Wound Debridement Techniques

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1. Introduction

Devitalized tissue, because it has no blood supply, has no chance of becoming viable. Accidental wounds of horses commonly contain devitalized tissue, biofilm colonized with multiple species of microorganisms, exudate, and foreign debris. Devitalized tissue delays healing by providing a focus for infection and by exacerbating the inflammatory response. Removing non-viable tissue or foreign material through debridement reduces bacterial populations on the surface of the wound, which enhances healing. However, for healing to proceed rapidly, as much viable tissue as possible must be preserved. The wound should be debrided when it is first examined, but debridement may need to be repeated throughout healing to address ongoing necrosis and infection. Although dirt and loose debris may be rinsed away by using copious sterile irrigation, wound debridement is often used in combination with irrigation to adequately prepare the wound for optimal healing. Various techniques of debridement available in clinical practice include autolytic, mechanical, enzymatic, surgical, biological, and negative pressure wound therapy. The method chosen depends on various factors, such as the type, size, location, and age of the wound; the extent of tissue damage and contamination; patient tolerance; economics; expertise of the caretaker; and available equipment. More than one type of debridement is often required to optimally prepare a wound for healing. The following subsections discuss the more common techniques of debridement available to the equine practitioner with an aim to provide an overview of the indications, cautions, and contraindications of each technique (Table 1).

Autolytic Debridement

Debridement occurs naturally within wounds by autolysis, a process whereby devitalized tissue is softened or liquefied by enzymes, which are released by macrophages, mast cells, endothelial cells, keratinocytes, and fibroblasts. Autolytic debridement is slow, selective (i.e., only devitalized tissue is liquefied), and virtually painless. This method uses the body’s own enzymes and moisture beneath a dressing, and nonviable tissue becomes liquefied. Dressing types commonly used are hydrocolloids, hydrogels, and transparent films (semioclusive and occlusive).

Mechanical Debridement

Mechanical debridement by debridement dressings include adherent open mesh gauze, antimicrobial gauze dressing, hypertonic saline gauze dressing, calcium alginate dressings, and occlusive dressings. Adherent open mesh gauze may be applied to the wound, either dry to an exudative wound or wetted (generally with sterile saline solution) to a dry wound. A clean bandage covers this dressing. The dressing clings to the wound's surface as it dries, so that when it is removed, tissue adhered to the gauze is also removed. Open mesh gauze mechanical debridement is nonselective because both healthy and unhealthy tissue are removed indiscriminately. Gauze dressings may disrupt angiogenesis, fibroplasia, and
epithelialization and, therefore, should be used exclusively for debridement and never beyond the inflammatory phase of healing. An in vitro study comparing the effectiveness of various dressings for debriding fibrin and blood clots in wounds of horses found that dressings hydrated with saline were better debriding devices than those hydrated with water because of their greater osmolarity. Gauze and hydrofiber dressings hydrated with saline were significantly (47%) more effective in breaking down protein (primarily fibrin) than were dressings impregnated with collagenase or papain-urea or hydrogel dressing. In that study, saline dressings reached a plateau in their rate of protein breakdown within 24 hours. Although this study did not consider the in vivo cellular effect on debridement, it did suggest that gauze, hydrofiber, and alginate dressings wetted with saline would be most effective in debriding wounds with a proteinaceous coagulum or those that have formed scabs. An Antimicrobial gauze dressing is an excellent dressing for treating heavily contaminated wounds because it is impregnated with polymyxamethylen biguanide, a powerful yet safe antiseptic that has a broad range effectiveness that has been shown to kill bacteria on the surface of the wound and decrease the amount of exudate formation. Hypertonic saline gauze dressing is ideal for treatment of necrotic, heavily infected exuding wounds. Calcium alginate dressings exert their bioactivity by stimulating macrophages within a chronic wound. In addition to providing a moist environment that is conducive to cell growth and migration, these dressings generate a proinflammatory signal that promotes fibroplasia via a cascade of mediators released from activated macrophages. Occlusive dressings are used for sealing particular types of wounds and their surrounding tissue off from air, fluids, and harmful contaminants. Occlusive dressings promote moist wound healing and “autolytic cellular debridement” and are best used on clean wounds primarily free of exudate.

