HEAL THY PATIENT
Aid the healing process by following these wound care and management techniques.

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WOUND MANAGEMENT

Basic Principles of Wound Care

MEET THE AUTHOR

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In veterinary medicine, wounds are common. Although they can be challenging, they can also be rewarding when managed properly by the veterinary team. The goal is to return the injured tissue to normal function; however, because not every wound is the same, treatment pathways and products used vary. Understanding the general principles of wound care and the techniques for managing them enables veterinary nurses to play an integral role in the care and treatment of wounds. This article covers wound classification, stages of healing, treatment, and pain management.

WOUND CLASSIFICATION

Wounds can be classified according to their degree of contamination and the length of time between injury and treatment of the wound. Although time can be used as a guideline, it should not be the ultimate factor for determining the level of contamination.[1]

- **Clean** wounds are made surgically, under aseptic conditions.
- **Clean-contaminated** wounds are created when a nonsterile organ (e.g., respiratory or genitourinary tract) is entered with little or no spillage of contents or when a minor breach in aseptic technique occurs when treating a clean wound. A wound less than 6 hours old is generally considered in this category.[1]
- **Contaminated** wounds result from spillage of organ contents into the incision, a major breach in aseptic technique, or presence of foreign debris. A wound

GLOSSARY

Angiogenesis Creation of new blood vessels

Apoptosis Death of cells

Cytotoxicity Toxicity of cells

Debridement Removal of necrotic tissue or debris

Exudate Fluid from blood vessels that leaks out into nearby tissues

Free graft A graft transplanted without its nourishing blood supply

Huck towel A lint-free, cotton towel named after its weave pattern

Lavage To wash or flush a body part with water or medicated solution

Occlusive Prevents air from reaching or fluid from leaving the tissue

Splash block Direct application of a local anesthetic to a site

Strike-through Wound exudate that has penetrated through the outer layer of a bandage

greater than 6 hours old is generally considered in this category.[1]

- **Dirty** wounds are those that are old or infected with >10^5 organisms per gram of tissue.[1,2] A wound greater than 12 hours old is generally considered in this category.[1]

STAGES OF WOUND HEALING

In addition to wound classification, the phase of wound healing should be determined. Wound healing occurs in 3 phases, each of which overlaps in terms of duration. Several phases may take place simultaneously within the wound.

Phase 1: Inflammation and Debridement

This phase begins at the time of injury and lasts 3 to 5 days. Blood vessels constrict, controlling hemorrhage. Thrombin forms, platelets aggregate, blood coagulates, and a clot is formed, providing hemostasis.[3] Blood vessels then dilate, increasing blood flow and bringing transudates into the wound, causing the heat, redness, and swelling of inflammation. White blood cells in the exudate initiate debridement.[4] Neutrophils help break down bacteria and debris while stimulating monocytes. Monocytes convert to macrophages, which continue to phagocytize debris and release growth factors that aid in tissue repair.[3]

Phase 2: Proliferation/Repair

This phase occurs 3 to 5 days after injury. Angiogenesis begins as capillaries grow into the wound from the surrounding healthy vasculature. Growth factors allow for migration of fibroblasts, which leads to creation of collagen (which provides wound strength) and myofibroblasts (which cause wound contraction).[3] Granulation tissue begins to form, followed by epithelialization and wound contraction.

Phase 3: Maturation/Remodeling

This phase occurs 7 to 14 days after injury, during which time wound strength increases at the fastest rate.[4] Cells undergo apoptosis. Over subsequent months to years, collagen matures and forms a scar,[3] the tensile strength of which will be only 70% to 80% that of uninjured healthy tissue.[5]

TYPES OF WOUND CLOSURE

Wounds can close in several ways, all of which depend on the wound classification and the stage of its healing.

- **Primary Closure (healing by first intention):** This is the immediate closure of a wound after injury. This process can be used to close clean or clean-contaminated wounds.
- **Delayed Primary Closure:** This type of closure occurs 2 to 5 days after injury, before granulation tissue is formed. This process can be used to close clean-contaminated or contaminated wounds.
- **Secondary Closure:** This type of closure occurs at least 5 days after injury and after healthy granulation tissue has formed. This process can be used to close contaminated or dirty wounds.
- **Healing by Second Intention:** This type of closure occurs when a wound heals on its own by forming granulation tissue, epithelializing, and contracting. Second intention healing is not selected for areas such as a limb on which the wound involves two-thirds or more of the limb because of the risk that wound contraction will cause decreased mobility and/or a tourniquet effect.

