CHAPTER 1

Open Wound Management

Open wound management is often necessary for infected or dirty wounds, areas with necrosis or questionable blood supply, large defects that cannot be managed with primary closure, or when the patient is too unstable for wound debridement and primary closure. Closure of open wounds falls under four categories. Immediate suturing (*primary closure*) is performed soon after a wound has occurred or if the entire wound can be resected and turned into a "fresh," clean wound. When a wound is infected or has excessive drainage or questionable circulation, closure can be delayed (*delayed primary closure*) for several days to allow daily evaluation, cleansing, and bandaging. In some cases, closure is delayed until after healthy granulation tissue has developed (*secondary closure*) because of persistent infection, inflammation, or necrosis. If a wound requires a skin graft or other reconstruction, a healthy bed of granulation tissue is preferred. *Second intention healing* occurs when a wound is allowed to heal by contraction and epithelialization.

Open wounds may take weeks to months to heal by second intention, depending on the wound size and other factors. Common factors that delay wound healing include infection, medications (corticosteroids, chemotherapeutics, and immunosuppressive agents), metabolic diseases (diabetes mellitus, hyperadrenocorticism, hypothyroidism, and uremia), nutritional status (e.g. starvation), local blood supply, wound location, and patient activity and self-trauma. Because of the time involved with second intention wound healing, secondary closure with direct apposition, flaps, or grafts is often performed once a healthy granulation bed is present.

For delayed primary closure, secondary closure, and second intention healing, the wound is covered with a topical dressing to provide ideal moisture, reduce or eliminate infection, and encourage healing; and the area is covered with a bandage to secure the dressing, protect the wound, and prevent contamination. For areas where encircling bandages are not possible to place or maintain, wound dressings can be secured locally with adhesive drapes, skin staples, tensioning suture (see Chapter 5), or a tie-over bandage technique. For wounds that are large or effusive, have been mesh grafted, or in which a faster time to wound closure is desired, negative pressure wound therapy can be applied first to speed the clearance of infection and formation of a granulation bed.

For any type of wound management, the area should be protected from self-trauma. This may require Elizabethan collars, a recovery body suit, bandages, or sedation. Systemic antibiotics, adjusted based on wound tissue culture and susceptibility results, are recommended in animals with heavy exudation; cellulitis, as evidenced by redness and swelling around the wound; or systemic signs of infection, such as pain, fever, and leukocytosis. Topical antimicrobial dressings are usually sufficient for animals with contaminated wounds and those with infection limited to the wound bed. Frequency of bandage changes depends on the amount of wound drainage. Some dressings, such as honey or silver sulfadiazine, will increase wound effusion.

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WOUND DRESSINGS FOR OPEN WOUND MANAGEMENT

Selection of a contact layer can be overwhelming because of the myriad dressings available and the lack of standardized research documenting or comparing their efficacy. In general, dressing selection should be based on the character of the wound and the desired local effect (e.g. nonadherent, anti-microbial, absorptive, and moisture retentive). Dressings should protect the wound, keep it moist without permitting maceration, treat infection when present, and promote (or at least not interfere with) healing. Some of the editors' favorite dressings are listed in the table below.

Wound character	Dressing type	Brand
Fresh, hemorrhaging, clean wound	Nonadherent pad	Telfa pad (Kendall, Covidien)
	Petroleum-impregnated gauze and absorptive layer (e.g. cast padding, and gauze)	Adaptic (Johnson and Johnson or 3M)
Copious thick drainage and infection	Antimicrobial-impregnated gauze	Kerlix AMD roll gauze (Kendall)
	Gauze combined with honey or 0.05% chlorhexidine	
Copious thin drainage	Superabsorptive polymer pad	Xtrasorb Classic pad (Dermasciences)
Infected and unhealthy wound bed with minimal to mild drainage	Honey under an absorptive bandage	Medihoney gel, paste, or pads (Dermasciences)
	Amikacin 1% topical spray for susceptible infections that are resistant to oral antibiotics	Multiple vendors: mix 1 g amikacin sulfate powder in 100 mL sterile saline or water
Infected but improving wound bed with minimal to mild drainage	Silver-impregnated absorptive pad with dextrans and alginate	Algidex pad (DeRoyal)
	Hydrophilic foam pad	Kendall Copa foam dressing (Covidien)
Dry and necrotic	Maggot therapy (or debridement with surgery or honey)	Medicinal maggots (Monarch Labs)
	Amorphous hydrogel dressing	Kendall amorphous hydrogel (Covidien)
Granulating wound with infection present but clearing	Antimicrobial ointment or cream	Silver sulfadiazine cream 1% or Triple antibiotic ointment (multiple vendors)
	Calcium alginate dressing	Kendall Curasorb calcium alginate dressing (Covidien)
Healthy granulation bed	Ointment on a nonadherent pad	Triple antibiotic or Mupirocin ointment (multiple vendors); Adaptic
	Enzymatic sea salt foam and a protective body suit or covering	VetAid Foam (VetAid, LLC)

