WOUND MANAGEMENT AND RECONSTRUCTIVE SURGERY: THE OLD (BUT STILL GOOD !) AND SOME NEW

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Wound management

Conventional wound management techniques

Most of the wounds are suitable to conventional treatment with wet-to-dry and later in the stage of healing non-adherent bandage. I like to use sugar under a wet-to-dry bandage to facilitate the debridement time. Sugar is used for its osmotic properties. A common misbelief is that placing sugar on a wound would provide nutrients to the bacteria and promote their overgrowth. A large amount of sugar will create a severe hyper osmotic environment that would dry up the necrotic tissue and bacteria therefore inhibiting their basal metabolism. Anecdotically, sugar decreases inflammatory edema, promotes attraction of macrophages to further cleanse the wound. Sugar also has a deodorizing action.

Tie over bandage are a frequently used option to cover open wounds. Loops of large gauge non absorbable sutures are placed evenly across the wound at least 1 cm away from the wound edge. Bandages are changed one to 2 times a day.

Primary dressing for open wounds varies depending on the amount of wound exudates anticipated. Dressing can be either highly absorptive (Hypertonic saline, calcium alginate, copolymer, starch gauze) or moisture retentive (polyurethane foam or film, hydrocolloid, hydrogel) One simplistic way of using those dressings is to use the former for debridement, contaminated and highly exudative wounds in the early phase of healing and use the latter for cleaner wounds with partial granulation tissue. Below is a table (*reproduced from Krahwinkel and Boothe, Vet Clin North Am, 2006, Topical and systemic medications for wounds*) summarizing various sort of dressings potentially used to enhance wound healing and to promote infection control and debridement.

Dressings to promote infection control and debridement

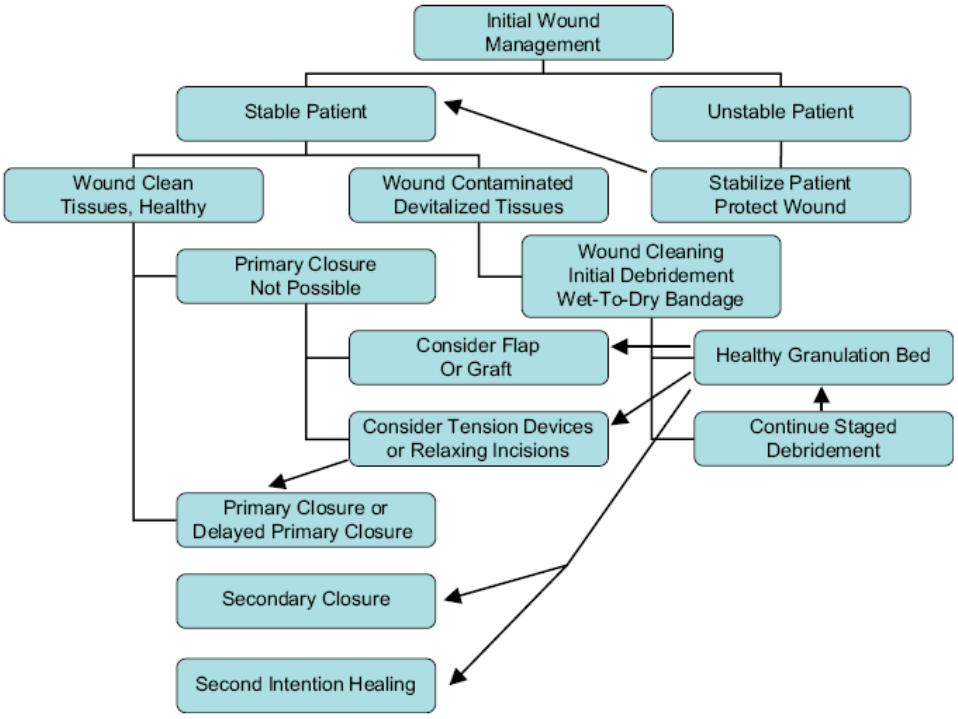
Classification	Product	Brandmane	ingredients
Topical antimicrobial	Gentamicin sulfate	Gentamicin sulfate	0.1% gentamicin sulfate
	Nitrofurazone	Fura·Septin	0.2% nitrofurazine
	Silver sulfadiazine	Silvadene	1% silver sulfadiazine
	Triple-antibiotic ointment	Neosporin ointment	Bacitracin zinc, neomycin, and polymyxin B sulfate
Topical antiseptics	Povidone-iodine solution	Betadine solution	2% povidone-iodine solution
	Chlorhexidine solution	Nolvasan	Chlorhexidine diacetate
	Dakin's solution	Dakin's solution	0.25% solution of sodium hypochlorite
	Tris-EDTA	TrizEDTA	Tromethanine edentate disodium

			dehydrate
Topical debridement	Granulex-V	Granulex-V	Trypsin, balsam of Peru, and castrol oil
	Elase	Elase	Desoxyribonuclease and fibrinolysin
	Collagenase	Santyl	Collagenase
	Papain/urea	Accuzyme	Papain and urea

