine 0.025 mg/kg/hr; Detomidine 0.0044 mg/kg/hr; Acepromazine 0.0022 mg/kg/hr (Abrahamsen ACVS Proc.2011). Most commonly used in conscious horses.

Table 2: Infusions for standing Sedation + Analgesia

Drug	**Dose**	**Tip**
Detomidine Used alone, the dose is usually higher than when used in combo. This 'sliding' dosing allows a quick onset of procedural sedation without continued deep sedation.	Loading dose: 8-10 mic/kg IV Start at 0.5-0.7 mic/kg/min and cut dose in ½ every 15 mins CRI: 0.5 mic/kg/min for 15 min, followed by 0.3 mic/kg/min for 15 min and finally 0.15 mic/kg/min until 5-15 mins prior to the end of the procedure. [0.5 mic/kg/min=30 mic/kg/hr]	QUICK TIP for 0.5 mic/kg/min starting dose: Remove 5 ml of fluid from a 500-ml bag of NaCl and add 5 ml of 10 mg/ml detomidine (for a final concentration of 100 microg/ml of detomidine). Following the loading dose, start the drip (using a 60 drop/ml set) at 0.005 drops/kg/sec (roughly 2 drops/sec/ 450 kg) for 15 mins; then 0.003 drops/kg/sec (roughly 1 drop/sec/450 kg) for 15 mins; and then 0.0015 drops/kg/sec (roughly 1 drop every other sec/450 kg) until 5-15 mins prior to the end of the procedure (the time between the discontinuance of the drip and the end of the procedure should be based on degree of sedation and invasiveness of the procedure). The drip rate should be adjusted to obtain the desired level of sedation. For smaller horses, 2.5 mls of detomidine

		can be added to the saline to improve accuracy of counting drops.
Detomidine + Butorphanol	Loading dose: 8-10 mic/kg detomidine + 20 mic/kg butorphanol IV CRI: 5-30 mic/kg/hr detomidine + 10-30 mic/kg/hr butorphanol	Can add butorphanol CRI. See tips on butorphanol in Table 1. When administered as a combination, the CRI rate is generally the same as the rate for either drug used alone but some clinicians advocate using only ½ of the butorphanol CRI rate.
Detomidine + Morphine	Loading dose: 8 mic/kg detomidine; WAIT 10 mins then 50 mic/kg morphine CRI: 5-30 mic/kg/hr detomidine + 30 mic/kg/hr morphine	More profound analgesia with addition of morphine. May cause more 'box walking' (pacing) after the CRI is discontinued but true excitement is highly unlikely. Can give additional dosages of alpha-2 agonists if pacing occurs.
Romifidine	Loading dose: 40-80 mic/kg CRI 18-30 mic/kg/hr	Can add butorphanol or morphine (see notes under detomidine)
Xylazine	Loading dose: 0.5-1.0 mg/kg CRI: 0.6-1.5 mg/kg/hr OR Loading dose: 1100 mic/kg CRI: 690 mic/kg/hr	TIP: Add 1000 mg (10cc) xylazine to 1-L saline and administer at 1 ml/kg/hr. Can add butorphanol or morphine (see notes under detomidine) (References for protocols at left: top protocol (Muller C. et al. Pferdeheilkunde 2012;28(6):668-674); bottom protocol (Ringer et al. Vet Anaesth Analg 2013;40(2):157-165 and Ringer et al. The Vet J 2013;195:228-234).
Medetomidine	Loading dose: 5 mic/kg CRI: 3.5 mic/kg/hr	Can add butorphanol or morphine (see notes under detomidine). More profound analgesia than other alpha-2s listed here. Also more expensive.

Table 3: Dr. Eric Abrahamsen's pentafusion protocol

Drug	Dose	Amount Required	Base Delivery Rate
Bag #1			68 ml/450 kg/h
Lidocaine	3 mg/kg/hr	1 liter	
Ketamine	0.6 mg/kg/hr	4000 mg	
Bag #2			68 ml/450 kg/hr

NaCl	NA	liter	
Morphine	0.025 mg/kg/hr	170 mg	
Detomidine	0.0044 mg/k/hr	30 mg	
Acepromazine	0.0022 mg/kg/hr	15 mg	

Dr. Abrahamsen likes 2 bags so that the rate of bag #2 can be decreased first and then, if the patient is comfortable, the rate of bag #1 can be decreased. The solution can also be made all in one bag and the rate decreased as pain is controlled. Primarily used for moderate to severe pain like pain of laminitis.

