HOW I TREAT OPEN WOUNDS

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Management of traumatic wounds in small animals can be simple and straightforward or difficult and frustrating to manage. Knowing the source of the wound is very important to initial decision making. Simple and clean lacerations, such as from glass or lawn edging, are often managed definitely in the first visit. Most large open wounds occur following blunt or penetrating trauma, and the animal should be assessed for life-threatening injuries prior to initiating wound care. Assessment of the entire patient is critical, with priority given to the cardiovascular, respiratory, and neurologic systems. Although the size of the defect and damage to underlying structures may be considerable, wounds are of lower importance in the initial period following presentation, unless there is a significant arterial bleed or penetration into the abdominal or thoracic cavity.

Animals sustaining bite wounds should be handled with great care and caution. Often there are multiple penetrating wounds, and the degree of trauma may not be initially apparent. The iceberg principle applies here, as the superficial wound is not reflective of deeper soft tissue damage. The crush pressure of the canine jaw ranges from 150 to 450 psi, and the trauma can result in neurovascular injury. The contamination to the wound is significant and often results in polymicrobial infection. Antimicrobial coverage should include an anaerobic spectrum. Bite wounds to the abdominal or thoracic cavity are an indication for immediate surgical explore. Imaging (radiographs or ultrasound) may help determine if there is cavity involvement, but also may underestimate the amount of internal trauma.

Good basic wound management will allow for rapid healing or provide a healthy wound bed for surgical closure. Principles of wound care include prevention of further contamination, wound lavage, debridement of devitalized tissue, and appropriate bandage placement and use of wound dressings. Gloves should always be worn when dealing with open wounds to prevent the introduction nosocomial infection. Large wounds may be overwhelming on presentation to both the owner and veterinarian. However, unless there is obvious, irreversible vascular, neurologic or musculoskeletal damage, the wound should be given time to declare itself before making hasty decisions, such as amputation.

Gross contamination of large wounds may be removed with tap water. For cleaner wounds, sterile isotonic solutions such as 0.9% saline and lactated ringers are preferred. Antiseptics can be added to lavage solutions, but are often unnecessary as the goal of lavage is to mechanically remove foreign material, necrotic tissue, and bacteria. If antiseptics are used, proper dilutions are important to avoid cytotoxicity. Chlorhexidine is diluted by adding 1 part of 2% chlorhexidine to 25 parts of normal saline to equal a 0.05% solution. Povidone iodine should be diluted to a 0.1 to 1% solution. Traditionally, achievement of mechanical cleansing without significant tissue damage (8 to 15 psi) was accomplished by administering with a 35-cc syringe and 18-gauge needle. Recent investigation has shown this method may not achieve expected pressures. An alternative is to utilize a 1-liter bag of fluids placed in a pressure bag at 300 mmHg connected to an extension set and 18-gauge needle.

Through the early inflammatory and debridement stages of wound healing, bandages can be used to assist in debridement of the wound. The conventional approach is to use adherent dressings during the initial stages of wound healing. The classic adherent bandage is the wet-to-dry bandage, where damp sterile gauze or laparotomy sponges make up the first (contact) layer of the bandage. Once granulation tissue is present, a non-adherent inner layer is used (ex. petrolatum-impregnated autoclaved gauze sponges). More recent methods of wound care include the use of interactive hydrophilic dressings, (e.g., hypertonic saline, honey, sugar, or calcium alginate) which cause an osmotic draw of bacteria and debris out of the wound bed. These materials cause less injury to healing tissues than adherent contact layers. The second or intermediate layer of the bandage should be additional dry sponges or cast padding to absorb fluid away from the wound, provide support, and reduce swelling. The tertiary or external layer of the bandage is used to secure and protect the other layers.

For wounds that are not on extremities, a tie-over bandage can be used to keep a wound completely covered without hindering the patient. Tie-over bandages are easily placed and require minimal materials. Loops of large gauge nonabsorbable suture are placed in healthy tissue at least 1 cm from the wound edge. The contact and intermediate layers of the bandage are placed on the wound and umbilical tape threaded from loop to loop in a shoelace type pattern to secure the bandage. This bandage also causes a degree of skin stretching that may assist in surgical closure.

A new method of wound management is **negative pressure wound therapy** (NPWT), which uses open-cell foam and subatmospheric pressure. Medical-grade, open-cell, polyurethane ether foam dressing with pore sizes between 400 and 600 µm fitted with an evacuation tube is cut to the specific wound configuration and placed into the wound defect. The wound site is bandaged, and the tubing is connected to a collection reservoir. The reservoir is connected to a vacuum pump and subatmospheric pressure (125 mm Hg) is applied continuously or intermittently for cycles of approximately 5 minutes on and 2 minutes off. Continuous suction may be less painful and is often applied during the initial 48 hours of use. The foam is changed every 48 hours (except initially after grafting) to prevent tissue ingrowth, and the bandage is changed as necessary. Fluid is pulled from the wound, creating a moist environment and reducing local tissue swelling.