Dressings potentially used to enhance wound healing

Classification	**Brand name**	**Action**	**Ingredient(s)**
Hydrocolloids	Procol, DuoDerm Tegasorb Nu-Derm	Hydrophilic	Hydrocolloid
Hydrogels	Iamin, Nu-Gel BioDres Aquacel Aquasorb,Curafil	Hydrophilic Increase growth factors Antibacterial	Tripeptide-copper complex, Hydrogel with collagen Polyethylene oxide Methylcellulose
Alginates	Curasorb, Kalginate Tegagen	Hydrophilic	Kelp (seaweed)

Decision making process in initial management of a wound *(From Dernell W, Vet Clin North Am, 2006, initial wound management)*



- PRIORITIZE! Large wounds often times come along with other lesions- never forget your complete clinical assessment even if the obvious (the wound) is starring at you!
- ALWAYS GIVE TIME FOR A WOUND TO DECLARE ITSELF !!. (Even if overwhelming for both veterinarian and owner !)- Never be overzealous with your scalpel blade and debride only what looks indisputably necrotic.
- ALWAYS TREAT PAIN AGGRESIVELY: large wounds are painful. Pain management plays a pivotal role in the comprehensive and successful treatment of open wounds.
- CLOSE ONLY WHEN TISSUE IS VIABLE. The safest way to assess viability is to see granulation tissue.

Rules for successful management of most skin wounds

Approach to the non-healing wound

Reasons for a non healing wound can be divided into several groups: those that are management related, related to the patient's overall health status, and factors relative to the wound itself. Below is a reminder list of the most common potential problems that can hamper wound healing:

***Tension*.** Tension is the most common triggering factor for complication of wound healing, especially when wounds are sutured.

Infection

Pressure/ischemia*:* Skin over bony prominences

Motion. Areas such as the axilla, inguinal area, footpads and skin over joints are subject to repeated shearing forces, which could potentially disrupt wound healing.

Devitalized soft tissues.

Malnutrition, uremia, endocrinopathies: Glucocorticoids have potent anti-inflammatory effects and will markedly slow down granulation tissue formation, and retard epithelialization.

Previously irradiated area, Chemotherapy (?)

Old age, Exposed bone, Seroma and hematoma formation, Envenomization….

Skin healing difference between cats and dogs

It appears that certain wound healing problems (chronic axillary wounds for example) are seen more commonly in cats. Studies from Dr Swaim's group (University of Tennessee) have shown differences in healing pattern between dogs and cats. Cats tend to have centripetal progression of the granulation tissue whereas dogs have centrifugal progression. Furthermore the rate of granulation tissue production is much slower in cats than in dogs. In dogs granulation tissue typically fills a 2 x 2 cm square wound by the 8th day after wounding; in contrast, most of the cats had just begun to produce a small amount of granulation by this time, and in one experimental study, none of the cats did have granulation tissue fill the wound before day 17. First intention healing strength progresses at a significantly slower rate in the cat than in the dog. Day 7 wound strength in the cats is only half of that in dogs. Furthermore, differences exist between dogs and cats in regard to the role of subcutaneous tissue in wound healing. It appears from studies done by the same group of researchers that overzealous subcutaneous tissue debridement

can severely impede wound healing especially during second intention healing. Those finding were more pronounced in cats than dogs.

