ONLY A FLESH WOUND: CARE FOR COMPLEX WOUNDS

Kelly M. Foltz, AAT, CVT, LVT, RVT, VTS (ECC)

BluePearl, Tampa FL USA

The reported percentage of pet ER visits due to trauma varies considerably, with estimates ranging from 12-13% of total visits. Trauma is further classified as blunt, penetrating, polytrauma, soft tissue, or orthopedic; presentations run the gamut from crushing injury, high rise syndrome, motor vehicle trauma, fractures, gunshot wounds, contusions, lacerations, bite wounds, and impalements or stabbing--all of which may cause wounds. Trauma is not always necessary for a wound to be present. Keeping this in mind, common ER "wound" presentations include vehicular trauma, bite wounds, abrasions, burns (thermal or chemical), incisional dehiscence or infection, and impalement/penetrating FB injuries. While decubitus ulcers and diabetic wounds are less commonly seen, they may also be complex. There is a vast body of research devoted to human wound management; in contrast, there are fewer evidence-based resources for veterinary professionals (although the body of literature is growing) and many wound management techniques are adapted from human medicine. Small animal patients present unique challenges for the management of complex wounds due to their size, conformation, normal behaviors (grooming in cats, for example), potential for site contamination (from the environment, urine or fecal soiling, or the patient's oral biome), and financial resources of the client.

First aid for emergent wounds is paramount. Due to the potential for contamination and zoonosis, personnel should always wear gloves when examining wounds and other PPE (gown, mask or face shield, etc.). Primary and secondary surveys of the patient should be performed to identify potentially life-threatening injuries to major body systems; if deficiencies of the cardiovascular, pulmonary, or neurologic systems are noted, interventions should be made before wound evaluation and care occurs. This might require treatment for shock to restore perfusion, oxygen supplementation, thoraco- or abdominocentesis, blood transfusion, or stabilization of increased intracranial pressure. Reliable vascular access is essential for the administration of fluids, analgesics, antibiotics, and sedatives or injectable anesthetics that may be required for comprehensive wound care, exploration, and/or bandaging. Early administration of analgesia may make handling and initial interventions easier and more comfortable for the patient. Active hemorrhage can be controlled with direct pressure, either administered by hand or with a pressure wrap. If bleeding cannot be controlled with pressure, vessels may require ligation or a topical hemostatic compound may be used. Tourniquets or a blood pressure cuff inflated to 200 mm Hg can be placed with dwell time not to exceed 1 hour and must be checked and removed lest significant iatrogenic injury occur. Open wounds should be kept clean and moist, especially if the patient is to be moved around the hospital (to imaging, from ward to ward, etc.) before comprehensive wound care can occur. This is best accomplished with a sterile water-based lubricant copiously applied to the site or saline-soaked sterile gauze/laparotomy pads applied to the site and covered with a soft padded bandage. Penetrating chest wounds represent considerable risk to the patient due to disruption of negative pressure within the thoracic cavity and should be covered ASAP with a glove, patch of plastic wrap, or occlusive adhesive dressing before the chest is bound with a circumferential padded bandage. It is imperative that penetrating chest wounds be sealed to restore negative pressure within the thoracic cavity before respiratory compromise leads to arrest. Once the patient has been stabilized and wounds covered, laboratory testing, imaging, and other evaluations should proceed.

Principles of optimal wound management are based on appropriate classification of the wound, the normal phases of healing, and the optimal intervention techniques for each type of wound. There are four wound classifications based on how contaminated the wound is: clean, clean contaminated, contaminated, or dirty (also referred to as "infected" in some references). "Clean" wounds are atraumatic and are created purposefully, using sterile instruments, under surgical/aseptic conditions (for example, the incision made for an exploratory laparotomy). "Clean contaminated" wounds are those that are created under surgical conditions and involve intentional incision and manipulation of organs that contain contamination where the contamination is easily resolved or controlled (for example, enterotomy or cystotomy). "Contaminated" wounds comprise the majority of wounds seen in the veterinary ER: those caused by trauma that have likely bacterial contamination (for example, a bite wound or impalement) or surgical wounds with major breaks in aseptic technique (ie, ruptured pyometra). The most contaminated wounds are classified as "dirty" or "infected;" these are generally wounds with extensive infection and/or tissue that is obviously devitalized, necrotic, visibly soiled, or populated by larvae (ie, abscess, penetrating thoracic wound with necrotic lung, myiasis, etc.). By classification, "dirty" wounds contain more than 10^5 bacterial organisms per gram of tissue although this is rarely evaluated or confirmed at the time of care. Open fractures are also considered wounds and are classified as Grade I, II, or III by the extent of soft tissue damage and etiology of the fracture. Grade I open fractures have a small opening in the skin caused by bone penetration; Grade II fractures have an opening in the skin with surrounding soft tissue trauma in conjunction with the fracture, and Grade III fractures have an open site with extensive soft tissue trauma in conjunction with a high degree of bone comminution (fragmentation).

