Wound Management of the Equine Patient

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Introduction

Wounds are a common occurrence in equine medicine. Due to a horse's environment, their use and their natural instinct, horses are prone to sustaining wounds.[9] The goals of wound healing are to prevent infection, heal the wound and return the horse to normal function as soon as possible.[14] Knowledge of wound healing enables veterinarians to choose an appropriate treatment method, minimizing infection and promoting healing.

Pathophysiology

The wound healing process can be divided into four phases. The phases are the inflammatory phase, debridement phase, repair/proliferative phase and maturation phase. Knowledge of these phases can help determine the best treatment for each particular wound.

The inflammatory phase begins immediately and peaks in around three to five days. After 5-10 minutes, vasodilation occurs and facilitates the diapedesis of cells, fluid and proteins to the area and contributes to the signs of inflammation typically seen with a wound (redness, edema, heat and pain). [3] An increase in permeability allows for release of cells, fluid and proteins. [15] Cells that are injured release thromboplastin, which initiates the extrinsic pathway. Blood coagulation and platelet aggregation will form a clot, which seals off the defect and prevents further bleeding. When a debridement phase is included in the phases of wound healing, the inflammatory phase is considered complete when white blood cells enter the wound from the blood vessels.[3, 11, 14]

The debridement phase occurs around six to twelve hours after tissue injury. This phase begins after white blood cells migrate into the wound. The primary goal of the debridement phase is phagocytosis of debris and microorganisms. [11] Neutrophils enter the wound and phagocytize organisms and debris contaminating the wound. In addition to phagocytizing bacteria and other damaged tissues, macrophages are responsible for also secreting growth factors for tissue formation and remodeling. [3] They also recruit cells involved in fibroplasia, angiogenesis and epithelialization. [15] Macrophages play such an important role in wound healing that with out them, the wound may not heal as quickly or properly. [3, 11, 14]

The repair/proliferative phase occurs three to twelve days after a wound is initiated. This phase is characterized by the appearance of granulation tissue, which eventually fills the defect created by the wound. This phase is composed of three distinct processes, each involving a prominent cell type. The processes and cells are fibroplasia (fibroblasts), angiogenesis (endothelial cells), and epithelialization (epithelial cells).

During fibroplasia, fibroblast proliferation is stimulated by macrophages, cytokines and the oxygen content and acidity of the wound.[11] Fibroblasts migrate along fibrin strands in the fibrin clot and create elastin, collagen and proteoglycans. They are initially arranged haphazardly, however, around day five of healing, the tension on the wound forces them to orient parallel to the wound edges.

During angiogenesis, capillaries enter the wound and grow from existing vasculature. New capillaries are needed to sustain the granulation tissue. [14] The new capillaries, fibroblasts, fibrous tissue and the extracellular matrix form granulation tissue. This tissue is usually present around five days after the injury. The granulation tissue is resistant to infection, plays a role in wound contraction and provides a surface for epithelial migration, and is thus, essential to wound healing. [3, 11, 15]

During epithelialization, epithelial cells migrate out from the edge of the wound to cover it. In a full thickness wound, commonly seen in equine medicine, epithelial cells proliferate at the wound edge only. In a partial thickness wound, the proliferation can occur from the remaining underlying epithelium. This is why partial thickness wounds heal at a faster rate than full thickness wounds. Once the epithelial cells come in contact with one another, the migration ceases because of contact inhibition. [15] The rate at which epithelialization occurs varies depending on the wound region and size. Trunk wounds epithelialize at 0.2mm/day and distal limb wounds epithelialize at 0.09mm/day. [11] Once the wound is covered, the cells proliferate and differentiate to form a new basement membrane. This phase is considered complete when the epidermis covers the granulation bed. [3, 11, 14]