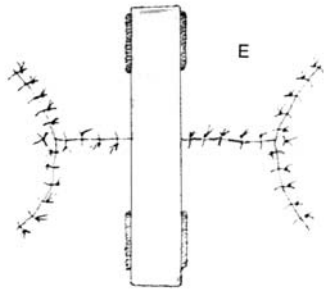
Vacuum Assisted Closure:
Vacuum Assisted Closure (VAC) is a new technology that can be used in the management of acute and chronic wounds. VAC uses medical grade open cell polyurethane ether foam as a dressing. The foam pore size is approximately 400-600 µm, which is reported to be optimal for tissue growth. The foam is cut to fit the selected wound and an evacuation tube (red rubber catheter) with side ports, which communicates with the foam, is embedded in it. An adhesive tape (Ioban ™) is then applied over the area with an additional 5 cm border of intact skin to provide an intact seal. When on a leg, the Ioban can be wrapped around and glued (stoma adhesive) to provide a better seal next to the wound. It is FUNDAMENTAL to protect the wound by placing a non adherent bandage BEFORE placing the foam, as the latter will stick to the wounds after several days! The evacuation tube is connected to an adjustable vacuum pump and a canister collects the effluent from the wound. I usually leave the bandage on for 2 to 3 days depending on the location of the wound, how the bandage is tolerated, its cleanliness etc…The vacuum pump can be adjusted in terms of continuous versus intermittent vacuum and also adjusted in the magnitude of the vacuum effect. Since blood flow to a wound peaked at 125 mmHg, this is currently recommended negative pressure that is applied to the system. The negative suction applied to the bandage is reported (at least in people) to be potentially painful.
VAC theoretically improves and accelerates wound healing. The reasons include removal of edema and exudates, reduction in levels of bacteria, mechanical stress causing granulation tissue formation and angiogenesis, and reverse tissue expansion or skin stretching. By removing excessive fluid and, it restores the vascular and lymphatic flow. Anecdotally, VAC therapy decreases the time needed for soft tissue reconstruction, shortens the total hospitalization times and lowers overall costs to the clients

Reconstructive skin surgery

Reconstructive skin surgery in dogs and cats is different from people as companion animal skin has a natural ability to stretch and deform. Therefore, relatively long flaps can be created in a “random” fashion and flaps can be rotated more readily that in human counterpart.

Skin stretchers:
Skin has the ability to stretch beyond the limits of its inherent extensibility. If a stretching force is applied over the skin , the skin will deform as a result of “mechanical creep.” In this process, the dermal collagen fibers break and leave a space colonized by fibroblasts which generate *de novo* collagen fibers. Those new fibers align parallel to the applied tension; As a result, skin stretches beyond its normal limits. If large areas of local and regional skin are stretched, there is a cumulative gain in the amount of skin recruited in the process. Upon removal of the stretching forces, the skin tends to maintain its deformed (stretched) state with little additional force: this phenomenon is termed “stress

relaxation.” Another way to stretch the skin is through the continuous suture, fishing sinker trick.



Skin stretchers: Velcro

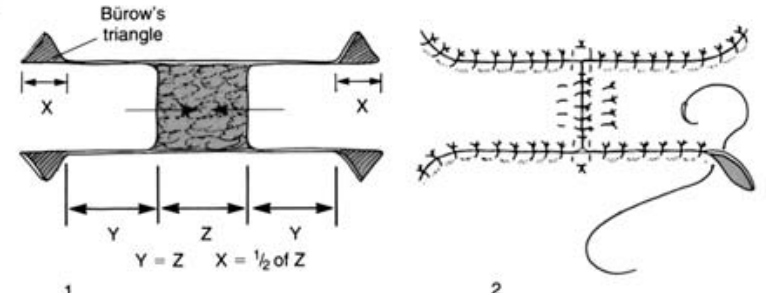
Tissue Expanders: In that case the stretching force is applied under the skin. Tissue expanders are silicone elastomeric devices placed in a subcutaneous pocket with an injection port attached. Tissue expanders are placed where additional cutaneous tissues are required for wound closure. A special hypodermic needle (Huber needle) is inserted into the injection port, transcutaneously, and sterile saline is injected in increments, often using an alternate day schedule. In humans those pockets are filled with saline until the patient feels discomfort from the stretch. The goal is that the tissue expander forces the skin to stretch and deform permanently; upon completion of the expansion, the device is removed and the overlying skin used to close the adjacent skin defect either by its simple advancement, or by creating a transposition flap (see infra) that will rotate into the recipient site. This technique is most popular in humans because of the lack of extensibility of human skin compared to companion animals. Even if applicable to veterinary patient, the use of skin expanders remains anecdotic.

Flaps

Random Flaps

By definition, random flaps are flaps nurtured by a random vascular supply (i.e. sub dermal plexus) as opposed to a known determined axial blood supply as axial flaps are (see infra).

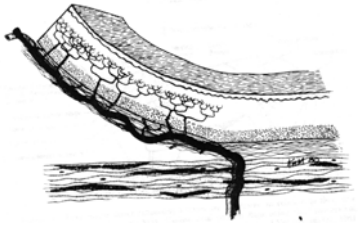
The main advantage of random flaps lays in the ability for the surgeon to create flaps in any area of the skin granted that strict compliance to dimension rules is respected. Basically, the length of the flap CAN NOT be more than 1.5 times the width (or base) of that flap. Furthermore, the use of these local flaps is usually limited to open wounds in the immediate vicinity of the flap base. Advancement, rotation and translation flaps all fall under the terminology of random flaps and can be safely used to treat the vast majority of open wounds.

