Diagnostic Approaches to Understanding Equine Limb Wounds

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KEYWORDS

• Early diagnosis • Visual examination • Manipulative examination
• Essential to understand all injured tissue

KEY POINTS

- Early diagnosis and treatment lead to best outcomes after wounding.
- Careful attention to all tissues involved in a wound can lead to best management decisions.
- Interpreting a wound from the deepest affected tissues out to the skin surface is important for a complete diagnosis.
- A complete physical examination is indicated for every wounded horse.
- Visual, palpation, and manipulative examinations help to determine the complete wound diagnosis.

Horses are prone to wounding and serious secondary repercussions, often owing to their innate inquisitiveness followed by rapid and aggressive flight from fright protective impulses. Unfortunately, horses' limbs do not have substantial protection with muscle or other tissue, which can often satisfactorily be repaired; and therefore, distal limb tissues under the skin are exposed to potential serious and long-lasting complications from wounding. The "1 wound–1 scar" concept described by Peacock[1] years ago still applies today, and especially so for horses. Tissues from the skin to the depths of a wound tend to heal as one, through the progressive stages of wound healing. Equine limbs, with a great capability of generating granulation tissue, can often have long-term function inhibited by this tendency to have 1 scar. This concern is long term for wounds on the flexor surface of the distal limb where scar tissue and fibrous adhesions can disrupt normal mechanical function of flexor tendons and the

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various ligamentous structures. As Dr Marvin Beeman has long described (Beeman MG. Personal communication, 2006), normal form is required for normal function. Thus, management of wounds of the equine distal limb often becomes a race against time and the tendencies toward 1 scar. Preserving normal limb function is a matter of preserving and returning wounded tissues to as close to normal form as possible.

Timely and accurate assessment of an equine limb wound is essential to achieve a satisfactory outcome for the horse and the owner. Delays and misinterpretations can result in the loss of normal tissue and normal limb function, as well as secondary complications like sepsis and fibrosis, which can broaden the influence of a local wound on total limb function. Avoiding long-term repercussions after an acute injury can often be achieved with an early understanding of what tissues are injured and to what extent the involved tissues are disrupted. The location of a wound and magnitude of skin and likely deeper tissue involvement, as well as what, if any, tissue has been lost are important early things to note. Consideration of likely complications from motion at a wound's anatomic location at the time of examination and through the needed time to achieve healing will also dictate management techniques (see Randy B. Eggleston's article, "Equine Wound Management: Bandages, Casts, and External Support," in this issue).

HISTORY

An accurate history can be a solid asset when evaluating a limb wound. Often an owner account of an injury incident does not fit well with the wound a veterinarian may be looking at in real time. This discrepancy is not usually an intent to mislead by the horse owner, but can simply be a lack of observation or a misunderstanding of what happened and when. Wounds that are acutely noticed may not necessarily have occurred in the recent past. A visual examination, followed by a thorough physical examination often can make this determination, but all accurate information regarding how a wound occurred, and when, is important to overall medical management (**Boxes 1–3**).

Noting the signalment of a wounded horse may not reveal anything specific to the nature and severity of a wound. However, age and potential age-related metabolic disorders may influence the management and progression of wound healing, and therefore a horse's age is worth understanding on initial examination.

Some historical action can be disruptive to a timely and accurate, complete wound diagnosis. Owners frequently feel compelled to do something, and often that something involves the topical application of a wound dressing in the form of ointments, powders, or solutions. Many of these available compounds are of various colors and most are of dubious indications. When possible, it seems to be wise to council an owner of a wounded horse to delay application of any topical substances until a

Box 1
Visual signs of an acute wound (day 1)

- Active hemorrhage
- Presence of "fresh" debris
- Laceration: sharp tissue margins
- Abrasion/tearing wound: tissues may have defined, yet frayed margins
- Acute pain from wounding