The normal wound healing process is comprised of four phases: inflammation, debridement, repair or proliferation, and maturation. Each phase is accompanied by specific physiologic responses designed to bridge to the next phase, although the phases may overlap and are not always obvious to an observer. The phases occur regardless of the etiology and classification of the wound. Phase one, inflammation, begins when the wound is sustained and lasts for up to five days afterward. As soon as the skin is breached and vessels are transected, bleeding begins that brings red blood cells, platelets, and white blood cells to the site of injury. Platelet aggregation, blood coagulation, and clot formation are instigated by blood vessel endothelial damage. Soon after, vasoconstriction follows to minimize bleeding and permit inflammatory mediators such as complement, histamine, growth factor, leukotrienes, and prostaglandins to be delivered to the site by plasma. WBCs are present, in part, to mitigate bacterial and other antigen colonization of the site. Vasoconstriction is followed in 5-10 minutes by vasodilation that encourages further clot and ultimate scab formation. Clot(s) serve as a framework for endothelial cells, fibroblasts, and WBCs to do their repair work. Debridement (phase 2) occurs simultaneously with inflammation. WBCs infiltrate the wound site and perform phagocytosis coupled with enzyme release to remove extracellular debris from the site on the following "schedule": neutrophils arrive approximately six hours after injury, monocytes approximately twelve hours after injury, and by 24-48 hours later the monocytes have become macrophages that are able to remove bacteria, dead tissue, and other foreign material via a variety of means. The proliferative phase (phase 3) begins three to five days after the initial injury and persists for two to four weeks. Proliferation/repair involves angiogenesis (growth of a new blood supply for the site), granulation tissue formation, and epithelialization (skin replacement). The fibroblasts that arrived earlier produce collagen which in turn facilitates the advancement of new capillaries into the site. Capillary repair is essential for the formation of granulation tissue that allows further epithelialization to occur. New skin will be present within 4-5 days after injury with contracture noted by days 5-9. The final phase, maturation, begins approximately 16-20 days after the initial injury and may last for years. During maturation, the site contracts and remodels. The final product, a scar, will only be 80% as strong as the original tissue.

The ultimate goals of wound management in small animal clinical practice are to optimize the body's innate wound healing processes by creating and maintaining healthy granulation tissue, adequate moisture, and eliminating infection. Some wounds are more straightforward than others; complex wounds may require days, weeks, or even months of management coupled with staged surgical procedures before they are fully healed. Wounds that did not receive appropriate early care or cleaning, that involve multiple layers of soft tissue, or that are located over high motion or bony sites such as the elbow or antebrachium may require long-term specialist management. When managing a wound patient in the clinic, the site should be evaluated at a minimum once daily to check for signs of infection and/or necrosis, monitor response to topical dressings and antibiotic therapy, perform cleaning and debridement, and replace bandages. Ultimately, many wounds require surgical closure, but this should not be attempted until it has been ascertained that the site is free of infection and underlying tissues are healthy. In the interim, there are a variety of bandaging techniques, topical dressings, and treatment modalities that enhance healing and are commonly used in small animal medicine. Appropriate multi-modal analgesia and antibiotic therapy are not optional. In support of evolving concerns around antimicrobial resistance, antimicrobial choice should be driven by culture and susceptibility results whenever possible. Following current guidelines, empirical antimicrobial choices should be made based on the drug's ability to penetrate the affected tissue, its spectrum of action, and microbial species most likely to be found in the wound. Empirical management should be converted to targeted therapy if possible, particularly if healing is prolonged.