The maturation phase, sometimes referred to as the remodeling phase, occurs around seven days to several months after wound initiation. During this phase, the newly formed collagen is strengthened and the wound contracts, which accelerates closure. The fibers will become thicker and align with the tension lines of the body.[11] Wound contraction is greater in areas of the body with loose skin, such as the trunk of the body at a rate of 0.8-1.0mm/day.[15] Areas of skin under tension, such as the distal limbs in a horse, have less wound contraction at a rate of 0.2mm/day. [11, 15] The greatest increase in wound strength occurs in the first seven days of this phase. Occurring at the same time as contraction, the extracellular matrix is being remodeled. This phase results in a scar that will be around 75- 80% of the tissue's original strength. [3, 14, 11] Remodeling of this scar can continue for up to two years and becomes more organized and less vascular. [5]

There are many factors that affect the rate and quality of wound healing. One of the biggest factors that affect wound healing is the location of the wound. Wounds occurring on the head, neck and body tend to heal better than wounds on the distal limbs.[2]The distal limbs have less skin available for closure. Also, there is decreased vascularity, increased infection, inflammatory response and reduce regional temperature in the distal limbs that negatively affect wound healing.[2] Wounds in area of high mobility, such as joints, are also prone to chronic inflammation because of the high motion in the area disrupting healing.[10] Other factors that need to be considered would be the age of the patient, and wound, nutritional status of the patient, the type of wound and the degree of contamination present.[2]

Wound Classification

There are four classifications of wounds: clean wounds, clean contaminated wounds, contaminated wounds and infected wounds. A clean wound is usually found in a surgical situation. The wound does not pass through any infected or nonviable tissue.[10]It is not infected nor does it involve the respiratory, alimentary or urogenital tract. A clean contaminated wound is also in a surgical situation, but does involve one of those tracts. Contaminated wounds are usually caused by trauma and have contamination and necrotic tissue. Finally, infected wounds are ones that involve large numbers of bacteria, inflammation, and edema.[2]In equine medicine, the majority of wounds are contaminated or infected. The classification of the wound is considered when determining a treatment plan.

Initial Wound Management

Directly after a wound occurs, placing a clean, dry bandage over the wound can help prevent further contamination and reduce hemorrhage.[7]Before the wound is evaluated, an initial triage of the major body organ systems should be performed. The respiratory, cardiovascular and central nervous systems must be evaluated. [1] Once the patient is determined to be stable, an assessment of the wound itself can be performed. Sedation may be required to examine the wound. Xylazine or Detomidine usually provides sufficient sedation for exploration of the wound.[17] Local anesthesia may also be utilized such as a regional block, perineural block or intralesional infiltration with 2% lidocaine.[14] If the wound is dirty, initially spray the wound with a hose. The hair around the wound should be shaved for better evaluation. To prevent hair and debris from going into the wound, sterile lube may be placed over the wound. Then, the wound can be cleaned with a mild soap or dilute chlorhexidine and rinsed with saline or another isotonic fluid.[5]The wound should be first explored digitally. Any foreign material or tracts need to be identified.[2]All structures involved in the wound need to be identified. This can be done through palpation, ultrasound or radiographs.

Once the wound is explored, any deterrents to healing need to be removed. These include excessive bacterial populations, necrotic tissue, and foreign material. These factors prolong the debridement phase and delay the proliferation and repair phases of healing. [1]

The most important factor in delayed wound healing is presence of an infection. [17] There are two main ways two determine if the wound is infected. The first is from the clinical appearance of the wound. Inflammation, discolored granulation tissue, odor, and draining tracts are all signs of infection. [2] The second way is to culture the wound. Every wound contains some amount of bacteria, however, if there are more than 10^5 bacteria per gram of tissue then the wound is considered infected. [2] The most common ways to reduce the amount of bacteria in a wound is through lavage and debridement.

The main goal of wound lavage is to remove any loose foreign material and necrotic tissue from the wound. At the same time, dilution of any bacteria present is achieved. These factors decrease the risk of infection and remove barriers to wound healing.[1] Lavaging the wound early and using large amounts of fluid aids in a successful lavage. The lavage ought to be administered as a controlled jet over the wound.[1] A pressure of 8-12psi is used at a 45-degree angle to the wound.[1] This pressure is sufficient to dislodge debris and loose tissue, and overcome adhesive forces of bacteria. At the same time, this pressure is typically not high enough to drive debris and bacteria deeper into the wound and open up previously uncontaminated tissue. To achieve this amount of pressure, a 20-30ml syringe with a 19G needle can be used.[1]