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Equine Sarcoidosis:
Review of Current Knowledge and Treatment Options

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2023 J.T. Vaughan Equine Conference

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1

Overview

- Introduction
- Types of sarcoid
- Cause of sarcoid
- Treatment options

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2

The Basics

- Most common skin tumor
- Multiple lesions
- Often persistent and resistant to therapy
- Commonly recur
- Not fatal
- Lead to loss of use

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Signalment

- Occurs world-wide
- Reported in horses, donkeys, mules, and zebras
- All ages, breeds and colors

TREATMENT OF EQUINE SARCOID IN SEVEN CAPE MOUNTAIN ZEBRA (*EQUUS ZEBRA ZEBRA*)

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[2] Corresponding author (email: johan.marais@up.ac.za)

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4

Types of Sarcoid

- Occult
- Verrucous
- Nodular
- Fibroblastic
- Malevolent
- Mixed

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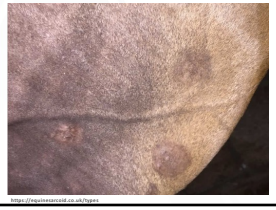
Occult Sarcoid



- Mild superficial form
- Mostly around the mouth and eyes, the neck, and other relatively hairless regions
- Generally slow growing
- Can turn into verrucous or fibroblastic-type sarcoid

https://equinesarcoid.co.uk/types

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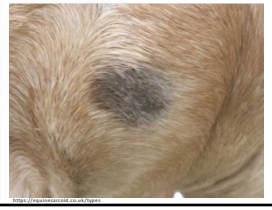
Verrucous Sarcoid



- Rough hyperkeratotic appearance
- Flaking and scaling
- Often on face, trunk, and groin/sheath areas
- Generally slow growing until injured
- Can turn into fibroblastic-type sarcoid

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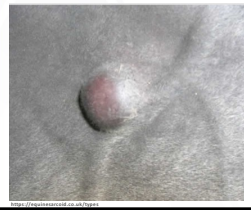
Nodular Sarcoid



- Well-defined subcutaneous spherical nodules
- Two types
  - Type A – entirely subcutaneous
  - Type B – involvement of overlying skin
- Often on groin, sheath, and eyelid
- Generally moderate growth
- Injury can lead to rapid growth and transformation to fibroblastic-type sarcoid

https://equinesarcoid.co.uk/types

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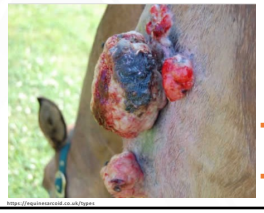
Fibroblastic Sarcoid



- Fleshy, ulcerated, aggressive appearance
- Two types
  - Type 1 – pediculated with limited base palpable
  - Type 2 – broader-based (sessile) without recognizable pedicle
- Often on groin, eyelid, lower limb, and coronary band
- Do no metastasize but locally invasive

https://equinesarcoid.co.uk/types

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Malevolent Sarcoid

- Most severe form
- Infiltration of lymphatic vessels
- Cords of tumor
- Highly invasive and destructive
- Often on jaw, face, elbow, and medial thighs

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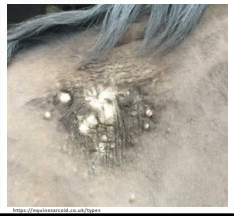
Mixed Sarcoid



- Mixture of any or all types
- Likely represents progressive or transient state between types

https://equinesarcoid.co.uk/types

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Sarcoid Histology

TABLE 1: Epidermal and dermal changes in 10 sarcoids from each clinical type. The epidermis was absent in one fibroblastic and one nodular sarcoid

