PEER REVIEWED

Helpful Tips for MANAGING WOUNDS in Veterinary Patients

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TEN TIPS FOR WOUND MANAGEMENT

1. Effective **wound irrigation** is determined by amount of solution used, not by solution type.
2. **Irrigation pressure** should remove bacteria from the wound but not damage the tissue.
3. Necrotic tissue should undergo **debridement**; if tissue viability is questionable, wait and reassess in a few days.
4. If unsure whether to **suture a wound** or **keep it open**, always err on the side of caution.
5. **Topical agents** applied at the right time are essential to healing; incorrect agents applied at the wrong time are detrimental.
6. Cover the wound by a **contact layer/bandage** after application of a topical agent.
7. **Honey and sugar** have unique antibacterial qualities that make them ideal topical agents.
8. **Tie-over bandages** provide the perfect covering for hard-to-bandage areas.
9. A **butterfly catheter** can be converted to an active drain if a **Jackson Pratt active closed drain** is unavailable.
10. Correct placement and management of **Penrose drains** is critical for efficient fluid drainage and minimization of complications.

Successful wound management depends on taking the correct approach to the lesion, including deciding whether to close it or manage it as an open wound. This article will:

- Review the decision making process regarding wound management
- Provide some tips and techniques for managing open wounds.

SKIN ANATOMY

In order to understand wounds and how to best treat them, it is important to understand the anatomy of the skin, which consists of 3 layers:

1. **Epidermis**
2. **Dermis**
3. **Hypodermis** (commonly referred to as subcutaneous tissue).

The most important component for wound management is the vascular supply, which is separated into 3 divisions:

1. **Superficial** (subpapillary) plexus
2. **Middle** (cutaneous) plexus
3. **Deep** (subdermal or subcutaneous) plexus.

Dogs and cats have direct cutaneous vessels, which are found in the deep plexus, rather than musculocutaneous vessels, which are present in humans.[1]

PATHOPHYSIOLOGY

In simple terms, *a wound occurs when there is a loss in integrity of the skin and underlying tissues.*

The ultimate goal of wound healing is restoration of the epithelial surface, and this process involves several physiologic steps:

- Formation of a fibrin-platelet clot
- Recruitment of white blood cells (neutrophils followed by monocytes and macrophages)
- Neovascularization and cellular proliferation
- Tissue remodeling.

These phases are more commonly described as inflammation and debridement, repair, and maturation. It is important to understand that all these phases overlap.

The inflammatory and debridement phase typically lasts 3 to 5 days after the wound has occurred. It is characterized by vasoconstriction (5–10 minutes), followed by vasodilation to allow entry of fluid and cells. Leukocytes kill bacteria, phagocytize debris, and recruit other secondary mediators to help with healing.

The repair phase, which typically occurs from days 4 through 12, is characterized by replacement of lost tissue and wound closure. This takes place by production of granulation tissue, wound contracture, and epithelialization.

The maturation phase begins when collagen fibers begin to orient along lines of stress,[2] and can continue for years. The ultimate strength of the skin will be about 10% at 14 days, 25% by 4 weeks, and up to about 80% at several months.[3]

INITIAL WOUND CARE

In any traumatic wound, the bacteria burden and degree of foreign material can be quite extensive. The initial goals of wound care are to:

- Lessen the bacteria load
- Remove foreign material
- Remove any necrotic tissue.

Wound Care Steps

1. First apply a sterile lubricant to the wound, which allows the hair around the area to be clipped.
2. After the hair has been clipped, copiously lavage the wound.
3. Once irrigation is complete, differentiate between healthy and necrotic tissue:
   - **Viable tissue** has a red or pink appearance and bleeds when incised.
   - **Necrotic tissue** has a dark purple to black color and fails to bleed when incised.
4. Use an aseptic debridement technique (sharp excision with scalpel blade or scissors) to remove necrotic tissue; debride until tissue begins bleeding or healthy tissue is encountered.
5. If tissue is pale, bluish, and/or light purple, its viability is difficult to assess—leave it in place until viability can be determined.

Irrigation Solutions

A common discussion regarding irrigation solutions revolves around which type is best to use; common examples include:

- Sterile saline
- Diluted chlorhexidine (0.05% solution; 25 mL of 2% solution in 1 liter of fluid)
- Diluted betadine (0.1% or 1% solution; 1 or 10 mL of 10% solution in 1 liter of fluid).

However, antiseptics nonselectively damage cells, and have little effect on reducing bacterial load.