The fluid used to lavage a wound needs to be nontoxic to tissues, not cause a sensitivity reaction, reduce the number of microorganisms and be cost effective and widely available. For this reason, Lactate Ringer Solution (LRS) is most commonly used. Chlorhexidine may be added to the solution at a low concentration. At low concentrations, chlorhexidine may enhance epithelial growth, however, if the concentration is too high it may cause a reduction in proliferation.[1] Addition of antibiotics is not recommended because it may cause a sensitivity reaction and promote resistance.[1]

Debridement reduces the bacterial load and minimizes necrotic tissue in a wound. [2] There are several types of debridement, such as surgical, mechanical, autolytic and biosurgical. Surgical and autolytic debridement is most often utilized in equine medicine. In many cases, multiple types of debridement are utilized in one wound.

Surgical debridement is one of the least traumatic methods of debridement where devitalized tissue is cut from the wound using a sharp scalpel.[1, 2] Scissors should not be used because they tend to crush the tissue as they cut.[2] The goal of surgical debridement is to remove devitalized tissue while preserving blood supply to the healthy tissue.[1]There are multiple ways to differentiate vital from non-vital tissues. Two criteria to look at is the color of the tissue and assessment of its attachment. If tissue is poorly attached, white, tan, black or green it should be removed. Tissue that is well attached and pink to dark purple is considered viable and should be left. Another method is to cut the devitalized tissue until it bleeds. Bleeding tissue is thought to be vital. However, air on the side of caution when using this method because different factors such as, vasoconstriction, temperature, and coagulation defects can affect the degree of bleeding of the vital tissues.

There are three types of surgical debridement; en bloc, layered debridement, and staged debridement. In en block debridement, the most effective method of surgical debridement, the entire wound is removed including a border of healthy tissue around the wound. This method is used in areas where there is adequate tissue to allow for closure afterwards. This would be in areas such as the trunk and proximal limbs.[1] In layered debridement, devitalized tissue is removed gradually in layers. This is used in areas where there is not adequate skin to allow for en bloc, such as the lower limbs and feet.[1] Layered debridement also helps prevent contamination of deeper tissues with debris from the more superficial layers.[17] In staged debridement, devitalized tissue is removed over the course of multiple days to avoid accidently removing viable tissue.[17]

If multiple surgical debridements are necessary, often times a dressing is placed in between surgical debridements. Dressings are a type of mechanical debridement. The dressings are intended to physically lift and remove necrotic and foreign material from the wound.[1] A common dressing used in mechanical debridement is a wet-to-dry dressing. With this method, sterile gauze is wetted with sterile saline and placed over the wound bed. A standard secondary and tertiary bandage layer is placed over the wet gauze. The moisture from the gauze dilutes exudates in the wound, which are then absorbed by the secondary layer. The wet gauze then dries and adheres to the wound surface. This dressing should be changed daily. Since the gauze is adhered to the wound, removal is often painful and may require sedation.[1] Debridement using adherent dressings is contraindicated when a wound is in the proliferative phase, because the bandage can damage new cellular populations.[17]During the proliferative and remodeling phases, a non-adherent dressing should be used.[9] A nonadherent dressing has an absorptive layer that facilitates draining of exudate and a petrolatum layer that allows for easy dressing changes without disrupting the new epithelium.[9]

In autolytic debridement, debridement occurs through the activation of phagocytes and the release of a patients own proteolytic enzymes, such as collagenase and elastase.[1] These enzymes breakdown necrotic tissue in the wound normally, however, they can be enhanced by adding products to the wound that keep the wound moist.[1] This moist environment promotes the activity of leukocytes, as well as promotes the swelling of necrotic tissue which will loosen it from the wound bed.[1] Products that keep a moist environment are hydrogels and honey. In addition to promoting autolytic debridement, honey also has an antimicrobial effect. It is thought to have this effect by osmotically dehydrating bacteria and by having a low pH.[1]