Epidermis (48)	Occult	Verrucous	Fibroblastic	Nodular	Mixed	Total (per cent)
Hyperkeratosis – mild	5	–	7	3	3	
– moderate/pronounced	–	10	1	2	7	38 (79)
Epidermal thinning	1	4	–	5	3	13 (27)
Hyperplasia – mild	2	5	3	2	5	
– moderate/pronounced	–	1	6	–	2	26 (54)
Rete pegs	–	9	2	2	9	22 (46)
'Picket fence' at junction (ep)dermis	–	8	4	3	8	23 (48)
Partial surface ulceration	–	2	10	–	4	16 (33)
Dermis (50)						
Increased density of dermal fibroblasts	10	10	10	10	10	50 (100)
Typical whorling fibroblast pattern	–	8	8	9	9	34 (68)
Cystic hair follicles	–	8	1	3	7	19 (38)

n, number of sarcoids where the respective changes were detected; –, no changes detected.

Martens et al. Histopathological characteristics of five clinical types of equine sarcoid(2000) *Res in Vet Sci*

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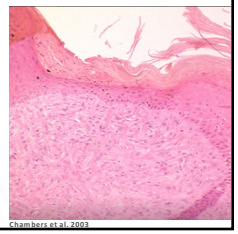
Verrucous Sarcoid

- Hyperkeratosis
- Rete pegging
- Fibroblastic whorls
- Ancanthosis
- Difficult to distinguish from dermal fibroma

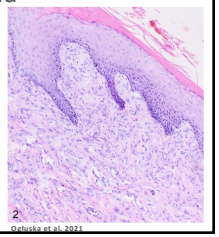


Chambers et al. 2003

13

Fibroblastic Sarcoid

- Spindle-shaped neoplastic cells
- "Picket fence"
- Hyperplastic epidermis
- Rete peg-like structures
- Compact hyperkeratosis



Ogłuska et al. 2021

14

Cause – Bovine papillomavirus?

Association of bovine papillomavirus with the equine sarcoid

G. Chambers,[1] V. A. Ellsmore,[2] P. M. O'Brien,[1] S. W. J. Reid,[2] S. Love,[2] M. S. Campo[1] and L. Nasir[2]

- Sarcoid associated with bovine papillomavirus types 1 and 2
- Most contain detectable viral DNA and RNA
- Express E5
- Do not produce infectious virions

15

Treatment Options

So many options!!!
But which one works?

16

Treatment - Benign neglect

Pro	Con
▪ Cheap ▪ Not generally fatal ▪ Do not usually metastasize	▪ Can be unsightly ▪ Limit use ▪ Secondary bacterial infections

17

Treatment – Topical therapies

Topical treatment of equine sarcoids with imiquimod 5% cream or *Sanguinaria canadensis* and zinc chloride – an open prospective study

Carina M. Pettersson*, Hans Broström†, Patrice Humblot‡ and Kerstin E. Bergvall‡

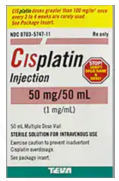
- Immune-modifying/anti-viral
  - Imiquimod
- Chemotherapeutics
  - AW5, 5-Fluorouracil
- Bloodroot
  - Xxterra

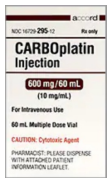
Owner Compliance!!!

18

Treatment – Intralesional chemotherapeutics

- Injectable chemotherapeutics
- Intralesional slow releasing chemotherapeutic beads.





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Treatment - Cryotherapy

- Aim to freeze tissue to -20C
- Use freeze cycles
- Can use spray canister or metal probe

The Treatment of Equine Sarcoids by Cryosurgery

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https://www.irongatequine.com/equine-cryosurgery

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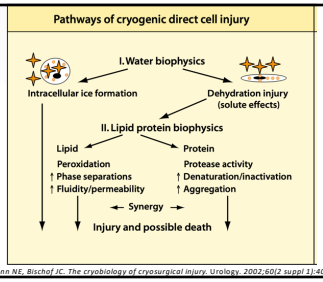

Hofmann NE, Bischof JC. The cryobiology of cryosurgical injury. Urology. 2002;60(2 suppl 1):40–49