The benefits of NPWT therapy are increased blood flow, increased rate of granulation tissue formation, more rapid reduction in numbers of microorganisms, and greater flap survival following application of this vacuum system. In addition, this system facilitates readhesion of degloved tissue and healing of chronic wounds, acute wounds, skin flaps, and skin grafts. Complications may include pain, wound margin dermatitis, excessive ingrowth of granulation tissue, and wound desiccation with vacuum loss.

The decision to close a wound depends on many factors: the location and size of the wound, the cause of the wound, degree of contamination and infection, the patient's behavior, and cost (Table 1). Fresh, clean wounds may be addressed straight away resulting in a primary closure. Contaminated wounds, particularly bite wounds, should be managed open for at least 24 hours.

Table 1. When to close wounds.

NOW	**LATER**
Fresh, clean wound	Patient unstable
Healthy granulation bed	Penetrating bite wounds
Continuous source of contamination	Grossly contaminated or infected
High risk for nosocomial infection	Large amount of dead space
Owner convenience	Need time to plan

Delayed primary closure occurs after devitalized and contaminated tissue has been removed from the wound, but before granulation tissue has developed. Closure following the development of granulation tissue is termed secondary closure. Second intention healing is when a wound is left alone to heal by contraction and epithelialization. Large wounds require planning prior to surgery, especially if skin grafts or flaps are to be used. Dehiscence occurs as a result of tension, infection, or seroma formation. Tension can be avoided by using regional flaps, walking sutures, stents, or releasing incisions.

Seroma and hematoma formation can be minimized by the use of active or passive (Penrose) drains. Active drains are particularly useful on limbs or areas of the body where a ventrally placed drain is problematic. Active drains can be fashioned from soft tubing, a 3-way stopcock, and a 60 cc syringe, or by using a butterfly catheter and a large redtop tube. Regardless of the type of drain placed, the principles of drain placement should be followed and drains should not be used as a substitute for inadequate or inappropriate open wound care.

Table 2. Principles of Drain Placement

PASSIVE	ACTIVE	BOTH
Place exit site in most dependent position	Place exit site in any direction separate from primary incision	Keep exit sites covered to minimize ascending infection
Create exit site separate from primary incision	Attach drain tubing to closed system with suction	Remove drain in 3 to 5 days
Do not have drain lie directly under incision	Use fluid volume and fluid analysis to help make decisions about removal	

Large wounds are often managed by utilizing regional skin for coverage, for example axial pattern flaps. Axial pattern flaps are named for and harvested around a direct cutaneous artery and vein (**Figure 1**), as opposed to pedicle flaps, which rely on the subdermal plexus. Consequently, axial pattern flaps have an excellent blood supply and larger areas can be elevated and transferred to a regional wound bed in a single stage. Flaps can be elevated as a rectangular or L-design depending on the location and shape of the wound bed requiring the flap. The flap is rotated to the wound bed and either a portion of the flap is tubed across the skin between the donor and recipient beds or a bridge incision is performed.

Although a flap can be developed around any direct cutaneous artery, the most frequently described flaps used to close major skin defects in dogs and cats are the caudal superficial epigastric, thoracodorsal, caudal auricular, superficial temporal, and reverse saphenous conduit flaps. Further, the thoracodorsal and caudal superficial epigastric flaps are the most versatile and most straightforward to perform.

The thoracodorsal artery and vein are located caudal to the scapula at the level of the acromion and reasonably sized arborizing vessels extend beyond dorsal midline. Therefore, a flap of substantial length can be developed to extend to the ipsilateral carpus in the cat, while only reaching mid-antebrachium in the dog. A marking pen is utilized to outline the borders of the flap prior to incision, as careful measurements of both the defect and the flap are required. The forelimb is placed in relaxed extension and the skin overlying the scapula is manipulated to allow the skin to lie in its natural position relative to the scapula. The flap is elevated below the cutaneous trunci muscle and great care is taken not to avoid damage to the thoracodorsal vessels.

The caudal superficial epigastric flap involves harvesting the caudal three to four mammary glands. The flap is undermined below the supramammarius muscle and above the fascia of the external abdominal oblique muscle. Again, a marking pen is used to outline the flap before an incision is made. The medial incision runs along the ventral midline. The lateral incision is made parallel to the first incision, equidistant from the mammary glands. The cranial extent of the flap can be between glands one and two or two and three depending on the length of flap required. This flap is extremely versatile and can be rotated various directions to cover defects in the caudal abdomen, flank, inguinal area, perineum, thigh, and stifle. In cats, the flap can easily extend to the level of the tibiotarsal joint, while it reaches mid-tibia in the dog.

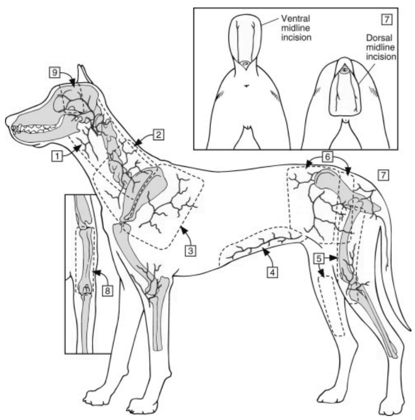

Figure 1. Direct cutaneous vessels available for axial pattern flaps in the dog.

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