Enzymatic Debridement

Enzymatic debridement uses an ointment or gel with enzymes that soften unhealthy tissue. The enzymes may come from an animal, plant, or bacteria. The papain-urea combination ointment may be more effective at degrading fibrin within the wound bed. Collagenase ointment derived from Clostridium histolyticum may be more effective at degrading collagen and elastin. Proteolytic enzymes dissolve collagenous tissue and cause superficial debris and devitalized tissue to slough. Collagenase or papain-urea-based agents may be used to speed the process of autolytic debridement in areas where surgical debridement is not possible or carries risk, such as in wounds that closely approximate nerves and/or blood vessels. Factors that optimize enzymatic debridement include a good delivery system that facilitates contact between the enzyme and the area requiring debridement, a sustained period of enzymatic activity, and an optimal wound environment. Frequently, proteolytic enzymes are applied along with other topical agents to address several objectives, including balancing moisture, managing exudate, controlling the measure of microbial contamination, and enhancing tissue regeneration. Enzymatic debridement may be inhibited when combined with other wound dressings. For example, iodine dressings and silver dressings have been shown to inhibit the activity of collagenase, resulting in inefficient debride-ment. Because proteolytic enzymes cannot penetrate thick, hard, fibrinous eschar, they are more effective when the necrotic tissue is soft. A study in horses evaluated the debriding ability of enzymatic formulations. That study, using an in vitro model to simulate a dry, fibrinous chronic wound eschar, showed that traditional gauze dressings, hydrated with isotonic saline solution or various forms of hydrofiber, hydrocolloid, or alginate dressing (fluid-donating dressings), were more effective at removing fibrin and blood clots than were enzymatic formulations (collagenase, papain-urea, and streptokinase-streptodornase). Enzymatic wound debridement has limitations when treating accidental wounds of equids, which are often heavily contaminated and include a large amount of necrotic tissue; therefore, other forms of debridement may be preferred.
Surgical Debridement