Techniques for Enhancing Wound Closure

The following can be used to aid in wound closure:

- **Skin grafts** involve removing skin from one location of the body and suturing it over the wound. Its survival depends on having an ideal (well-vascularized) recipient bed and rapid re-establishment of circulation.
- **Skin flaps** involve detaching an area of healthy skin adjacent to the wound, elevating it on all but one side, and then rotating and suturing it onto the wound. Often more cosmetic than grafts, skin flaps are more resistant to infection because the blood supply is maintained, which also helps improve circulation to the recipient bed.[2]
- **Skin advancement** uses the viscoelastic properties of the skin to distribute tension (e.g., releasing incisions, undermining, walking sutures, or skin stretchers). Skin advancement can be used when there may otherwise be too much tension on the suture line.

TREATMENT OF WOUNDS

The objectives for treating wounds are many, including but not limited to preventing wound infection by removal of foreign matter, debridement of necrotic tissue, and maintenance of a clean wound bed; adequately removing exudate; maintaining a moist wound environment to promote healing; and protecting the wound until it is able to endure normal activity. The goal is to minimize pain while helping the body's process of wound healing so the tissue can return to normal function as quickly as possible.

Numerous factors can negatively affect wound healing and therefore should be considered when managing wounds. These factors include but are not limited to chemotherapy, diabetes mellitus, geriatric age, hematoma, hyperadrenocorticism, hypotension, hypothermia, malnutrition, necrotic tissue, radiation therapy, seroma, skin disease, and patient species (e.g., wounds can be slower to heal in cats than in dogs).[2,3]

Initial Treatment

The first step is determining if the patient is clinically stable and able to tolerate sedation or anesthesia for wound treatment. Temporarily, the wound can be covered with a sterile huck towel until it can be evaluated. After the patient has been sedated or anesthetized, the wound should be covered either directly with sterile lubricating jelly or with gauze saturated in sterile lubricating jelly or sterile saline. This covering prevents further debris from entering the wound while the area is being prepared. The hair around the wound should be clipped generously to enable evaluation of surrounding tissue for further damage and to provide an area for the bandage to adhere. The surrounding tissue should be cleaned aseptically, taking caution not to get hair or antiseptic fluids into the wound, potentially causing further tissue damage from cytotoxicity. If saturated gauze was used, it can be removed and the wound can be flushed to remove contaminants. Various irrigation solutions can be used for flushing; most commonly used are lactated Ringer's solution and 0.9% sodium chloride. Warm fluids provide more comfort for the patient. A fluid pressure of 7 to 8 psi is desirable because it provides enough pressure to remove debris but not so much as to damage the tissue or further seed bacteria into the wound.[6] The most reliable way to achieve the desired pressure is to use a 1-L bag of fluids attached to a

TABLE 1 Wound Debridement Methods

METHOD	ACTION
SELECTIVE DEBRIDEMENT	
Autolytic	Uses primary layer applications such as acemannan, alginates, hydrocolloids, hydrogels, honey, or sugar
Biotherapy	Uses medical maggots or leeches
Chemical/Enzymatic	Causes degradation of nonviable proteins within the wound via proteolytic enzymes[a]
Surgical	Performed with scalpel blade or scissors
NONSELECTIVE DEBRIDEMENT	
Hydrodynamic	Uses lavage. The needle can also be used to remove tissue and debris while flushing.
Mechanical	Uses force, such as adherent bandages, to debride tissue

[a]*Pavletic MM.* Atlas of Small Animal Wound Management and Reconstructive Surgery. *3rd ed. Ames, IA: Wiley-Blackwell; 2010.*

venoset and a needle (16- to 22-gauge), placed inside a pressure bag and pressurized to 300 mm Hg.[7] If wound healing seems to be impaired, a culture should be taken after all gross contaminants are removed via lavage to determine if any bacteria remain in the wound.[8]

Debridement

Debridement can be achieved by several methods (**TABLE 1**; **FIGURES 1 AND 2**), and often several methods are used during various stages of wound treatment. Selective debridement targets unhealthy tissue only, whereas nonselective debridement affects all tissue. Debridement should continue until granulation tissue has formed.

FIGURE 1. Hydrodynamic debridement using lavage along with mechanical debridement using a finger.