TIE-OVER BANDAGES

When placed appropriately, tie-over bandages are less likely to slip or to obstruct lymphatic or venous drainage than encircling bandages. They also provide a method for stretching and lengthening the local skin to facilitate wound closure. The amount of eventual skin relaxation depends on the location of the wound and the characteristics of the local skin. Maximal stretch is usually noted within 2 to 3 days after placement of tension on the skin.

Placement of tie-over bandages may be performed under heavy sedation and analgesic (usually opioid) administration, but wound management is easier to perform and more comfortable for the patient when the animal is fully anesthetized, particularly if undermining or debridement is needed. To reduce hair contamination, wound beds are filled with a water-soluble gel before clipping. The area is clipped widely; the gel and any loose hair are then rinsed out with sterile saline or tap water. Use of tap water does not increase the risk of infection. After cleaning and prepping with an antiseptic solution, tissue samples for culture are obtained by punch or incisional biopsy from the beds of chronic,

nonhealing, or effusive wounds. Taking the sample after aseptic preparation of the wound surface will remove contaminants so that final results are more likely to reflect what is growing in the tissue.

A tie-over bandage is usually constructed by placing suture loops in the skin. If skin stretching is desired, the local skin is first freed from the wound edges and undermined, and the necrotic or unhealthy tissue is debrided with scissors or a scalpel blade. To make a suture loop, a suture bite is taken in and out of the skin 2 to 3 cm from the wound edge, using 0 or 2-0 monofilament, nonabsorbable suture on a cutting needle. Bites taken perpendicular to the wound edge may cause less vascular compromise, while those taken parallel to it may spread out tension better (fig. 1-1).

Because hitching can occur when tying suture loops, a syringe case can be placed over the skin bite, and the suture loop tied over it with 5 or 6 square throws. The syringe case is then slid out of the loop once the knots are secured. Loops are placed around all sides of the wound; because suture loops may pull through skin or be accidentally cut during bandage changes, extra loops should be placed. Once all loops are in place, dressings and absorptive materials are positioned over the wound bed and secured with umbilical tape or shoelaces, which is threaded through the loops and crisscrossed over the bandage (fig. 1-2). On large wounds, two laces might be required. The lacing should be tightened enough to secure the dressing but not enough to cause skin pallor or severe distortion, as this could result in skin necrosis. If desired, the tie-over bandage can be covered with an adhesive drape or polyurethane film (fig. 1-3).

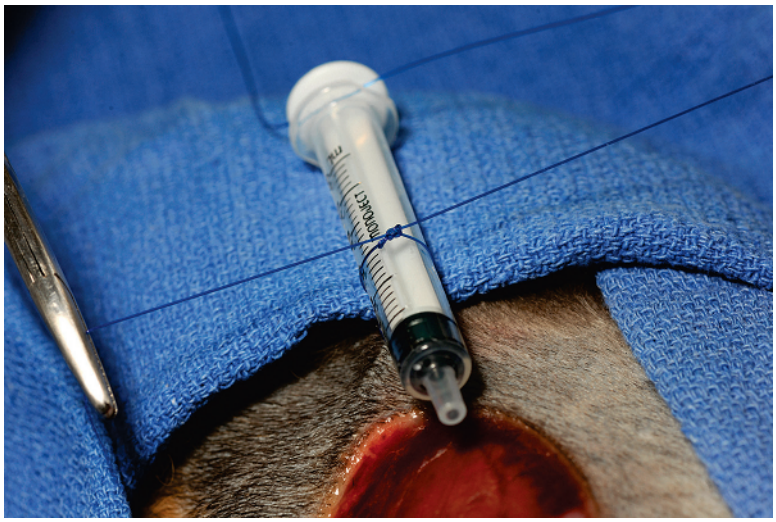

FIGURE 1-1 Loops can be formed and tied over a syringe or syringe case.