Box 2
Visual signs at days 2 to 3 after wounding

Serum or other fluid (ie, synovial fluid) presence replaces frank blood

Early exudate (purulent) is possible

Swelling

Lameness (indicates further examination of structural tissues)

veterinarian can complete a thorough physical and wound examination. It is very frustrating to try to remove a substance that may occlude visual examination, stain tissues, and potentially harm deep, wounded vital tissues. Likely nothing is superior to good hygiene practices with sterile solutions or clean water, especially as a prelude to veterinary examination (see Karl E. Frees' article, "Equine Practice on Wound Management: Wound Cleansing and Hygiene," in this issue). It is often good advice to a horse owner to cover a limb wound with a sterile, or even clean, bandage, as a triage maneuver to address the time between a phone call and when a veterinarian can evaluate the horse and the wound. This step can reduce the likelihood of further trauma and contamination before appropriate wound examination and care can take place.

COMPLETE PHYSICAL EXAMINATION AND PATIENT RESTRAINT

Examination of a wound should begin with an overall examination of the wounded horse. A thorough physical examination is indicated. Assessment of the horse is often accomplished quickly and appropriately for the situation at hand and should include systemic evaluation such that threats to overall health are not missed owing to specific attention to the wound itself. Assessment of vital signs and other systemic factors can lead to a more thorough understanding of a horse's current health status. Tachycardia, fever, mentation changes, and other systemic indicators may dictate the necessity of further investigation of wound influence beyond just local tissue disruption.

Noting the severity of lameness after wounding is usually intuitive on first visual observation of an affected horse. Horses with grades 4 to 5, out of 5, on the American Association of Equine Practitioners lameness scale should not be moved from where they are found until a complete veterinary examination has been completed. Horses with less severe lameness can be confounding at times, because acute wounding that involves synovial or other vital support tissues may not demonstrate lameness that is consistent with deeper tissue injury. Similarly, more chronic wounds into these tissues that establish drainage through the wound, will not be as lame as a horse with a closed septic compartment (see Elsa K. Ludwig and Philip D. van Harreveld's article, "Equine Wounds over Synovial Structures," in this issue). When evaluating lameness secondary to wounding, all possibilities must be evaluated and the most severe repercussions considered possible until proven otherwise.

Box 3
Clinical signs of day 3 or more after wounding

Granulation tissue may become evident (fibroblasts arrive in wound site on days 3–5)

Wound margin contraction may be present

Deep-seated sepsis may be present (ie, pain and lameness)

Appropriate restraint is needed to accomplish accurate diagnostic interpretations. Restraint can be as simple as having a competent handler on a lead line and halter, but frequently chemical restraint means are necessary. Individual veterinarians have personally preferred methods and drugs, and several factors are common when selecting what will be used for chemical restraint. Duration of time needed to complete the diagnostic and treatment tasks should be estimated when making drug choices. It is also important to avoid making the situation more complicated. Avoiding excessive ataxia from sedation is important for the horse, the handler, and the veterinarian. Careful sedative/tranquilizing drug use is essential. Most commonly, agents like xylazine and detomidine should be administered in doses below those described for preanesthesia on the labels. Xylazine (0.2–1.1 mg/kg administered intravenously [IV] or intramuscularly)[2] will typically restrain an adult horse in place but also produce some degree of mental stupor and ataxia. The same can be described for detomidine (0.005–0.02 mg/kg administered IV or intramuscularly).[2] Similar considerations should be made for the use of analgesic agents like butorphanol (0.05–0.1 mg/kg administered IV).[2] Also, it should be understood that butorphanol will potentiate the sedative and ataxia-inducing effects of xylazine and detomidine when administered in combination. Systemic influences of these sedative agents on vital signs (ie, reducing heart rate) should be kept in mind as data from a total examination are summarized and interpreted. Tranquilizing medications, like acepromazine, should be used with care and understanding of expected results, because restraint can be difficult to obtain when these drugs are administered to a wounded horse already agitated, and/or if negative cardiovascular effects of wounding are a concern.