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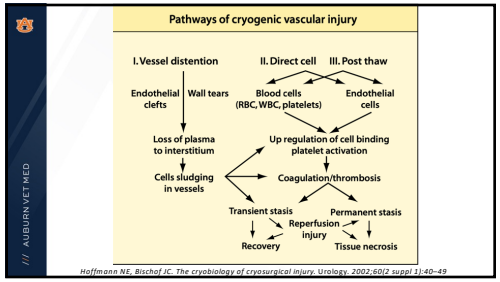
Pathways of cryogenic vascular injury
I. Vessel distention
II. Direct cell
III. Post thaw
Endothelial clefts
Wall tears
Blood cells (RBC, WBC, platelets)
Endothelial cells
Loss of plasma to interstitium
Up regulation of cell binding platelet activation
Cells sludging in vessels
Coagulation/thrombosis
Transient stasis
Reperfusion injury
Permanent stasis
Recovery
Tissue necrosis
Hoffmann NE, Bischof JC. The cryobiology of cryosurgical injury. Urology. 2002;60(2 suppl 1):40–49
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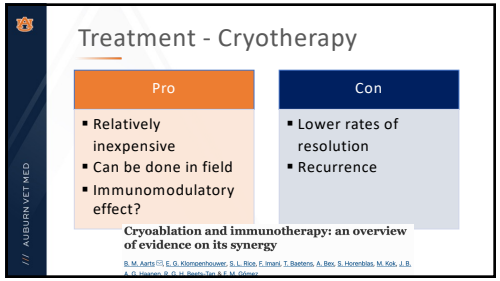
Treatment - Cryotherapy
Pro
Relatively inexpensive
Can be done in field
Immunomodulatory effect?
Con
Lower rates of resolution
Recurrence
Cryoablation and immunotherapy: an overview of evidence on its synergy
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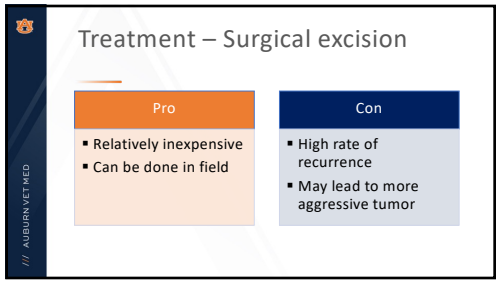
Treatment – Surgical excision
Pro
Relatively inexpensive
Can be done in field
Con
High rate of recurrence
May lead to more aggressive tumor
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Treatment – CO2 laser

Use of a carbon dioxide laser for surgical management of cutaneous masses in horses: 32 cases (1993–2000)

Charles T McCauley [1], Jan F Hawkins, Stephen B Adams, John F Fessler

- Local tissue ablation
- Minimize seeding possibilities
- Up to 80% resolution reported

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Treatment – CO2 laser

Pro	Con
▪ Standing sedation ▪ Improved margins to excision alone	▪ Less accessible ▪ Recurrence ▪ Cost

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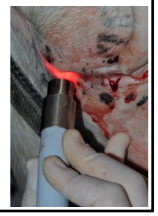
Treatment – Photodynamic therapy

***In Vitro* and *In Vivo* Evaluation of Hypericin for Photodynamic Therapy of Equine Sarcoids**

A. MARTENS*, A. DE MOOR*, E. WAELKENS†, W. MERLEVEDE† and P. DE WITTE‡



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Treatment – Photodynamic therapy

Pro	Con
▪ Standing sedation ▪ Improved margins to excision alone	▪ Less accessible ▪ Repeated treatments ▪ Cost ▪ Recurrence unknown

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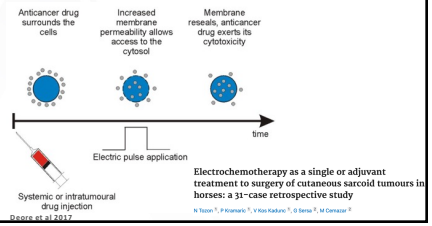
Treatment - Electrochemotherapy



Electrochemotherapy as a single or adjuvant treatment to surgery of cutaneous sarcoid tumours in horses: a 31-case retrospective study

29

Treatment - Electrochemotherapy

Pro	Con
▪ Improved margins to excision alone ▪ Complete response in 92% of cases	▪ Less accessible ▪ General anesthesia ▪ Repeated treatments ▪ Cost