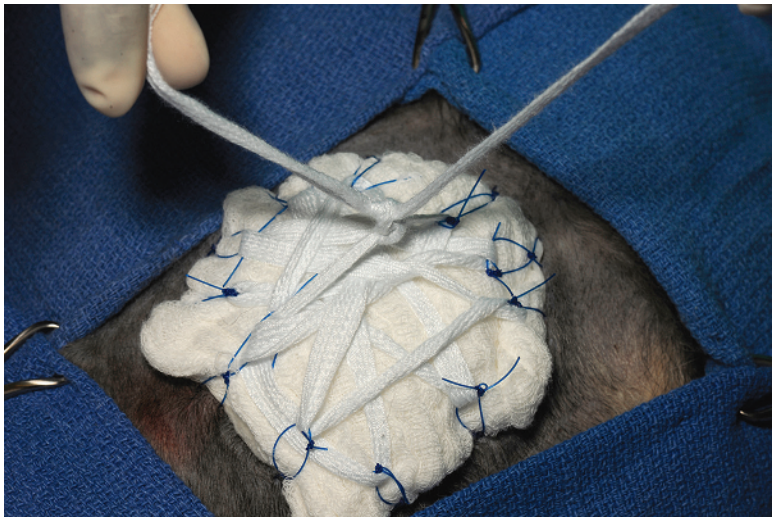

FIGURE 1-2 Secure the primary and secondary layers of the bandage with umbilical tape laced through the suture loops.

FIGURE 1-3 To keep the wound moist or prevent contamination or leakage, cover the bandage with an occlusive tertiary layer such as an antimicrobial-impregnated adhesive drape.

Tie-over bandages are usually changed once daily or more frequently if strike through occurs (fluid visible through the absorptive secondary layer). Heavy sedation and analgesics are usually required for the first 3 to 5 days of dressing changes. The lacing material is cut, and the laces are removed from the loops. The dressing is removed, the wound is inspected and cleaned, and a new dressing is applied. New lacings are used to secure the dressings; in most cases, they can be pulled slightly tighter than the previous bandage. If adhesive drape is used over a tie-over bandage, the drape is cut immediately around the dressing near the suture loops; the outer rim of the adhesive drape is left in place, and any new drape adhered to it. Once adhesive drape is no longer needed, the adhesive can be softened with a skin safe (e.g. silicone- or alcohol-based) medical adhesive remover to reduce local skin trauma. If the lacings are being used for tensioning, they are tied in a bow, left uncovered, and tightened two to three times a day to gradually increase tension.

Local inflammation is expected where the loops penetrate the skin, and the associated redness is usually apparent by day 3. Other complications of tie-over bandages include skin necrosis and suture loop failure from breakage or hitching. Loops may pull out if placed too close to the skin edge, or if they are made of fine suture material that is placed under too much tension. Large loops may need to be replaced as the distance between the skin edges decreases. Skin necrosis is common when loops are placed under too much tension (fig 1-4).

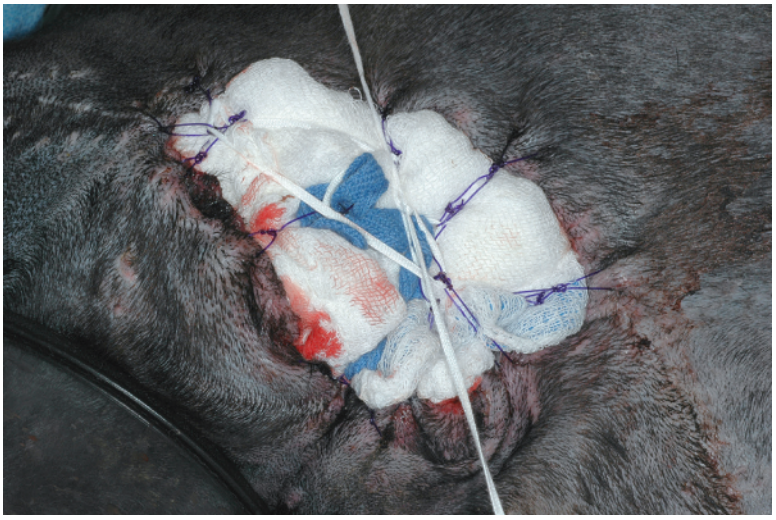

FIGURE 1-4 In this dog, the umbilical tape is tied too tightly, resulting in inappropriate tension on the skin. Tension should be gradually increased over several days to prevent skin damage.