Systemic administration of nonsteroidal antiinflammatory drugs does not often complicate wound examination; however, a complete physical examination will determine safety of using these drugs. Influences of nonsteroidal antiinflammatory drugs on wound healing are discussed in R. Reid Hanson's article, "Medical Therapy in Equine Wound Management," in this issue.

Regional and local anesthesia of wounded limbs should be performed with caution if any supportive tissues (ie, bone, ligament, tendon) are considered to be involved in the wound. Complete local anesthesia can remove the innate protective mechanisms of an injured horse, and potential decompensation of a wounded limb should be evaluated and avoided.

FIRST AID

Rendering first aid can postpone complete wound examination. Controlling voluminous hemorrhage, providing structural support, neurologic assessment, and life-saving systemic treatment should be prioritized over a complete understanding of wounded tissues. A complete physical examination and the initial wound examination can help to determine these appropriate delays in wound management. The realities of the situation may alter what would be ideal for wound examination and treatment scenarios. Timing to an accurate wound diagnosis can be critical to long-term success and return to function, but delays in this assessment may be necessary at times when systemic factors so dictate.

DIAGNOSTIC EXERCISES

As a guideline, it makes sense to consider a wound as having occurred "from the outside "in"" (ie, from the skin surface to the depth of the wound), and complete diagnostic understanding of a wound should be "from the inside out." In other words, a complete understanding of a wound should concentrate on knowing the deepest reach of tissue disruption and each individual tissue between there and the skin

surface (**Fig. 1**). This can be accomplished in a number of manners, from the simplest visual observations to the most intricate of manipulative and imaging modalities.

It is essential to have the most thorough understanding possible of the status of any vital tissues associated with a wound. Vital tissues in this regard are vascular, neurologic, and structural (bone, ligament, tendon, and synovial; see Elsa K. Ludwig and Philip D. van Harreveld's article, "Equine Wounds over Synovial Structures," and Randy B. Eggleston's article, "Wound Management: Wounds with Special Challenges," in this issue). Vascular tissue is most commonly a consideration when hemorrhage is notable, if not excessive. In this circumstance, first aid initiatives directed at hemorrhage control and systemic cardiovascular support are appropriate (ie, pressure bandaging; IV fluid therapy; see Randy B. Eggleston's article, "Equine Wound Management: Bandages, Casts, and External Support," in this issue). In the less common situation where circumferential wounding may affect limb vasculature and potential perfusion of the limb distal to a wound, it is important to recognize that a complete understanding of subsequent and future blood flow to the affected aspects of the limb may be delayed for up to 5 to 7 days. Therefore, in this circumstance delayed wound management may be prudent (see **Boxes 1–3**; see Louis

Fig. 1. Severe metatarsal region wound of an adult horse: determining what tissues are wounded is essential for appropriate management decisions. Consider tissues from the outside in. Tissues involved in this wound include skin, subcutaneous tissues, extensor tendon, periosteum, and superficial cortical bone. Potential "vital" tissue involvement includes the tarsometatarsal joint, metatarsophalangeal joint, and digital flexor tendon sheath.

Kamus and Christine Theoret's article, "Choosing the Best Approach to Wound Management and Closure," in this issue).

VISUAL EXAMINATION

Not all wounded tissues can be visualized in every equine limb wound. However, a good initial examination should evaluate wounded tissues as completely as possible without doing further harm to vital structures (see **Fig. 1**). Taking a close initial look and continuing the visual examination throughout the cleansing process (see Karl E. Frees' article, "Equine Practice on Wound Management: Wound Cleansing and Hygiene," in this issue) should not be ignored as a valuable tool. Useful information can be missed simply by not carefully looking at a wound. Once again, careful restraint is needed to closely visualize limb wounds.