Initial cleaning of a wound begins with protecting the wound from further contamination during evaluation. Sterile, water-based lubricant is introduced into the wound in copious quantity before the surrounding fur is clipped in a wide margin. If the wound is on an extremity, the clip should be circumferential to enable evaluation of all surfaces. If the wound is large and extensively contaminated with organic matter (grass, dirt, gravel, or other debris) following the initial lubrication and clip, it can be lavaged with tap water until gross contamination is resolved. Smaller wounds can be lavaged using sterile saline or lactated ringer's solution, either from a bottle with multiple holes punched in the lid with a large-bore hypodermic needle for ease of use or using a saline bag hooked up to a three-way stopcock and 18g IV catheter. LRS is an appropriate choice since some research indicates that both tap water and normal saline can be toxic to fibroblasts. A sterile two-inch or longer IV catheter with the stylet removed is ideal for cleaning deeper wounds since it is largely atraumatic (unlike a needle) and can be inserted further into the site. It has often been said that "dilution is the solution to pollution," so generous lavage is preferable to a conservative approach. Chlorhexidine scrub or povidone-iodine scrub can be used to clean the surrounding intact skin but should *never* be used on disrupted skin, exposed mucosa, or damaged tissues due to their tissue toxic properties. Well-diluted povidone-iodine is preferred for facial lacerations near the eye(s) or periorbital wounds.

Following lavage, the wound is explored and debrided if necessary. It is important for the person performing exploration and debridement to use aseptic technique; this includes wearing sterile gloves, gown, cap, and mask and draping the site with sterile drapes. Sterile instruments should also be used for wound exploration, bandage changes, and wound closure. A sterile instrument is used to probe deeper wounds and gauge dead space that may surround a seemingly small entry defect. Unidentified and unaddressed dead space predisposes the patient to abscesses or seromas (pockets of serum). Following wound exploration, any necrotic tissue should be removed either as en bloc debridement (removing the old wound by making a new, clean, larger wound) or by layered debridement (excision of one layer of tissue at a time), unless an alternative method of debridement is required (such as mechanical debridement, using adherent dressings to remove devitalized tissue with each bandage change or larval debridement, using sterile lab-grown medical maggots to consume necrotic tissue). Following lavage, exploration, and debridement, simple wounds are closed. Most complex wounds are not closed when sustained but are maintained for a period sufficient for the tissue to “declare itself” or devitalized tissue to become apparent. During this time, the site is protected and checked daily for signs of widening necrosis; further debridement is performed until the site appears healthy enough to close.

Wound closure is classified by the time frame in which closure occurs. The type of closure selected depends on the size of the wound, its severity, the site, type of debridement employed, and degree of contamination. There are four types of wound closure: primary or first intention, delayed primary closure/third intention/tertiary, secondary closure, and second intention healing. Primary closure is used for wounds that are sutured closed within hours after the trauma occurs. Delayed primary closure occurs 3-5 days after the initial injury but prior to the development of granulation tissue develops; it is recommended for mild-moderately contaminated wounds that may benefit from additional lavage and debridement before closure. Secondary closure is used after granulation tissue has developed (ie, after the 3-5 day window for delayed primary closure); it is recommended for contaminated/dirty wounds. Second intention healing provides no surgical closure but relies on the body to produce a new granulation bed and go through all stages of wound healing to regrow skin; it is the most protracted type of wound closure and requires long-term support. Wounds situated in awkward areas, those that are extensive, or degloving wounds on the extremities may need to heal by second intention.

Topical treatments can be effective in the management of complex wounds, particularly those that require time for an adequate granulation bed to form. They are also advantageous for supplementing and maintaining the moisture necessary for healing. Products readily available to the small animal practitioner include alginates, honey, hydrogels, hydrocolloids, and sugar. Alginates (also known as calcium alginates) have hydrophilic (“water-loving” or attracting) properties that enhance granulation tissue formation. Hydrocolloid dressings are occlusive dressings designed to reduce contamination, stimulate collagen development, and retain fluid in the tissues; however, they may encourage exuberant granulation and allow bacteria already in the wound to proliferate. Hydrogels are manufactured as gels or as gel-impregnated sheets that are placed over a wound. They are designed to retain fluid in a wound, enhance granulation, and encourage contracture; their use may result in smaller scars. Honey and sugar have been used in human and veterinary wound management for centuries, are easy to find, and inexpensive. Both have antibacterial properties, reduce wound edema, accelerate soughing of necrotic tissue, attract macrophages, provide nutrition for cells, and provide a mild debridement effect. They are ideal for dirty and contaminated wounds. Table sugar is more practical for deep wounds since it can be poured in, and honey may be more useful for large wounds since it can be spread on. Care should be taken to prevent contamination of the sugar or honey container. Manuka honey has been documented to have specific advantages over other honeys. Both sugar and honey have an osmotic effect on wounds and should be avoided in visibly dry/desiccated wounds, since their use will further dry surrounding tissues. Bandages placed over topical sugar or honey require close monitoring and frequent changes since both will induce increased wound exudate. Sugar and honey should be used until healthy granulation tissue is seen, at which point their use can be discontinued.