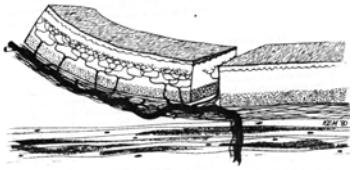


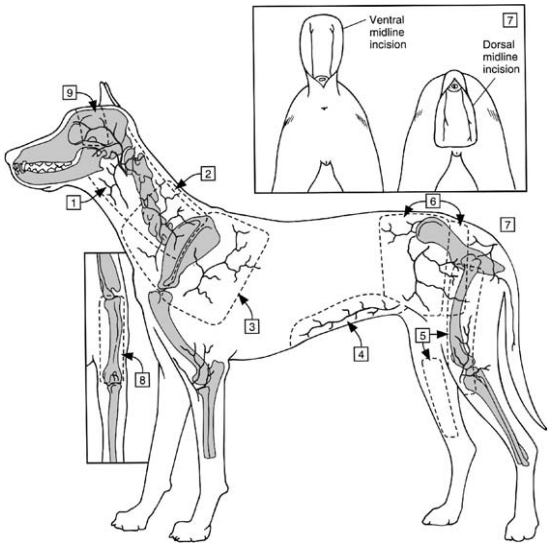
Example of a random flap : monopedicular advancement flap

Axial Flaps

An axial pattern flap is a skin flap containing a single, consistent direct cutaneous artery, vein and nerve that supply a specific region of dermal tissue. As a result, axial pattern flaps have a more (reliable) and robust blood supply as compared to randomly chosen local flaps, which rely on the subdermal plexus alone for their circulation. The main advantage of axial pattern flaps over randomly chosen subdermal flaps is that they can be made with a narrow base or with no skin connection, thereby allowing considerable flexibility in flap rotation and transfer of skin to more distant areas. Since the blood supply is well preserved and the flaps are created from full-thickness skin, the cosmetic appearance of the flaps is considered excellent.


Typical axial flap


Island flap (connected only by the vascular supply)



Blood supply (direct arteries) and anatomic boundaries for the most common axial pattern flaps . Numbers refer to next table.

List of axial flaps in dogs and cats.

* most commonly used axial pattern flaps

Name of the Flap	Clinical Application-
Caudal Auricular Axial Flap (1)	lateral aspects of the head, cervical area
Omocervical Axial Flap (2)	head and neck and axillary region
Thoracodorsal Axial Flap (3)*	thoracic defects, proximal forelimb defects, axillary region
Caudal Superficial Epigastric Axial Flap (4)*	flank defects, perineal defects, stifle defects, preputial area
Genicular Axial Flap (5)	medial or lateral aspects of the proximal pelvic limb
Deep Circumflex Iliac Axial Flap (6)	pelvic and sacral defects, flank defects, lateral abdominal wall, defects over the greater trochanter
Superficial lateral caudal(7)	Perineum, caudal aspect of the tigh
Superficial Brachial Axial Flap (8)	elbow and proximal forelimb defects
Superficial temporal.(9)	Rostral portion of the head

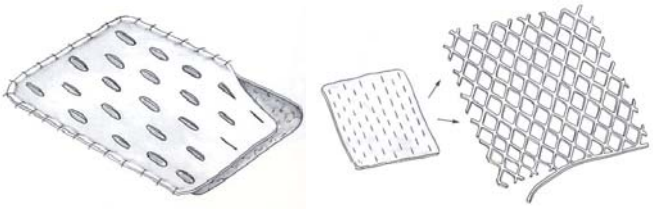
A perfect knowledge of the boundaries (please refer to Surgery textbooks) of the flap (especially knowing precisely where the direct cutaneous vessel originates so accidental disruption during flap dissection is avoided) as well as strict application of non traumatic surgery principles are essential to perform an axial flap procedure. Partial flap necrosis is a frequent complication of axial pattern flap reconstruction and additional wound care or surgical intervention to achieve healing is often times warranted. Dehiscence of donor site incisions is usually due to excessive skin tension. Always be prepared to deal with potential complications and potential lengthy wound management if partial or complete flap necrosis happens!

Grafts:

Skin grafts autologous pieces of skin and are classified as full or split thickness. Full-thickness skin grafts incorporate the entire dermis and epidermis. Split-thickness skin grafts (epidermis and a potion of the dermis) may be further classified as thin, intermediate, or thick split-thickness grafts depending on the relative thickness of dermis incorporated into the graft. Full thickness skin grafts are more easily harvested by surgeons without extensive experience in grafting techniques and without special equipment (dermatome). However they “take” less readily as their nutrient needs are increased compared to split thickness grafts. Full-thickness grafts also carry a full complement of adnexal structures that provide a better cosmetic result than for split-thickness grafts.