The initial examination should also include consideration of the factors that have the potential to delay or interfere with wound healing. Contamination with foreign materials and innate tissues like hair can complicate evaluation and tissue management. The presence of soil contamination, which is common in equine wounds, can enhance the establishment of local sepsis. Typically, 10^6 microorganisms are required to cause bacterial infection. This inoculum can be reduced to 10^2 organisms in the presence of 5 mg of clay, the inorganic component of soil.[3] Early and appropriate cleansing and debridement can reduce potential healing delays. With chronicity, factors such as uncontrolled wound site movement and local sepsis can also delay and complicate healing. These factors should be considered on the initial examination.[4] Appropriate initial lavage can assist in removing contaminates, exudate, and other materials that complicate wound diagnostics. Guidance for lavage solution selection, volume, pressure, and other considerations are described in Karl E. Frees' article, "Equine Practice on Wound Management Wound: Cleansing and Hygiene," in this issue.

Investigating and noting the conformation of a wound is important to management decisions. This observation may be most pertinent to skin wounds, but the direction and extent of a wound should also be determined for deeper tissues. In skin, wound conformation can substantially influence vascularity, future blood flow and decisions on wound closure (see Louis Kamus and Christine Theoret's article, "Choosing the Best Approach to Wound Management and Closure," in this issue). For example, noting the conformation of a skin flap is very important. A skin flap with a proximally oriented broad base is much more amenable to successful closure with suture than the very common "inverted V" conformed flap. This inverted V is also often associated with tearing of skin versus sharp laceration, another consideration when regarding future vascular perfusion.

Puncture wounds can also present diagnostic challenges. Even discovering that a puncture through the skin has occurred can be difficult, as an obvious external wound may not be apparent. The presence of small volumes of blood, serum, or other fluid may be the only external sign over haired skin. Therefore, suspected puncture wound sites should have hair clipped such that the underlying skin can be investigated thoroughly. Manipulation, probing, and imaging may be required to gain a complete diagnosis of potential puncture wounds.

Another factor that should be noted is present and future motion of wounded tissues. The horse is an obligate weight bearer and will therefore typically use the wounded limb and place injured tissues in motion. The extent of limb motion at the time of initial wound management and throughout the time needed for healing should be carefully considered. Controlling motion can be a key to success in managing equine limb wounds and may require substantial external support. Appropriate use

of bandages and rigid support are discussed in Randy B. Eggleston's article, "Equine Wound Management: Bandages, Casts, and External Support," in this issue.

Tissue loss is often a result of many equine distal limb wounding episodes. This occurrence is common with wounds from fence materials like barbed wire. Acute tissue loss can be obvious and occasionally can be subtle, with varying volumes of skin loss being most common. It is important to observe and note any loss of skin and other tissues, because wound management decisions are greatly influenced by this determination. Some tissue loss is delayed owing to vascular influences on torn tissue (skin) margins and occasionally secondary to crushing injury, which involves the local vasculature. Management decisions may need to be delayed several days while wounded tissue viability is completely delineated (**Figs. 2** and **3**).

MANIPULATIVE EXAMINATION

When deemed safe to perform, a manual palpation examination is indicated in the early diagnostic efforts for most equine limb wounds. Exceptions to prioritizing palpation would be the early need to more completely evaluate structural tissues via imaging techniques. Palpation and manipulation can cause air accumulation under wounded skin margins and potentially complicate imaging interpretations. To avoid this, discretion may indicate taking radiographs or performing an ultrasound examination before wound and deep tissue palpation. This strategy is especially true for suspected bone, ligament, tendon, tendon sheath, and joint involvement in a wound. Wounds that potentially involve a synovial compartment (ie, joint, tendon sheath, bursa) should be very closely evaluated, because delays in addressing potential or existing synovial sepsis can negatively influence future soundness and even survival. This issue is addressed in greater detail in Elsa K. Ludwig and Philip D. van Harreveld's article, "Equine Wounds over Synovial Structures," in this issue.