OPEN WOUND MANAGEMENT WITH NEGATIVE PRESSURE WOUND THERAPY

For large and highly effusive wounds, standard open wound management may require daily or twice daily bandage changes for a prolonged period of time before the wound is healthy enough for secondary closure. Negative pressure wound therapy (NPWT), also known as vacuum-assisted closure, speeds that process. This treatment consists of application of subatmospheric pressures to a wound that has been covered with a foam dressing and sealed with nonpermeable drape. Typically, the foam is either polyurethane ether or polyvinyl alcohol foam, though open weave moistened gauze has also been used. Subatmospheric pressures are applied via some form of evacuation tubing with a controllable vacuum system, which allows extracted fluid to be collected into a reservoir cannister.

Reported benefits of NPWT include withdrawal of wound exudate, leading to less frequent bandage changes; increased blood supply to the wound; decreased wound edema; reduced need for debridement; improved granulation tissue formation; and quicker wound closure. Disadvantages include the need for special equipment, continuous monitoring, and the possibility that a bandage change might be required in the middle of the night. NWPT bandages are changed every 2 to 3 days; between bandage changes, negative pressure (−110 to −125 mmHg) is maintained continuously. If suction fails because the vacuum canister is full, the canister can simply be replaced. If negative pressure is lost because of foam obstruction, clots in the tube, or bandage failure; however, the animal must be heavily sedated or anesthetized, and the bandage is replaced to prevent the wound bed from soaking in noxious fluid. Once a healthy granulation bed develops, NPWT is discontinued after, since it can inhibit epithelialization and contraction.

PREOPERATIVE MANAGEMENT

General anesthesia is recommended for the first bandage placement, since any movement during bandage placement can affect the seal made by the drape, and animals may experience pain when negative pressure is initiated at the first bandage application. Standard clipping, cleansing, and tissue culture (if needed) are performed before NPWT bandage placement. Wide clipping is recommended to provide a larger surface area for drape adhesion.

SURGERY

Debridement of necrotic tissue must be performed prior to the first NPWT bandage placement and may need to be repeated at subsequent bandage changes. Debridement can be performed with a scalpel blade or scissors. A tensioning suture line (see chapter 5) can be used in combination with NPWT to stretch skin edges and hold the foam in position while the adhesive drape is placed.

SURGICAL TECHNIQUE: NEGATIVE PRESSURE WOUND THERAPY BANDAGE

1. Set up a sterile instrument table with supplies and don surgical gloves.
2. If wound debridement is needed, this should be completed first.
3. Using sterile scissors, cut the NPWT foam to the size of the wound or slightly larger, then set it aside.
   - **a.** Cut the foam away from the wound and sterile supplies so no pieces end up in the wound.
   - **b.** When in place, the foam should fill the wound and extend down into any explored deep pockets. If there is a wide wound with a pocket off to one side, a smaller piece of foam can be inserted into the pocket and a larger piece laid on the wound bed and in contact with the smaller piece. For some systems, a different type of foam is used to fill a pocket.
   - **c.** If there are two wounds separated by skin, cut a piece of foam for each wound bed and a separate, longer piece of foam to "bridge" the skin between the wounds. That will allow use of one suction unit for two wounds.
4. Clean and fully dry the skin surrounding the wound.
   - **a.** If the periwound skin is oily, use an alcohol wipe to clean the skin.
   - **b.** To reduce irritation from the adhesive drape, paint the dry, clean periwound skin with a barrier film (e.g. Cavilon™ NoSting Barrier Film, 3M Healthcare) (fig. 1-5)

FIGURE 1-5 Peripreputial abscess in a dog. The area around the wound has been clipped widely, cleaned, and dried. An appropriately sized piece of foam is inserted in the wound, and the skin around the wound is painted with a barrier film.