In our opinion, the key is not necessarily the type of solution used, but the amount used. The recommended amount of solution varies depending on size and contamination of the wound but, in general, 500 mL to 1 liter is appropriate. In a study of humans, no difference in infection rates was found between use of tap water or sterile saline as the initial lavage solution.[4]

Irrigation Pressure

There is a fine balance between using the pressure of irrigation application to remove bacteria and damaging the tissue. Pressures as low as 1.6 psi can reduce bacteria contamination[5]; although, 7 to 8 psi is commonly cited.[5]

Recently, a study found that a 1-liter saline bottle with a hole in it generates 3.9 psi, while a 35-mL syringe, with a 16- or 18-gauge needle, produced 18 or 16 psi, respectively. A 1-liter bag, within a cuff that was pressurized to 300 mm Hg consistently, produced a pressure of 7 to 8 psi, regardless of needle size.[6]

The preferred pressure needed for effective, but not traumatic, irrigation is 7 to 8 psi. The recommended method of application is use of a 1-liter bag pressurized to 300 mm Hg. Connect the IV tubing to a hypodermic needle to thoroughly lavage the wound.

WOUND MANAGEMENT TECHNIQUES

Closure Approaches

The decision to close a wound or keep it open depends on several factors. This decision is not always a black and white process, but always err on the side of caution if in doubt.

Closing a wound helps increase the speed of healing by bringing the wound edges closer together. There are numerous factors to consider when closing a wound (**Table 1**). If these factors are not favorable, a decision to close the wound might result in slow wound healing or a non-healing wound.

One important aspect is species differences between dogs and cats. In general, primary closure in cats has less strength than primary closure in dogs. Also, in cats, less epithelialization occurs, less granulation tissue is produced, and open wounds heal more slowly.[7,8]

Types of Closure

Types of wound closure can be classified as:

1. **Primary closure** (first intention healing) allows apposition of wound edges, which then facilitates healing by first intention. Primary closure is indicated most often for:
   - Surgically created wounds

Table 1. Factors to Consider When Deciding Whether to Close a Wound

- Amount of foreign material in wound
- Completeness of debridement
- Degree of contamination
- Elimination of dead space
- Extent of tissue damage
- Patient's systemic condition
- Potential for wound infection
- Potential to close wound without undue tension
- Status of blood supply to wound
- Time since injury occurrence

STEP-BY-STEP: TIE-OVER BANDAGE APPLICATION

1. **Place suture loops**, using monofilament, nonabsorbable suture, in healthy tissue around the periphery of the wound, approximately 1 to 2 cm from its edges (**Figure 1**). These sutures will hold the tie-over bandage material. ***Note:*** *If the suture loops are too big, tension will be lost; if the loops are too tight, blood flow will be impeded.*
2. **Apply sterile bandage material** to the top of the wound; wound type will determine whether this is a wet-to-dry or nonadherent bandage (**Figure 2**).
3. **Loop umbilical tape** through the sutures and tie it onto itself to secure the bandage material. It is helpful to have at least 5 interrupted sutures placed in a star pattern; however, more are used for larger wounds.
4. **Use a final outer impermeable layer** to prevent nosocomial infections (**Figure 3**).

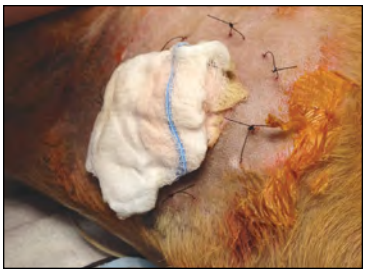

Figure 2. *A wet-to dry bandage with sterile gauze placed in a wound prior to tie-over bandage placement.*

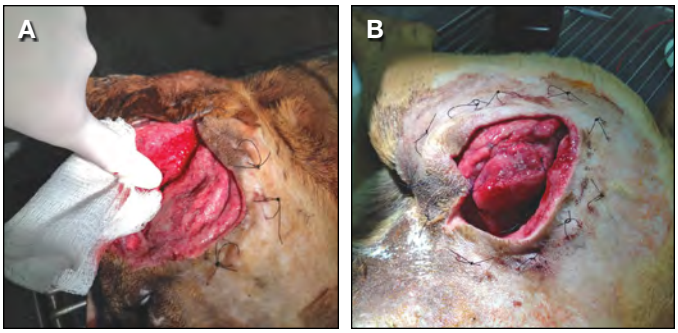

Figure 1. *Full-thickness wound on the head of a dog (**A**) and full-thickness wound over right flank area (**B**); both are candidates for tie-over bandages; note that simple interrupted sutures have been placed around the periphery of the wounds, approximately 1 to 2 cm from their edges.*