After appropriate initial wound cleansing (see Karl E. Frees' article, "Equine Practice on Wound Management: Wound Cleansing and Hygiene," in this issue), manual palpation can be very helpful in the diagnostic understanding of what tissues are injured. Sterile

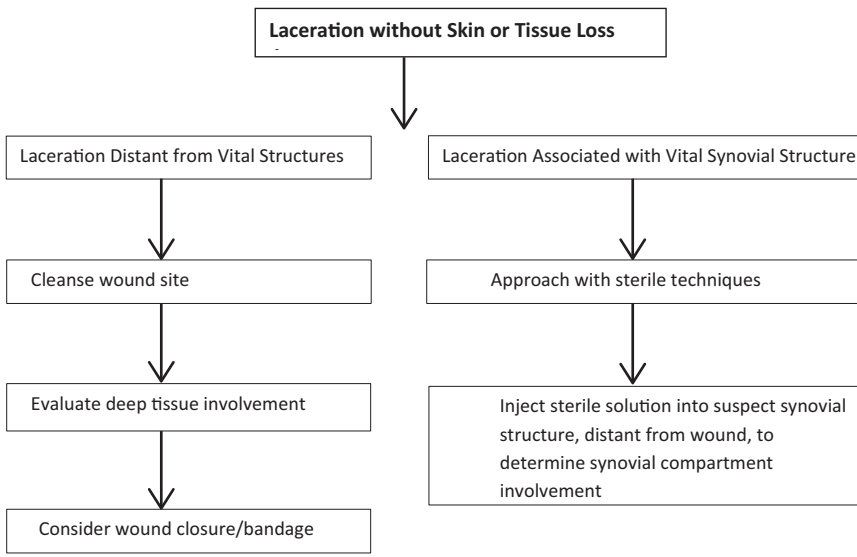

Fig. 2. Diagnostic and decision tree for equine wounds without skin or tissue loss.

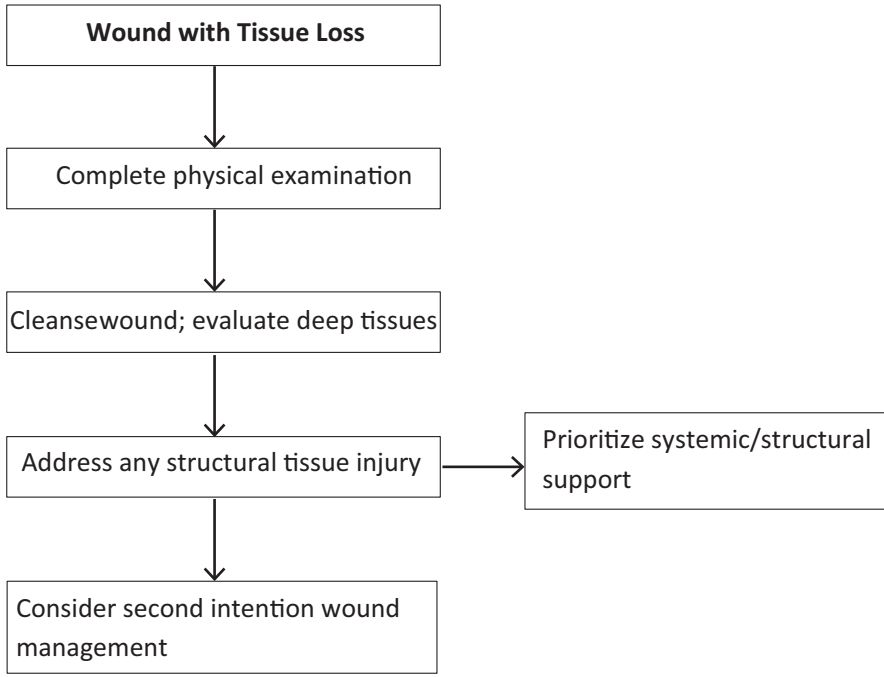

Fig. 3. Diagnostic and decision tree for equine wounds with skin or tissue loss.

gloves are recommended such that additional, inadvertent contamination is avoided. The tactile advantages of using fingers are hard to overemphasize. Careful tissue manipulation with fingers or with a sterile probe or forceps can reveal tissue disruption and also gauge the degree of deep contamination with foreign material. This examination can also occur while cleaning the wound site. As described in Karl E. Frees' article, "Equine Practice on Wound Management: Wound Cleansing and Hygiene," in this issue, it is important to avoid any additional harm to the wounded tissues. The selection of cleansing agents and techniques should be carefully determined.