Surgical debridement includes the use of sharp, hydrosurgical and low-frequency ultrasound-assisted debridement. Sharp surgical debridement using a scalpel is the optimal method for rapidly cleansing wounds containing a large amount of devitalized tissue and microbial contamination of the tissues. This method of debridement is very selective because the surgeon has complete control over which tissue to remove and tissue to remain. The intent of debridement is to create a well-vascularized wound to support second intention healing or skin grafting. The ability to correctly identify tissue types and anatomic structures is required to avoid inflicting further injury during surgical debridement. Aseptic technique prevents iatrogenic contamination. Repeat surgical debridement may be necessary or, alternatively, may be followed by another form of debridement, such as dressing-enhanced autolytic debridement. Various methods of surgical debridement include excisional, en bloc, piecemeal, and staged debridement. Excisional debridement may be layered, which involves sequential removal of devitalized tissue, progressing from the wound’s surface to the wound’s depths, or en bloc, which entails excising the entire wound including its margin, so that all wounded and contaminated tissues are removed. En bloc debridement is often used for wounds with draining tracts. Piecemeal debridement is used for very large wounds, usually those of the trunk. Progressing from the beginning of the wound margin to the end, all devitalized tissue is removed a little at a time while preserving important anatomic structures. Staged debridement occurs over a number of days to avoid inadvertent removal of viable tissue. This approach is appropriate for most wounds on the distal aspect of the limb, where unwarranted removal of healthy tissue could have debilitating results. When surgical debridement is performed, the two governing criteria are color and attachment. White, tan, black, and green tissues, as well as those that are poorly attached, should be de-brided. Tissues that are pink to dark purple and that are well attached should be spared. Devitalized, nonarticular bone should be removed, whereas well-perfused bone with hardly soft-tissue attachments should be left. Fragments of bone with questionable viability or bone that has lost its periosteum should be aggressively debrided to reduce the risk of sequestration and to improve blood supply to the bone sur-face. Debridement of cortical bone is best accomplished with a bone rasp; however, a curette, bone chisel, or osteotomy can be used. Hydrosurgical debridement involves the use of pressurized water or saline solution as a cutting/cleansing tool to rapidly and selectively debride a wound. A commercial hydrosurgical device \(^1\) generates a high-pressure (≤15 000 psi) jet of fluid (sterile saline solution) that emerges through a 0.127-mm orifice of the handpiece. Emergence of fluid from the outlet produces suction (Venturi effect) that draws devitalized tissue into a cutting chamber where it is shredded and evacuated. Hydrosurgery can often be performed with the horse standing, but sedation and/or regional anesthesia may be required for restraint. Hydrosurgical debridement is reported to be well tolerated because it is less painful than sharp debridement. \(^10\) If hydrosurgery is used to debride a fresh wound that is to be sutured, some form of local anesthesia is necessary; conversely, local anesthesia is not usually required if hydrosurgical debridement is used to debride a wound covered by granulation tissue that has been left unsutured to heal by second intention. A recent ex vivo study comparing the efficacy of different methods of debridement in reducing the load of *Staphylococcus aureus* from contaminated equine muscle showed that hydrosurgical debridement using the hydrosurgical device \(^7\) was more effective than irrigation with an isotonic saline solution, scraping with a scalpel blade, or a combination of irrigation and scraping. \(^10\) Low-frequency, ultrasound-assisted debridement \(^6\) uses low-frequency ultrasonic waves (20-60 Hz), emitted in contact or noncontact mode, produced by streaming saline solution through tubing into a sonotrode head. \(^11,12\) Microcavitation, resulting from oscillation of saline gas bubbles, cleaves necrotic tissue from healthy tissue, thereby debriding the wound and disrupting the biofilm; the necrotic tissue is suctioned or washed away. \(^11\) Healthy, more elastic tissue is preserved and stimulated to epithelialize. \(^12,13\) Because the recommended time of treatment is 20 to 30 sec/cm\(^2\) of surface area, ultrasound-assisted debridement is likely less applicable to debride large wounds commonly found in horses. \(^13\)

Biological Debridement

Biological debridement involves the use of maggots, *Lucilia sericata* (green bottle fly), that are grown in a sterile environment and digest dead tissue and pathogens. Biological debridement is recommended for use in horses to enhance healing of subacute and chronic, nonhealing wounds when complete surgical debridement is difficult and to enhance healing of obviously infected wounds. \(^14\) The sterile maggots are applied to the wound bed with a dressing used to "confine" the maggots to the wound. The beneficial action of maggots on wound healing is attributed to producing potent proteolytic enzymes, upregulating expression of genes involved in wound healing, creating an antiseptic effect, and inhibiting formation of biofilm. \(^15–18\) During the process of dissolving fibrin and necrotic tissue, maggots also destroy and digest bacteria, and the excretions/secretions of *L. sericata* possess significant antifungal properties. \(^19\) In relation to the rising incidence of antibiotic resistance, the excretions/secretions of the blowfly *L. sericata*, exhibit potent, thermally stable, protease-resistant antibacterial activity against methicillin-resistant *Staphylococcus aureus* in vitro. \(^20\) Sterile maggots can be applied to a wound by using a direct (free-range) or indirect (contained) contact method. With the direct contact method, maggots are applied...
onto the wound with a dressing fixed to the surrounding healthy tissue. After the maggots are placed on the wound, a nylon mesh is fixed to the dressing to confine the maggots within the wound. In the indirect contact method, maggots are supplied within a closed polyester net filled with absorbent hydrophilic polyurethane foam and applied with the wound.21,22 Biological debridement using the direct contact method is superior in the horse.23 The direct method of applying maggots is also less expensive than the indirect method. In horses, biological debridement therapy is described as an alternative approach to the management of septicnavicular bursitis, lamellar necrosis associated with complicated laminitis, and subsolar infection-associated osteomyelitis of the distal phalanx.22,24 Biological debridement therapy has also contributed toward the successful healing of chronic nonhealing limb lacerations, orthopedic infections free of bony sequestra, various soft-tissue abscesses, supraspinous bursitis, and dehiscence of the linea alba following exploratory celiotomy.25 In a retrospective study of 41 horses treated with biological debridement, a favorable response was noted less than 1 week after initiation of therapy.25 Lesions of the horses enrolled in this study were subacute or chronic and had been managed in diverse ways prior to receiving biological debridement. A preliminary surgical debridement usually precedes biological debridement, although this may not be necessary in the absence of foreign bodies and/or nonorganic matter in the wound. In some cases, after 3 to 4 days of biological debridement, a second treatment is required to reach the desired degree of debridement, disinfection, and fibroplasia (i.e., healthy granulation tissue filling the wound). Orthopedic shoeing, stent bandaging, and nonocclusive sleeve bandaging, typical to biological debridement, are adapted for each type of wound and anatomic location.20,26 For biological debridement to work effectively, free drainage of exudate is necessary and the maggot must have an adequate supply of oxygen.