30

Autologous/Autogenous vaccine

Autologous vaccination for the treatment of equine sarcoids: 18 cases (2009–2014)

Caitlin C. Rothacker, Ashley G. Boyle, David G. Levine

Remove a sarcoid and section → Freeze in liquid nitrogen → Re-implant frozen sections in neck

31

Autologous/Autogenous vaccine

Pro	Con
▪ Standing sedation ▪ May prevent future sarcoids	▪ Rates of complete resolution not reported ▪ Surgical site complications

32

Treatment - Radiation

- Noted particularly equine head and nasal tumors
- No data for rate of success
- Reported success of refractory cases
- Con – up to 10 sessions of general anesthesia, cost

33

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Hoof Care in the Field – Traumatic Injuries to the Hoof

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Abstract

Traumatic injury to the hoof capsule is commonly encountered in the field and can result in acute lameness. Ultimately, chronic lameness can transpire if the injury is not addressed. In general, timely evaluation, proper identification of involved structures, and prompt treatment of traumatic hoof injuries are essential to improving recovery and long-term outcome. Additionally, having a good working relationship with a farrier and setting realistic expectations with owners are key to successful management in podiatry related cases. Common traumatic injuries to the hoof will be discussed, as well as application of a foot cast.

Keywords

Hoof Care, Podiatry, Equine, Traumatic Injury, Penetrating Injury, Abscess, Heel Bulb Laceration, Quittor, Hoof Wall Crack, Avulsion, Fracture, Foot Cast

Penetrating Injuries to the Foot

A street nail is a sharp object such as a nail or screw that penetrates the bottom of the foot. Superficial penetrating injuries can seal quickly, and abscess formation can commence. Deep penetrating injuries can result in infection of the coffin bone, coffin joint, navicular bone, navicular bursa, deep digital flexor tendon, and digital flexor tendon sheath. Diagnosis is based on visual examination, radiography (+/- contrast), and synoviocentesis. Treatment is based largely on which structures are involved but in general includes debridement of the tract, synovial structure flushing, arthro-/burso-/tenoscopy, antibiotics (systemic vs regional limb perfusion (RLP)), non-steroidal anti-inflammatories (NSAIDs), tetanus toxoid, and rest. The prognosis good for penetrating injuries that do not have bone, tendon, or synovial involvement, however, prognosis is generally poor if a synovial structure is involved [1].

Abscess

Abscess formation can result from penetrating injuries to the foot by a foreign body (street nail, rocks, sticks, horseshoe nail, sole bruise, etc.). Penetration of the insensitive portions of the hoof allows bacterial infection of the underlying sensitive tissue which results in accumulation of pus. Pressure of the abscess within the hoof capsule can result in moderate to severe lameness, and sometimes non-weight bearing lameness. Other clinical signs associated with a foot abscess are

generalized distal limb swelling, bounding digital pulses in affected limb, and heat in the affected foot. Diagnosis is made based on history of acute lameness, presence of draining tract, hoof testers, local anesthetic nerve blocks, and radiographs. Treatment involves paring out the abscess, removal of undermined horn, daily soaking with warm diluted betadine and Epsom salts for approximately three days, keeping the foot bandaged (+/- poultice pad), NSAIDs, and finally shoeing the foot once the abscess is no longer draining. Subsolar abscesses carry a very good prognosis following a single episode. However, if deeper structures are involved and co-morbidities are present, the prognosis reduces [2].

Heel Bulb Laceration

Lacerations involving the heel bulbs are plagued by proximity to important structures, motion, infection, and repair dehiscence. Severity of the injury and lameness depends on the structures involved which can include the coronary band/hoof wall, collateral cartilages, coffin joint, navicular bursa, digital flexor tendon sheath, superficial and deep digital flexor tendons, palmar/plantar neurovascular bundle, as well as the ligaments distal to the fetlock. If significant hemorrhage occurs, a tourniquet and pressure bandage should be applied. Like other wounds, proximity to synovial structures should be evaluated and synoviocentesis may be necessary to determine involvement. Following aseptic preparation, primary closure of the wound should be performed if possible and application of a foot cast which can help minimize motion and promote wound healing. Additional treatments include systemic antibiotics (+/- RLP), NSAIDs, tetanus toxoid, and rest. It should be noted that lacerations involving the coronary band may result in permanent hoof wall defect. The prognosis for superficial laceration involving the heel bulbs and coronary band is good if primary closure is achieved and the foot is stabilized. The

prognosis may reduce with soft tissue and synovial structure involvement, as well as the presence of infection [3-5].