Noting the cardinal signs of inflammation is important to gaining a complete understanding of a limb wound, as well as local and potential systemic repercussions. Heat, pain, and swelling are the most likely signs of inflammation to be present and the extent of these signs should be noted. Redness and capillary dilation are difficult to determine in dark pigmented and haired skin; however, these cardinal signs may be apparent in lightly colored, clipped regions. Lameness and/or reduction in normal weight bearing of an injured limb should also be noted and approached carefully in diagnostic efforts. Understanding the cardinal signs of inflammation in concert with other diagnostic results can enhance an understanding of the effects of a wound on a horse and limb.

RANGE OF MOTION EXAMINATION

Manipulation of an injured limb can also expose the depths of wound penetration. When the systemic physical examination and restraint indicate it is safe, a wounded limb can be picked up such that injured tissues can be observed through a passive range of motion exercise that can reveal more information than when a limb is in weight bearing. "Do no harm" should be the guiding principle.

EXAMINATION UNDER GENERAL ANESTHESIA

In some circumstances, a wound can be best evaluated with the affected horse under general anesthesia. This process can be safe if the horse is considered a stable candidate for anesthesia and the musculoskeletal and neurologic tissues are stable enough to support a safe and successful anesthetic recovery. If weight bearing support tissues are a concern, rigid external support may be required for safe anesthetic recovery (see Randy B. Eggleston's article, "Equine Wound Management: Bandages, Casts, and External Support," in this issue). Wound exploration and complete cleansing can be enhanced, and wound management more successfully initiated with a horse under general anesthesia. Removing a horse's avoidance responses and negative responses to painful stimuli allow more aggressive and thorough wound exploration. Although not often necessary, general anesthesia in the field with IV anesthetic drugs and/or in an operating room with IV or inhalant agents should be considered when safely possible.

DIAGNOSTIC INJECTION TECHNIQUES

Diagnostic injection techniques can be very helpful for complete wound assessment. This process is carefully reviewed in Elsa K. Ludwig and Philip D. van Harreveld's article, "Equine Wounds over Synovial Structures," in this issue in regard to potential synovial wounds. These techniques can also be helpful when synovial involvement is not suspected. The use of sterile, clear solutions (ie, saline, lactated Ringers) and vital stains, as well as the use of opaque, radiographic dyes (ie, iohexol) can assist diagnosis. With large surface wounds, wounds with widespread subcutaneous air presence, or with skin loss, these techniques are not very rewarding and perhaps should be avoided. The best return of diagnostic information is obtained when evaluating puncture wounds, wounds that may have foreign material in the deepest wounded tissue, or wounds that may enter a vital compartment (ie, synovial compartment; **Fig. 4**). A small exit portal, as seen with puncture wounds, likely allows the best information to be obtained. Survey radiographs are recommended before injection of any solution into a wound. This is due to the image altering capabilities of these liquid solutions, as well as accompanying air that is often injected with the chosen solution. Radiographic dyes and vital tissue stains can help to identify the depths a puncture wound may have reached, as well as outline the presence of foreign material. This finding can be helpful in acutely and chronically draining wounds with narrow or small exit wounds or fistulas. When a wound is considered to have potentially penetrated a synovial compartment, confirmation of suspected penetration can be determined with injection techniques. Injecting sterile, clear solutions into a suspected synovial compartment, distant from the wound, through intact, disinfected skin can make this diagnosis. It is important to maximally distend the compartment. If injected fluid egresses from the wound, joint, tendon sheath, or bursal penetration from the wound is confirmed. Distention of the synovial compartment without egress of the injected fluid strongly implies that the synovial compartment is intact and not wounded. In some unusual instances, suspect synovial compartments, having been assessed as intact, have become open and contaminated after tissue necrosis occurs 3 to 5 days after wounding. This secondary opening of a synovial space is likely due to latent vascular interruption to overlying tissues. Although not common, this phenomenon should be recognized as possible, especially with torn, potentially devitalized tissue associated with any suspect synovial compartment.