Bio-surgical debridement involves the use of medical grade maggots. Not all fly species can be used for biosurgical debridement. Only flies that feed primarily on necrotized tissues and not affect healthy tissues are used. The best and most commonly used species of fly is *Lucilia sericata*, the green bottle fly. The immature larvae aggressively feed on dead and infected tissue.[8] Indications for using maggot therapy would be necrotic, infected or non-healing wounds. Maggots remove necrotic tissue, disinfect the wound and promote granulation tissue formation.[6] Maggots function by secreting proteolytic enzymes, such as leucine aminopeptidase, collagenase and chymotrypsin-like proteases.[8] These enzymes convert the dead tissue into a liquid form that can drain away from the wound or be consumed further by the maggots.[8] The maggots disinfect the wound through the removal of dead tissues and by secreting substances with bactericidal activity. Maggots also secrete ammonia into the wound, which causes a rise in the wound pH. This alkaline environment also impedes bacterial development.[8]When using maggot therapy, 5-10 larvae per cm^2 of wound should be placed inside the wound. Once the maggots are in place, the wound should be covered with a breathable material such as nylon stockings.[8]This allows for oxygen to reach the maggots and for drainage of the wound. **[13]** Maggots should be left in place for approximately 48-72 hours.[13] One single maggot can consume up to 75mg of necrotic tissue per day.[7] Also, due to maggot’s small initial size, they are able to access and efficiently debride deep infections and sinus tracts.[13] Studies have shown that maggot therapy yields almost complete debridement, decrease in wound size, increase in granulation tissue are and decrease in wound odor and pain.[8] Maggot therapy is especially useful in cases where there is resistance to antibacterial agents.

If a horse has a deep wound, it is at a higher risk of developing tetanus. If a horse is thought to be at risk, at tetanus vaccine should be administered and the horse should receive prophylactic penicillin therapy.[17]

Wound Closure

After the wound has been thoroughly debrided, closure may be considered. The golden period to close a wound with primary closure is 4-12 hours. [17] The most important factor in deciding whether or not to close a wound is the degree of contamination and amount of necrotic tissue present.[1] There are four main categories of closure: primary closure, delayed primary closure, delayed secondary closure and secondary intention. When deciding which method to use to close a wound, several factors need to be considered.

In order for a wound to undergo primary closure, and thus first intention healing, the wound must be less than 6-12 hours old.[16] The wound should have minimal tissue loss, bacterial contamination and tension on the wound edges.[2] If the wound meets these criteria, it should be debrided and then closed using a suture pattern that minimizes tension, such as near-far-far-near, vertical mattress or horizontal mattress. [5] If excess bacteria are present in a wound, it greatly increases the chance of dehiscence.[2] Sutures are removed around 10-14 days after placement. This will be after the granulation phase is complete and the wound is beginning to contract.[2]

If a wound has mild to moderate tissue damage or contamination, delayed primary closure should be considered. In delayed primary closure, the wound is debrided and managed openly to decrease the contamination and bacteria present in the wound.[1]The wound is usually closed around 2-5 days after the wound occurred, after the threat of infection has been controlled but before fibroplasia has occurred.[17]

In a wound with severe tissue damage and heavy contamination, delayed secondary closure should be utilized.[1]The wound should be debrided, managed and closed only once granulation tissue has formed. This usually will be over 5 days after the wound occurred.[1]

If a wound has a large amount of skin loss where closure is not possible or if the wound is severely contaminated or infected, the wound is allowed to heal by second intention.[2, 17] Second intention healing includes fibroplasia followed by contraction and epithelialization.[17]

Bandages

After a wound has been closed, and especially in wounds that are allowed to heal by second intention, a padded bandage needs to be placed for protection and prevention of further contamination and trauma.[9] If a bandage is placed properly, it can help prevent further contamination, restrict trauma and reduce swelling.[5] There are typically three layers to a bandage. The primary layer is a padded material, such as a cotton roll. The main purpose of this layer is to absorb damaging agents such as blood, exudate and bacteria.[9]It also protects the wound against trauma and excessive motion.[9]The secondary layer is a compressive layer, usually brown gauze is utilized for this layer. The purpose of the third layer is to hold the second layer in place, as well as to prevent further contamination and minimize swelling of the limb.[9] This layer should be waterproof and elastic, therefore, vetrap is commonly used. After the bandage is placed, the top and bottom of the bandage should be taped to keep the bandage in place and debris out.[5] Bandages should be changed every three to five days, or sooner if bandage becomes torn, wet, or if there is strike through.[5]

Conclusion

In conclusion, there are many factors involved in determining the best treatment for each individual wound. Knowledge of wound healing will help determine the wound phase and customize treatment. Utilizing different methods to decrease contamination and choosing the appropriate closure can alter the outcome of the wound. It is important to remember that every wound is different and treatment should be tailored to each individual wound to receive the best results.