Negative-Pressure Wound Therapy

Negative-pressure wound therapy (NPWT) is a method for controlling wound infection and enhancing wound healing. Indications for the use of NPWT in veterinary medicine include traumatic wounds (avulsions, degloving, and shear injuries), full-thickness burns, dehiscence of surgical incisions, myofascial compartment syndrome, and chronic nonhealing wounds.27–29 NPWT is also excellent for enhancing acceptance of free grafts, and it can be used effectively over sutured incisions to splint closures under tension, prevent formation of a seroma, particularly in closed incisional wounds with underlying dead space, and minimize edema.29–32 NPWT stimulates the rapid formation of granulation tissue, reduces the size of the wound, and effectively removes fluid from the wound.33,34 The early appearance of granulation tissue is remarkably consistent with the use of NPWT and correlates with observed increases in fibroblast activity and angiogenesis.33,35 Although NPWT

should not replace the basic tenets of wound management, such as cleansing, debridement, irrigation, and treatment for infection, its use for debridement of an infected wound is likely to stimulate fibroplasia and increase resistance to infection early in the postwounding period.36 Other identified and validated mechanisms of NPWT include the removal of interstitial fluid; thereby reducing edema; altered blood flow to the wound; and upregulated gene expression of cytokines associated with wound healing.37–40 NPWT involves sealing the wound from the environment and delivering a controlled subatmospheric pressure, typically not exceeding −125 mmHg, to the entire wound. Fluid produced by the wound is collected into a disposable reservoir canister attached to the pump. The open-cell nature of the foam and the cell size of 400 to 600 μm ensure an even distribution of negative pressure to the entire surface of the wound. NPWT may be particularly useful in the treatment of wounds of horses allowed to heal by second intention. NPWT prevents retraction of the wound margins, decreases the size of the wound, reduces wound edema, and stimulates early onset of fibroplasia. Granulation tissue forms earlier in wounded tissue treated by NPWT and is smoother, nonexuberant, and has well-organized collagen fibers, as demonstrated histologically.11 This makes wounds treated with NPWT less likely to develop “proud flesh” and more amenable to early reconstructive procedures, such as skin grafting. Furthermore, NPWT increases the likelihood of acceptance of a free skin graft by immobilizing grafts at the wound.30,42

2. Conclusion

To promote healing, reduce risks of infection, and improve patient outcomes, an array of debridement methods can be included in the patient’s wound management plan of care. The use of more than one debridement method will provide consistency in wound bed preparation toward healing.

Acknowledgments

Declaration of Ethics

The Author has adhered to the Principles of Veterinary Medical Ethics of the AVMA.

Conflict of Interest

The Author has written wound care book chapters and has no conflict of interest with any manufacturers.

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