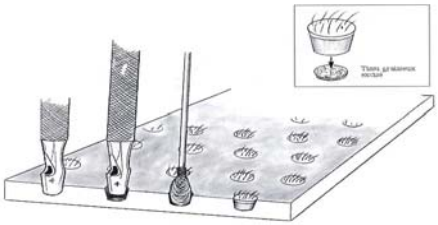
Skin grafts can also be named after the configuration of the graft. One can harvest graft in 1) sheet which corresponds to a single piece of skin sutured on the recipient bed. In that configuration there is no room for the exudates an serum to escape and their rate of failure is extremely high (not recommended), 2) mesh : provides partial coverage and is

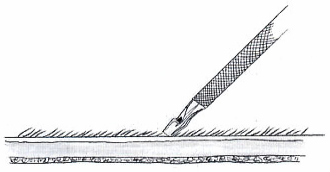
created with perforation through the entire thickness of the skin (mechanically or by



hand) (most preferred method),

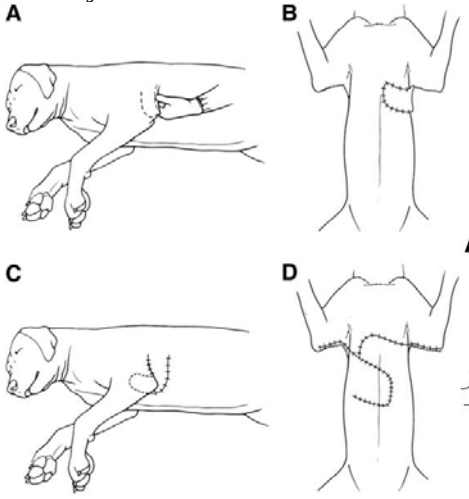
3)strip , or 4) seed (harvested with a biopsy punch).



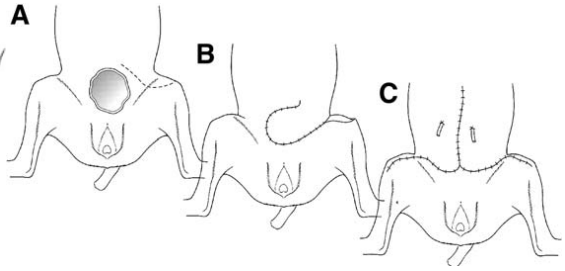


Skin fold advancement flaps

The use of skin fold advancement flaps for closing large sternal and inguinal wounds was first described in 1996 by Dr Hunt. Refinements to the technique enabling closure of lateral trunk wounds and wounds of the upper fore and hind limb were published in 2000.Those flaps can be used to assist closure in the following anatomic sites: Sternum, Inguinal area, Pubis Lateral elbow, Lateral thigh and stifle, Thorax, Flank Sacrum, Lateral neck. Those flaps take advantage of the redundant skin (folded) in the inguinal and auxiliary area. Limitation of motion is generally not an issue postoperatively.



Axillary skin fold advancement flap



Inguinal skin fold advancement flap

References:

1. Bohling MW, Henderson RA, Swaim SF, Kincaid SA, Wright JC. Cutaneous Wound Healing in the Cat: A Macroscopic Description and Comparison with CutaneousWound Healing in the Dog.Vet Surg 33:579-587, 2004.
2. Bohling MW, Henderson RA, Swaim SF, Kincaid SA, Wright JC. Comparison of the role of subcutaneous tissue in cutaneous wound healing in the dog and cat.Vet Surg 35:3-14, 2006.
3. Ben-Amotz, R. O. N., Lanz, O. I., Miller, J. M., et al. The use of vacuum-assisted closure therapy for the treatment of distal extremity wounds in 15 dogs. Veterinary Surgery 36: 684-690, 2007
4. Hunt, G. B., Tisdall, P. L. C., Liptak, J. M., et al. Skin fold advancement flaps for closing large sternal and inguinal wounds in cats and dogs. Veterinary Surgery: 30; 440-448, 2001
5. Hosgood, G. Stages of wound healing and their clinical relevance. Vet Clin North Am Small Anim Pract 36, 667-85, 2006.
6. Aper R, Smeak DD. Complications and outcome after thoracodorsal axial pattern flap reconstruction of forelimb skin defects in 10 dogs, 1989-2001.Vet Surg 32:378-84, 2003.