FIGURE 1-6 Using a syringe, stoma paste is applied on the skin around the wound.

5. Apply a continuous line of barrier paste (e.g. Stomahesive® ConvaTec) to the intact peri-wound skin, approximately 2 cm from the wound edge. (fig 1-6)
   a. This material improves the seal between the skin and the adhesive drape.
6. Place the precut foam in the wound bed.
   a. The foam will need to be held in place by an assistant or with a piece of sterile adhesive drape or sutures while the drape is being readied.

7. Apply the adhesive, sterile drape over the foam within the wound bed and the periwound skin beyond the line of stoma paste.
   a. The drape must be placed so that there are no creases in it along its skin margins.
   b. The drape should extend over 5 to 7 cm or periwound skin, including several centimeters beyond the stoma paste line.
   c. Press and smooth the adhesive drape around the edges so it is fully adherent to the skin around the wound, and there are no creases.
   d. Some systems have a two-peel drape. The first peel is removed so the adhesive is exposed; that side is adhered over the foam, stoma paste, and skin beyond. The second peel – the drape stabilization layer – is removed to decrease the drape thickness and improves the negative pressure generation. (fig. 1-7). The suction tubing will be secured to the drape after the second peel is performed.
8. Cut a hole in the drape over the middle of the foam.
   a. The defect size should be the same diameter as the suction tube disc opening (the opening on the evacuation tube attachment).
9. Remove the backing layers over the suction tube skirt to expose the skirt adhesive. Center the suction tube disk/opening over the drape hole, with the tube pointing in the desired direction depending on the wound location, and attach the tube skirt to the drape. Press down on the disk and skirt to seal the attachment.
   a. Before attaching the tubing, consider how it will be positioned when the animal is recumbent, sitting, or walking. The tubing may need to be secured to the animal and should therefore be directed in an appropriate position.
10. Connect the tubing to the cannister tubing and make sure all clamps are open.
11. Turn on the NPWT device to −110 to −125 mmHg and verify that negative pressure has formed and is being maintained. The foam should collapse, and there should be no hissing sounds. If leaks are noted, add additional barrier paste and adhesive drape to seal the site (figs. 1-8 and 1-9).

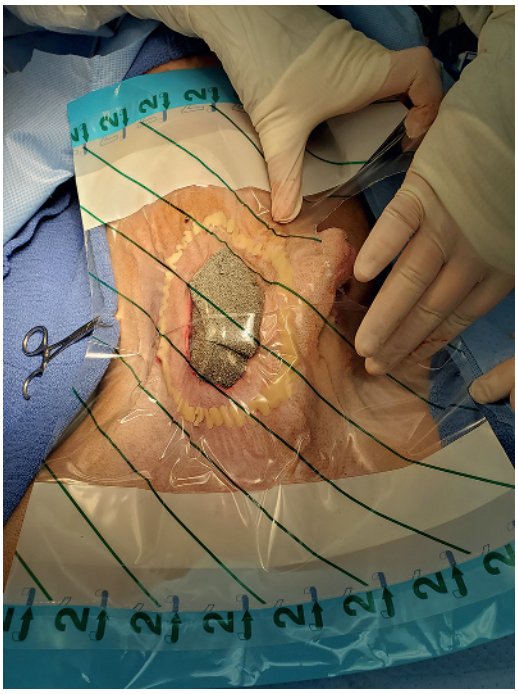

FIGURE 1-7 The adhesive drape is applied to the skin as it is stretched. In this dog, a section of the drape was subsequently cut out to free the end of the prepuce and allow urination. The drape is then pressed and smoothed down on the skin to improve adherence.

FIGURE 1-8 After cutting a hole in the drape over the foam, the suction tube skirt is adhered to the drape.