Until a wound can be closed, it must be protected from the environment, particularly if topicals are used. A simple padded bandage with or without a splint is appropriate for most wounds and open fractures depending on location; if the wound is large, exudative, mechanical debridement is used, or it is on a part of the body where a conventional padded bandage cannot be used (stifle, inguinal or axillary fold, etc.), an alternative bandaging method is selected. Options include combinations of wet to dry, tie-over, and/or polyurethane film bandages. Wet-to-dry bandages use sterile gauze or laparotomy pads soaked in sterile saline to pack the wound; these are then covered with a padded or adhesive bandage and are often used as part of a tie-over bandaging technique. Wound exudate is wicked from the site into the padding, which becomes less moist over time. When the padding is removed, dead tissue is also removed; however, healthy tissue can also be damaged when a wet-to-dry bandage is changed and these bandage changes can be uncomfortable for patients so appropriate analgesia or anesthesia should be used. Tie-over bandages are ideal for deep, large wounds. In a tie-over bandage, stay sutures are placed around the periphery of the wound before the site is packed with sugar or absorbent material. Additional sterile material (usually laparotomy pads) is placed over the packing before umbilical tape is laced over the top through the stay sutures. If desired, a portion of drape or a huck towel can be placed between the packing and the ties for additional protection and the entire bandage covered with an adhesive film or sheet dressing such as Ioban™, Tegaderm™, or Hypafix™. When the bandage is changed, the ties are removed, the packing taken out, the wound checked, debrided, and lavaged if needed, and the packing and ties are replaced. The stay sutures enable the bandage to be changed with less discomfort for the patient and mild skin stretching can performed over time, making eventual closure easier. A tie-over bandage can be maintained for several days while a wound declares itself and granulation tissue is developing. Film bandages provide a cost-effective barrier between wounds and the environment. In addition to their utility over flat areas such as the abdomen or lateral thorax, they can be used over high motion areas, such as joints. Padding and film combinations such as Tegaderm™ + Pad, Primapore™, and Kliniderm™ may be appropriate for smaller wounds.

If a wound is deep, exudative, or contains a large amount of dead space, a drain is desirable. Drains are classified as active or passive. The most common active drain used in small animal medicine is the Jackson-Pratt or suction grenade. A Jackson-Pratt drain is a ported bulb (resembling a hand grenade, hence the name "grenade drain") attached to a long segment of tubing that terminates in a heavily fenestrated, soft, hollow paddle. The fenestrated end is surgically placed into the wound's dead space using aseptic technique before the wound is closed. The bulb is "charged" by opening the port and squeezing out as much air as possible before re-sealing the port. The gentle negative pressure created by the bulb extracts fluid from the wound and encourages contracture of the dead space. Over time as the bulb fills, the negative pressure becomes exhausted, and the grenade must be emptied at intervals via syringe to re-charge the drain. Fluid production can be quantified and cytologic examination performed if needed, although cytology results should be evaluated with caution due to the dwell time and potential contamination of fluid. The drain is removed when fluid production tapers off. In contrast, the most common exemplar of passive drainage is the Penrose drain, a segment of soft hollow tubing that is placed into a wound's dead space. Fluid travels down the drain and exits the wound via gravity flow. Penrose drains may predispose the patient to bacterial infection more than active drains, although both have the potential to introduce environmental contamination into the wound. If used without a bandage to cover them, Penrose drains can be messy and are at risk of patient removal. Drain sites should be monitored closely and always handled with gloves and aseptic technique.