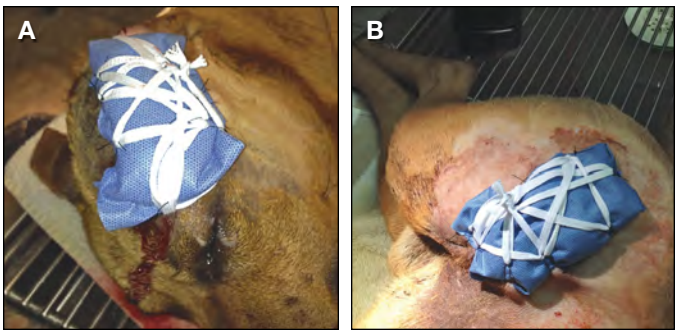

Figure 3. *Full-thickness wounds on the head (**A**) and right flank (**B**) from Figure 1 after completion of tie-over bandaging; note that the underlying layer has been covered with an impermeable layer and secured with umbilical tape.*

Wound Closure: Infection Considerations

An overall goal of wound management is to facilitate healing without infection, and this consideration plays a part in the decision whether or not to close a wound.

Timing of closure is important but does not necessarily determine the potential for wound infection. A bacteria count of 10^5 colony-forming units per gram of tissue is considered indicative of infection, and the time required to achieve this bacterial population is approximately 6 or more hours.[9]

In addition, other factors, such as virulence of the organism, tissue trauma, and the presence of foreign material, can lead to a large bacteria burden in more or less time.

- Sharply incised wounds, with minimal trauma and contamination (in our opinion, dog bite wounds do not fall in this category).

2. **Delayed primary closure** describes appositional closure within approximately 3 to 5 days post initial wound management, but before formation of granulation tissue. Wounds that fit in this category are:
   - Mildly contaminated wounds that require some debridement
   - Those initially treated by open wound management for a short period of time.
3. **Secondary closure** describes a wound that is managed as an open wound for longer than 3 to 5 days; then closed after the formation of granulation tissue. This management strategy is applied to:
   - Severely contaminated wounds
   - Wounds that require more intensive debridement.
4. **Second intention healing** leaves the wound open to heal by contraction and epithelialization.[2] This type of healing can apply to any wound but, in particular, is useful for wounds:
   - With resistant bacterial infections
   - That run perpendicular to the skin's tension lines

ONGOING WOUND CARE

Once the wound has been treated and a wound healing technique (closed *vs* open) chosen:

- Topical agents can be used to assist with healing of open wounds
- Open wounds should be bandaged after topical treatment to protect

STEP-BY-STEP: CREATING AN ACTIVE CLOSED DRAIN

A butterfly catheter can be converted into an active closed drain by (**Figure 4**):[10]

1. Cutting off the syringe adaptor
2. Fenestrating the end of the tube with a needle
3. Passing the fenestrated end into the wound.
4. Attaching the butterfly needle to a blood collection tube, which provides the vacuum for suction.

Figure 4. *Butterfly catheter providing active drainage after removal of a salivary gland that resulted in an excessive amount of dead space.*

healing tissue from further damage, such as self-mutilation, hospital organisms, and the outside environment.

Topical Agents

Topical agents can be a double-edged sword: use of the correct agents at the right time is essential to healing, but application of incorrect agents at the wrong time can be detrimental to healing.

- In general, topical agents, especially **antimicrobial agents** that have broad spectrum activity, are useful early in the course of wound management.
- Other topical agents, such as **honey or sugar**, are best used during the inflammatory or early repair phases.

Honey is a unique agent in that it has antibacterial activity, reduces edema and inflammation, and enhances granulation tissue and epithelialization. Sugar has a hyperosmotic effect, creating an antibacterial environment within wounds.

Types of Bandages

After application of a topical agent, a contact layer must cover the wound. The type of layer and frequency of bandage changes will depend on the expected amount of exudate. Regardless, any open wound should have its bandage changed every 24 hours at a minimum.

STEP-BY-STEP: PLACING A PENROSE DRAIN

Penrose drains are commonly placed incorrectly or in inappropriate places (**Figure 5**). To correctly place the drain:

1. Chose the most ventral aspect of the wound for drain placement.
2. Place the proximal end of the drain in the most dorsal aspect of the wound, not outside the wound or skin.
3. We prefer to insert a monofilament nonabsorbable suture blindly through the skin, which exits from the dorsal aspect of the wound.
4. Place a mattress suture through the proximal aspect of the drain; the suture then exits the wound back through the skin where the suture is tied, securing the drain in place in the most proximal aspect of the wound (**Figure 6**). Removal is made easier by using a different color of suture to secure the drain than the color used to close the wound.
5. Place the drain in as much of the wound as possible; then create a stab incision that allows the drain to exit the wound ventrally (**Figure 7**).
6. Monitor drains daily and remove them once drainage decreases or changes to a more serosanguineous appearance. However, do not leave drains in place for more than 3 to 5 days.