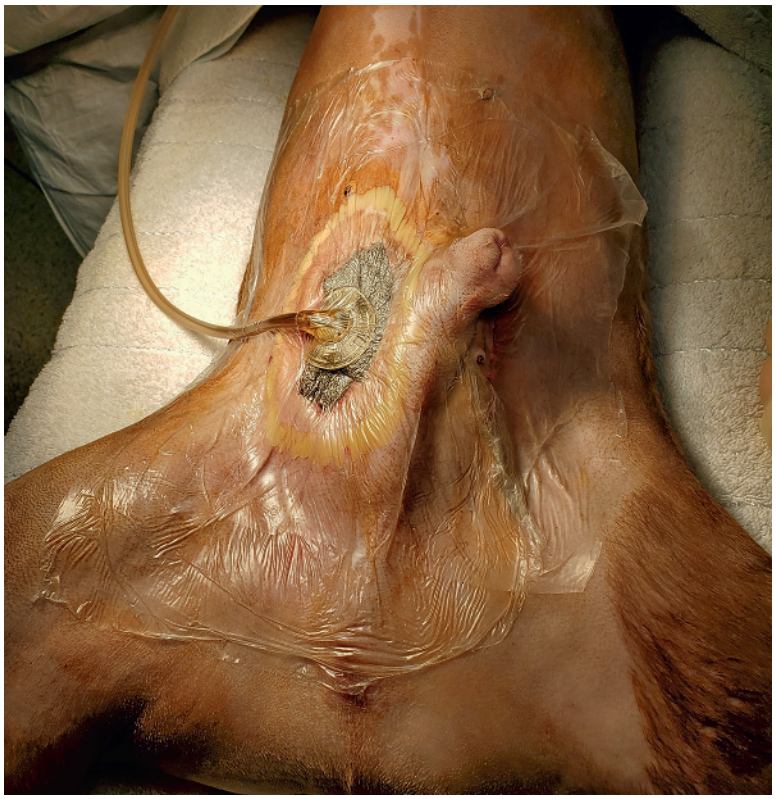

FIGURE 1-9 Once negative pressure is achieved, the foam sponge shrinks.

12. If using a wall suction unit, red rubber tube, and standard single peel adhesive drape instead of a commercial device:
    - **a.** Prepare a 12 or 14 French red rubber catheter by adding fenestrations along the length of catheter that will be in or on the top of the foam. Each fenestration should be less than 40% for the diameter of the catheter. If the catheter is to be placed on the top of the foam, fenestrations should all be placed on the side that will be in contact with the foam.
    - **b.** Cut foam to fit the wound.
    - **c.** If the red rubber catheter will be inserted in the foam, make a tunnel in the center of the foam with a hemostat or scissors.
    - **d.** Insert the fenestrated end of the catheter into the foam tunnel or lay the fenestrated side of the catheter across the top of the foam.
    - **e.** Cut a small opening in the adhesive drape, wide enough for the catheter adaptor end to fit through.
    - **f.** Remove the protective peel layer from the drape and place it over the skin, stoma paste, and wound foam. Have an assistant pass the catheter adaptor end through the drape as you secure it to the area.
    - **g.** Add additional adhesive drape over and around the fenestration and exteriorized catheter to seal around the exit site.
    - **h.** Use a double Christmas tree adaptor to connect the red rubber catheter to the wall suction, then turn on the negative pressure and test the seal.
13. Depending on the location of the wound, add a soft padded bandage over the NPWT bandage, if desired.

POSTOPERATIVE CONSIDERATIONS

Most commercial NPWT units are portable and can be placed on the battery mode when the animal is being walked. For animals attached to wall suction units, the catheter should be clamped, aseptically disconnected, and both connection ends covered with a sterile material when the animal is being walked. Time away from the wall suction should be limited. The animal is reconnected aseptically.

The most common complication of NPWT is the loss of negative pressure. This can be due to a tear in the adhesive draping, a leak through a crease in the draping, or an incomplete seal between the skin and the drape. In animals with heavy bleeding from the wound bed, use of NPWT is avoided because it can result in anemia. Granulation tissue may grow into the foam if the bandage is not changed soon enough; in some dogs, 3 days may be too long between bandage changes. Although constant suction to the wound continuously removes wound exudate, it is still possible for anaerobic bacteria to proliferate under the bandage. A deep culture should be obtained if delayed healing is noted or there are plans to close the wound. Granulation tissue may not develop in poorly vascularized wounds, e.g. those lined with a thick layer of fat.

Bandages should be used until the wound is no longer infected and can be closed without tension. Animals should wear Elizabethan collars until the wound is healed. Restriction in animal activity is also needed during bandage care and postoperatively if the wound closed.

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