New wound management techniques are constantly emerging in veterinary medicine. Of particular interest within the past decade are vacuum-assisted closure (VAC) or negative pressure wound management, hyperbaric oxygen therapy (HBOT), and photobiomodulation or laser therapy. VAC uses a portable, low power suction unit attached to tubing that is surgically placed into a wound to stimulate granulation tissue formation and removal of contaminated exudate. VAC also aids in contracture and closure of dead space. It is a good choice for contaminated, large, and open wounds, decubitus ulcerations, degloving wounds, and surgical dehiscence of the abdomen ("open abdomen"). It is not a good choice for patients with coagulopathy, neoplastic wounds, or wounds with exposed vasculature. VAC only works when a totally airtight seal can be achieved and maintained around the entire perimeter of the wound; changing the dressings on a VAC patient requires sterile supplies and general anesthesia. HBOT involves putting the patient in a specialized chamber that delivers pressurized oxygen at 100% (room air is 21% oxygen at sea level); the increased pressure gradient increases the amount of oxygen dissolved in plasma, which can then be moved to tissues. It is believed that HBOT increases angiogenesis, aids in fibroblast proliferation, and may assist WBCs in the oxidative destruction of bacteria. Most of the information available on HBOT is extrapolated from the extensive study performed in human patients with burns and non-healing wounds. HBOT is not widely available but is becoming more accessible. Photobiomodulation uses micro doses of red and near-infrared light to penetrate tissues; exposure to the light increases cellular ATP production and may decrease inflammation and aid healing. There is evidence to support use of photobiomodulation but many variations in the available technology exist. VAC, HBOT, and photobiomodulation should not be attempted without training, certification (in the case of HBT and laser therapy), and access to the proper equipment.

Wound management presents many opportunities for veterinary technicians to use their skills. In addition to the practical matters of first aid, clipping/cleaning, and bandage placement and maintenance, technicians can also use their knowledge of anesthesia and analgesia to support these patients and positively affect their outcomes. Technicians also have the option to pursue additional training and certification in HBOT and photobiomodulation. Although they require patience and vigilance, complex wound cases are rewarding to treat.

References

Bohling MW, Henderson RA, Swaim SF et al. Cutaneous wound healing in the cat: a macroscopic description and comparison with cutaneous wound healing in the dog. Veterinary Surgery. 2004;33:579–587.

Bohling MW, Henderson RA, Swaim SF et al. Comparison of the role of the subcutaneous tissues in cutaneous wound healing in the dog and cat. Veterinary Surgery. 2006;35:3–14.
Brashear M. Emergency wound care. The Veterinary Nurse. 2017;8(7):358-362.
Curtis A, Sherwood A. How to manage bite wounds in veterinary practice. The Veterinary Nurse. 2018; 9(2): 110-116.
Curtis A. Biofilms and their significance in veterinary wound management. The Veterinary Nurse. 2020;11(2):75-81.
Fahie MA, Shettko D. Evidence-based wound management: a systematic review of therapeutic agents to enhance granulation and epithelialization. Vet Clin Small Anim. 2007;37:559-577.
Garzotto CK. Wound Management. In: Silverstein DC, Hopper K editors. Small Animal Critical Care Medicine. 2nd ed. St. Louis: Elsevier; 2015, pp.734-743.
Hochman L. Photobiomodulation therapy in veterinary medicine: a review. Topics in Companion Anim Med. 2018;33:83-88.
Van Hengel T, ter Haar G, Kirpensteijn J. Wound management: a new protocol for dogs and cats. In: Kirpensteijn J, ter Haar G editors. 1st ed. Reconstructive Surgery and Wound Management of the Dog and Cat. Boca Raton: Taylor & Francis; 2013, pp. 21-48.
Rivituso NL. Integumentary and Musculoskeletal Emergencies. In: Norkus CL, editor. Veterinary Technician's Manual for Small Animal Emergency and Critical Care. 2nd ed. Ames: John Wiley & Sons; 2019, pp.239-255.
Vine K. Stress and anxiety implications on long-term patients — nursing considerations. The Veterinary Nurse. 2020;10(10):516-519.
Volk SW, Bohling MW. Comparative wound healing—are the small animal veterinarian's clinical patients an improved translational model for human wound healing research? Wound Rep Reg. 2013;21: 372–381.