FIGURE 2. Surgical debridement using a scalpel blade.

Bandaging

Selection of bandage technique from among the various options depends on the location and type of wound. Bandaging allows for debridement; compression; maintenance of a moist environment; pain management; wound protection; reduction of dead space, edema, and hemorrhage; and stabilization. Bandages are typically made of 3 layers: primary (contact), secondary, and tertiary.

- **Primary Layer**: This layer contacts the wound and can provide debridement, medicinal therapy, moist wound healing, protection, and transfer or absorption of exudate. The primary layer can be adherent or nonadherent, semiocclusive or occlusive.
  - **Adherent:** This type of layer provides nonselective mechanical debridement in either a dry-to-dry or wet-to-dry bandage. Although this type of debridement has been commonly used in the past, moist wound healing has proven more benficial for the following reasons:[2,4,5,9-12]

FIGURE 3. Cast padding being applied with 50% overlap.

- Bacteria can penetrate the moist gauze
- Fiber from the gauze can remain in the wound
- Pulling dry gauze from a wound can release bacteria into the air
- This technique can lead to wound dehydration, healthy tissue destruction, and/or pain

- **Nonadherent:** Removal of this type of layer is atraumatic to the wound. Dressings that protect healthy granulation tissue to help with epithelialization can be made of cotton, which provides some absorption, or of petroleum-impregnated gauze. Other types of nonadherent dressings include acemannan, alginates, bioactive dressings, biotherapy, honey, hydrocolloids, hydrogels, and sugar (**BOX 1**).

- **Secondary Layer:** This layer provides absorption, compression, and stabilization. For a Robert Jones bandage, which is placed on extremities only, roll cotton is used for this layer. For a modified Robert Jones bandage, which can be placed anywhere on the body, cast padding is used for this layer. Cast padding should be wrapped distally to proximally with a 50% overlap (**FIGURE 3**). Roll gauze/conforming gauze/stretch bandage is next applied in the same fashion (**FIGURE 4**). Although cast padding will tear before it is applied too tightly, roll gauze will not, so use extra caution when applying roll gauze.
- **Tertiary Layer:** This layer keeps the other layers in place and protects them from the environment. Materials for this layer are elastic adherent wrap or porous adhesive tape. As with roll gauze, be careful not to wrap too tightly.

FIGURE 4. Roll gauze being applied with 50% overlap.

BOX 1

Nonadherent Autolytic Dressings Used as Primary Layers to Promote Moist Wound Healing

- **Acemannan:** Derived from aloe vera and used on burns, dermal ulcers, lacerations, and radiation therapy wounds.[11]
- **Alginates:** Derived from kelp and used in the inflammatory and repair stages. Absorb fluid from the wound, convert to a gel, and thus should not be used on dry wounds.
- **Bioactive dressings:** Derived from living tissue and used in the inflammatory and repair stages. Provide a matrix for cell migration.[4]
- **Biotherapy:** Living organisms such as leeches or maggots. Leeches decrease edema and venous congestion. Maggots debride necrotic tissue, and their secretions provide antimicrobial benefits.
- **Honey:** Nonpasteurized honey (e.g., Manuka) provides antibacterial benefits, reduces edema, hastens sloughing of devitalized tissue, and promotes granulation tissue formation.[10]
- **Hydrocolloids:** Composed of hydrophilic polymers. Used during the repair stage on low-exudate to medium-exudate wounds. As exudate from the wound is absorbed, the hydrocolloid liquefies to form a gel.[10]
- **Hydrogels:** Composed primarily of water or glycerin. Used in the inflammation and repair stages and contribute a large amount of moisture to the wound. Therefore, they should be used in wounds with no exudate or low exudate.
- **Sugar:** Reduces edema and bacterial proliferation and promotes granulation tissue formation.[1] Application should be at least 1 cm thick.[1]

Other bandaging techniques include tie-over bandages, free graft bandages, and negative pressure wound therapy (NPWT).