References

1. Aldridge, Paul. "Management Of Traumatic Wounds: Promoting Wound Healing." *Companion Animal* 20.6 (2015): 352-359. *Academic Search Complete*. Web. 3 June 2016.
2. Auer, Jörg A., and John A. Stick. *Equine Surgery*. St. Louis, MO: Saunders Elsevier, 2012. 47-323. Print.
3. Balsa, Ingrid M., and William T.n. Culp. "Wound Care." *Veterinary Clinics of North America: Small Animal Practice* 45.5 (2015): 1049-065. Web. 16 Apr. 2016.
4. Brumbaugh, Gordon W. "Use of Antimicrobials in Wound Management." *Veterinary Clinics of North America: Equine Practice* 21.1 (2005): 63-75. Web. 16 Apr. 2016.
5. Caston, Stephanie S. "Wound Care in Horses." *Veterinary Clinics of North America: Equine Practice* 28.1 (2012): 83-100. Web. 16 Apr. 2016.
6. Dart, Andrew J., Brad A. Dowling, and Christine L. Smith. "Topical Treatments in Equine Wound Management." *Veterinary Clinics of North America: Equine Practice* 21.1 (2005): 77-89. Web. 16 Apr. 2016.
7. Davidson, Jacqueline R. "Current Concepts in Wound Management and Wound Healing Products." *Veterinary Clinics of North America: Small Animal Practice* 45.3 (2015): 537-64. Web. 16 Apr. 2016.
8. Davydov, L. "Maggot Therapy in Wound Management in Modern Era and a Review of Published Literature." *Journal of Pharmacy Practice* 24.1 (2010): 89-93. Web. 16 Apr. 2016.
9. Gomez, Jorge H., and R. Reid Hanson. "Use of Dressings and Bandages in Equine Wound Management." *Veterinary Clinics of North America: Equine Practice* 21.1 (2005): 91-104. Web. 16 Apr. 2016.
10. Hendrickson, Dean, and Joanna Virgin. "Factors That Affect Equine Wound Repair." *Veterinary Clinics of North America: Equine Practice* 21.1 (2005): 33-44. Web. 16 Apr. 2016.
11. Mochal-King, Cathleen. “Approaches to Wound Management” 19 November 2014. PowerPoint presentation.
12. Polat, Erdal, Ilayda Aksöz, Hülya Arkan, Ender Coşkunpınar, Fahri Akbaş, and Ilhan Onaran. "Gene Expression Profiling of Lucilia Sericata Larvae Extraction/secretion-treated Skin Wounds." *Gene* 550.2 (2014): 223-29. Web. 16 Apr. 2016.
13. Sherman, Ronald A., Scott Morrison, and David Ng. "Maggot Debridement Therapy for Serious Horse Wounds – A Survey of Practitioners." *The Veterinary Journal* 174.1 (2007): 86-91. Web. 16 Apr. 2016.
14. Stashak, Ted S., and Christine L. Theoret. *Equine Wound Management*. N.p.: Blackwell Pub, 2008. 20-189. Print.
15. Theoret, Christine L. "The Pathophysiology of Wound Repair." *Veterinary Clinics of North America: Equine Practice* 21.1 (2005): 1-13. Web. 16 Apr. 2016.
16. Vowden, Kathryn, and Peter Vowden. "Wound Dressings: Principles and Practice." *Surgery (Oxford)* 32.9 (2014): 462-67. Web. 16 Apr. 2016.
17. Wilson, David A. "Principles of Early Wound Management." *Veterinary Clinics of North America: Equine Practice* 21.1 (2005): 45-62. Web. 16 Apr. 2016.