Quittor

Quittor is infection and necrosis of the collateral cartilages within the hoof capsule. This can occur via a laceration involving the collateral cartilages proximal to the coronary band or a penetrating injury from the sole. A characteristic, chronic draining tract/fistula forms above the coronary band in the quarters. Lameness may be apparent in the acute phase however the lameness may resolve as the lesion becomes chronic. Diagnosis is made based on history, presence of a characteristic fistula, and radiography (+/- contrast). Treatment of quittor is surgical debridement, trephination of hoof wall for ventral drainage, serial flushing, antibiotics (systemic vs RLP), and NSAIDs. The prognosis for conservative management alone is poor, however, surgical treatment carries a favorable prognosis [6].

Traumatic Hoof Wall Crack

Cracks can be superficial or deep and penetrate sensitive tissues. Cracks can result in instability or can be a result of instability of the hoof capsule. Diagnosis is based on visual examination and manipulation. Hoof testers and local anesthetic nerve blocks can be useful in determining pain associated with the crack. Treatment of the crack is based on the underlying cause. Most superficial cracks are non-painful and may not require further treatment other than routine hoof care. Depending on the level of instability and pain, deep or unstable crack may require debridement of affected tissues, stabilization of the crack if present, and supportive shoeing such

as a bar shoe with a pad. The prognosis for a traumatic crack and resolution of associated lameness is good with appropriate stabilization [7].

Hoof Wall Avulsion

Hoof wall avulsions can be partial or complete and are a result of acute trauma or chronic insult to the hoof wall that results in weakening and subsequent avulsion. Radiographs may be warranted in cases of traumatic hoof wall avulsion to evaluate underlying structures. Partial avulsion of the hoof wall involving superficial structures may only require removal of detached insensitive horn and supportive shoeing. However, avulsions of the hoof wall involving deep structures can become infected and require debridement, RLP, and supportive shoeing. Complete avulsion of the hoof capsule is uncommon that can result from trauma, laminitis, and systemic events (such as selenium toxicity, sepsis, endotoxemia, etc.). Trauma to adjacent structures should be evaluated. Treatment includes pain management, application of a heart bar shoe to the contralateral limb, daily wound cleaning/bandaging in the acute phase followed by long term application of a foot cast changed every two-four weeks. The prognosis for complete avulsion of the hoof capsule is guarded to grave for long-term soundness [8].

Fracture of the Distal Phalanx and Navicular Bone

The distal phalanx and navicular bone can be primarily fractured due to trauma. The distal phalanx can fracture secondary to concurrent disease such as pedal osteitis, laminitis, keratomas, etc. The treatment depends on the type of fracture observed but can include external coaptation (bar shoe and pad vs. foot cast), internal fixation, pain management, and rest. The prognosis for

fracture of the distal phalanx and navicular bone varies depending on articular involvement, fracture healing, development of osteoarthritis, and athletic goal for the horse [9-10].

Injury to the Collateral Ligaments of the Distal Interphalangeal Joint

Traumatic injury to the collateral ligaments of the distal interphalangeal joint (DIPJ) can occur in conjunction to other injuries to the hoof or be presented as occult challenging lameness conditions. While ultrasound can be helpful to diagnose tears in the origin of the DIPJ collateral ligaments, these ligaments lie primarily within the hoof capsule. Therefore, MRI remains the gold standard for diagnosis of these injuries. Injury to the collateral ligaments of the DIPJ carry a fair to good prognosis for return to work [11].

Application of a Foot Cast

Indications for application of a foot cast (phalangeal cast), considerations for differences between forelimb and hindlimb casting, complications of casting, and how to apply a foot cast will be discussed.

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