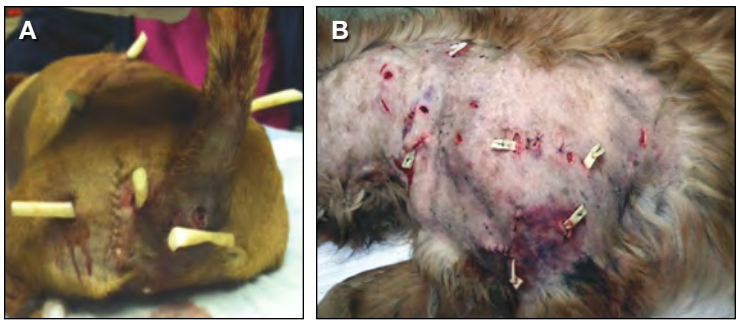

Figure 5. *Improper placement of penrose drains: In **A** (dog), note the entrance and exit points, placement in an area where fecal matter can contaminate the wound, and lack of covering. In **B** (cat), note the entrance and exit points, longitudinal drain placement, and lack of covering.*

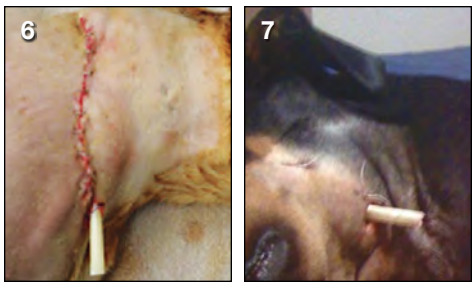

Figure 6. *Proper placement of drain (dog's head) prior to being covered; note the single exit site of the drain. A single suture at the most proximal aspect is securing the drain in place; another suture is securing the exit point of the drain.*

Figure 7. *Proper placement of a drain (dog's neck) prior to being covered; note the single exit site of the drain (ventrally) and the new wound created for the drain's exit. Not clearly visible is the most proximal aspect of the drain, which is buried and tacked to the skin at the most dorsal aspect of the wound.*

Table 2. Commonly Used Bandaging Techniques

Technique & Purpose
NONADHERENT BANDAGES • Keeps wound moist • Allows atraumatic removal of dressing
ADHERENT BANDAGES ***Wet-To-Dry Bandages*** Provide mechanical debridement for wounds with: • Incomplete debridement • High viscosity fluid/exudate • Loose/foreign debris and/or necrotic tissue ***Dry-To-Dry Bandages*** Provide mechanical debridement for wounds with: • Low viscosity fluid/exudate • Loose/foreign debris and/or necrotic tissue
TIE-OVER BANDAGE • Covers hard-to-bandage areas • Facilitates closure by stretching skin over 2–3 days
See **Step-By-Step: Tie-Over Bandage Application**.

Bandaging techniques are based on the type of injury and treatment goals. The function of the contact layer varies but may include:

- Protection
- Debridement
- Exudate absorption
- Topical medication delivery
- Promotion of healing.

See **Table 2** for brief descriptions of commonly used bandaging techniques.

Use of Drains

When a large amount of dead space is within a wound, yet the wound can be closed, a drain may need to be placed to allow drainage of fluid.

Active Drains. We prefer to use active closed drains, such as a Jackson Pratt drain; if this type of drain is unavailable, a butterfly catheter can be converted into an active closed drain (**Step-by-Step: Creating an Active Closed Drain**).

Passive Drains. Penrose drains are used frequently to help drain excess fluid from large areas of dead space, resulting from trauma or surgical procedures. Fluid drains along the outside of the tube, not through it, and the drain's cylindrical shape provides a high surface-area-to-volume ratio, which allows significant drainage.[10]

The penrose drain must be placed correctly to work efficiently and minimize complications (**Step-by-Step: Placing a Penrose Drain**). The 2 most important aspects of drain placement are:

1. Ensuring the drain only has a ventral exit through the skin, not an entrance and exit
2. Covering the drain while it is in place to prevent secondary infections. ■

Photo Acknowledgements

Figures 1 through 3 courtesy Kristen Welch, DVM, Diplomate ACVECC, Charleston Veterinary Referral Center, Charleston, SC

Figure 4 courtesy Cory Fisher, DVM, MS, Diplomate ACVS, Mississippi State University

Figure 5A courtesy Rick Hurt, DVM, Mississippi State University

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