The use of these diagnostic injection techniques may need to be delayed or avoided if survey radiography indicates other management steps should take

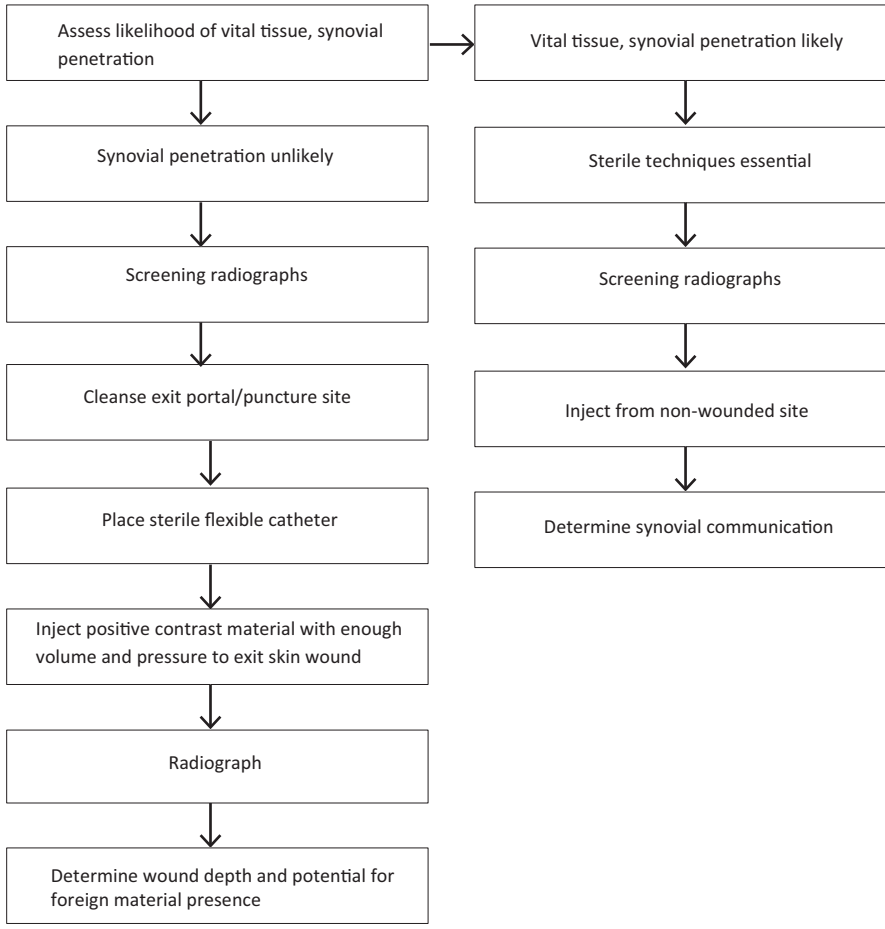

Fig. 4. Diagnostic and decision tree for equine puncture wounds.

priority. Radiographic evidence of bone injury, septic osteitis, and extensive dissection of air/gas warrant further investigation and probably prioritization of treatment protocols.

SUMMARY

A complete physical examination is indicated for any wounded horse. Systemic influences from a wound, like substantial hemorrhage, should be prioritized over wound management exercises to address any potential life threatening repercussions. However, most equine limb wounds are not life threatening and a direct wound evaluation can progress in a timely fashion. Visual, manipulative, and some invasive examination techniques should progress in a systematic manner such that all injured tissues are understood and treatment decisions can be made to maximize healing potential, decrease a horse's down time, and achieve the most satisfactory result possible.

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