BOX 2

Additional Wound Therapy Options

Therapeutic Laser

- Relieves pain
- Reduces inflammation
- Accelerates tissue repair and cell growth
- Promotes angiogenesis
- Reduces fibrous tissue formation

Platelet-Rich Plasma (PRP) (FIGURE 7)

- Blood is drawn from the patient (autologous) by using a PRP kit
- At the time of application, thrombin and/or calcium chloride are combined with the PRP, which activates the platelets and forms a gel[14]
- Growth factors and cytokines stimulate and accelerate wound healing
- PRP can be effective against methicillin-resistant *Staphylococcus aureus*[15]

- **Tie-over bandages:** Tie-overs are used in areas that are difficult to bandage (e.g., axillary, inguinal, hip, or perineal regions). Several stay sutures are placed circumferentially around the wound (**FIGURE 5**). To keep the bandaging material in place, after the primary and secondary layers are applied, umbilical tape is passed through the stay sutures and tied (**FIGURE 6**). Last, an impervious layer (e.g., a laparotomy sponge plastic wrapper or transparent medical dressing) is applied to help decrease the risk for wound contamination.
- **Free graft bandage:** This bandage uses the same or similar supplies as a modified Robert Jones bandage. To allow the graft to attach without disruption, this bandage is left on for 3 days.
- **NPWT:** With foam as the primary layer, NPWT involves application of a continuous pressure of –125 mm Hg to the wound, thereby increasing blood flow to the wound, removing bacteria and edema, and accelerating the rate of granulation tissue formation.[13] Use of NPWT is contraindicated on exposed blood vessels or nerves, fistulas, necrotic tissue, organs, wounds with malignancy, or in conjunction with osteomyelitis or coagulopathies.[13]

Two additional therapy options are shown in **BOX 2**.

Bandage Care

How often a bandage should be changed depends on the amount of exudate, the type of bandage, and the status of the bandage. Bandages should be observed for strike-through, contamination, proper placement, and quality. The following bandage care should be discussed with clients at the time of patient discharge, along with instructions for them to bring their pet in for a bandage change should they observe any status changes.

- If there is strike-through, the bandage should be changed.
- Keep the bandage dry by:
  - Keeping the patient's bedding clean and dry
  - Securing food and water bowls so that they cannot be spilled or stepped in
  - Covering the bandage if the patient goes outside in a wet environment and removing it after the patient is back inside, so moisture does not

FIGURE 5. Stay sutures placed to hold the layers of a tie-over bandage.

FIGURE 6. Tie-over suture with umbilical tape.

collect and soak the bandage
- Observe the tightness of the bandage (**FIGURE 8**).
  - If a bandage is too loose, it may slip, exposing the wound or causing the bandage layers to slip and/or rub
  - If a bandage is too tight, it may cause biting or licking of the bandage, abnormal swelling of the surrounding areas, and potential necrosis and sloughing of the skin
- Keep an Elizabethan collar on the patient at all times, to prevent bandage destruction.
- Restrict the patient's exercise for the duration of bandage care (i.e., keep the patient crated and take outside on a leash for urination and defecation purposes only).

Drains

Drains—passive or active—can be used to remove fluid from wounds and should be handled with aseptic technique. Drain fluid should be evaluated for volume and character.

- **Passive:** These are open drains that work via capillary action and gravity, removing fluid from the wound along the outside of the drain, and exiting the body. Although less expensive than active drains, they do not allow for quantification of the drainage and can lead to ascending infections. A bandage is required to absorb the fluid.
- **Active:** These are closed drains and work via suction. A closed negative-pressure device is placed at the end of the drain, suctioning and storing fluid from the wound. Fluid from active drains can be quantified, qualified, and cultured. A homemade version can be made by using a butterfly catheter and a sterile Vacutainer (BD, bd.com) blood collection tube.

How often a bandage should be changed depends on the amount of exudate, the type of bandage, and the status of the bandage.

Drains should be removed when fluid accumulation decreases to 1 to 2 mL/kg/day[16] or when drainage has reached a plateau and the fluid quality is normal. After drain removal, a small bandage can be placed to absorb any residual drainage before the insertion site is healed.

FIGURE 7. Blood collected for PRP.

FIGURE 8. Two toes visible to check for swelling.

PAIN MANAGEMENT

Most patients need to be sedated or anesthetized for initial wound management, and analgesics (e.g., opioids or nonsteroidal anti-inflammatories) should be a part of the pain management protocol. In addition, local or splash blocks in or around the wound can add to patient comfort. Although chemical restraint may not be required in the later stages of treatment, pain should still be managed, not only for patient comfort but also because pain can impede tissue perfusion, thereby delaying wound healing.

CONCLUSION

Wounds are complex and vary in severity. Understanding the basic principles of wound management will help veterinary nurses aid in proper wound care and management to maximize the healing process. TVN

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