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College of Veterinary Medicine

TREATMENT OF COMPLICATED WOUNDS

A Graduation Project Submitted to the Department Council of the Internal and Preventive Medicine-College of Veterinary Medicine/ University of Al-Qadisiyah in a partial fulfillment of the requirements for the Degree of Bachelor of Science in Veterinary Medicine and Surgery.

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بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

فَتَعَٰلَى ٱللَّهُ ٱلْمَلِكُ ٱلْحَقُّ ۗ وَلَا تَعْجَلْ بِٱلْقُرْءَانِ مِن قَبْلِ أَن يُقْضَىٰٓ إِلَيْكَ وَحْيُهُۥ ۖ وَقُل رَّبِّ زِدْنِى عِلْمًا ﴿١١٤﴾

صَدَقَ اللهُ العَظِيمُ

من سورة طه

Certificate of Supervisor

I certify that the project entitled (**Treatment of Complicated Wounds**) was prepared by **علي جميل هيجل** under my supervision at the College of Veterinary Medicine / University of Al-Qadisiyah.

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22 / 5 / 2021

Certificate of Department

We certify that **علي جميل هيجل** has finished his/her Graduation Project entitled (Treatment of Complicated Wounds) and candidate it for debating.

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Summary

Any wounds do not heal naturally, posing a risk to the doctor. There are wounds that are unable to treat. There are a variety of reasons for such wounds, and when they arise, the veterinarian should understand all of the factors involved. Diagnostic assessments should be carried out as they are recommended. Finally, action should be taken to address the root cause of the difficult to heal wound.

INTRODACTION

A wound is a disruption to the body's tissues anatomic, physiologic and mechanical integrity**.** The healing process starts as soon as the wound is inflicted and proceeds in a complicated and well-coordinated series of steps. Delayed healing and chronic or non-healing wounds arise from the failure of any part of the process or the disruption of any point. While most wound injuries are not life threatening, they can cause the animal to be in pain for a long time and necessitate further veterinarian treatment, as well as higher costs for the owner. Many wound conditions, though, can be safely treated with the right care. This article explains what to expect from a typical healing wound in animals, as well as the most common causes of complications and how to deal with them. Therefore Wound treatment that ignores patient factors and fails to provide adequate wound therapy can stall the healing process and prevent the skin from regaining its normal structure and function [(1)].

Phases of wound healing

- Inflammatory Phase
- Proliferative Phase
- Debridement or destructive phase
- Maturation and remodeling

While the stages of wound healing are separated for ease of discussion, phases can overlap, and a wound can have sections that are in various phases at the same time. Wound healing processes begin as soon as the wound or incision develops, and the timeline below shows a normal, noninfected skin wound in an otherwise healthy patient.[(2)]

Inflammatory Phase: Time 0

Vasoconstriction happens as a result of endothelin synthesis and the release of epinephrine, norepinephrine, and prostaglandins at the moment of wounding [(4)]. Platelet aggregation and coagulation, as well as fibrin and fibronectin crosslinking, result in clot forming and the formation of a scaffold [(5)] . The fluid engorgement facilitates the movement of healing and repair cells to the wound site. Damaged cells, parasites, and bacteria are eliminated from the wound region during the inflammatory process. Swelling, heating, discomfort, and redness are normal during this stage of wound healing because of these white blood cells, growth factors, nutrients, and enzymes. Inflammation is a normal part of the healing process and is only a concern if it lasts for long.

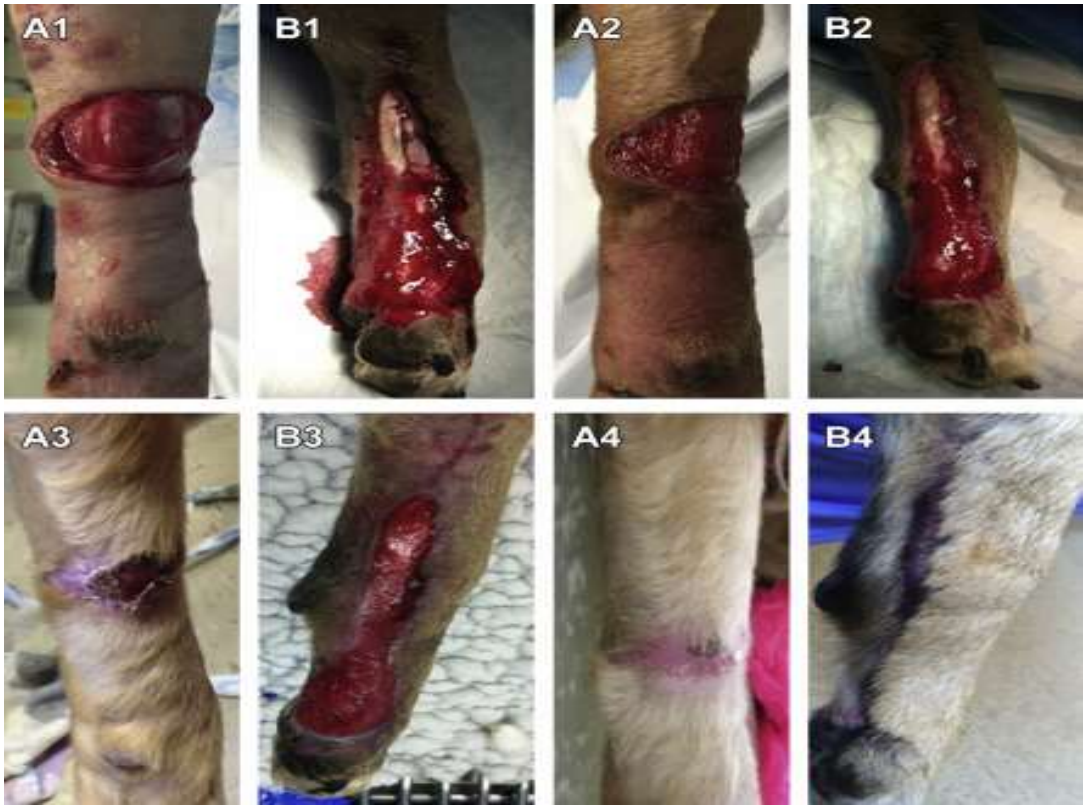


Fig. 1. Stages of wound healing for a surgical resection of a sarcoma (A) versus traumatic wound (B) by second intention healing. (A1, B1) Inflammatory phase, day 1. (A2, B2) Repair phase, at days 12 and 4, respectively. (A3, B3) Late repair phase, days 34 and 7, respectively. (A4, B4) Maturation phase, days 41 and 120, respectively

Debridement Phase: Time 6 to 12 Hours After Wound injury

Debridement is the next phase of inflammation. Although neutrophils phagocytose bacteria, monocytes, rather than neutrophils, are consider essential for wound healing. Monocytes secrete a number of growth factors required for wound healing. Additionally, after migration out of the blood vessels, monocytes are consider macrophages. In addition to the phagocytosis of necrotic debris, macrophages also attract mesenchymal cells. Finally, mononuclear cells may coalesce to form multinucleated giant cells found in chronic inflammation. Lymphocytes may also be present in the wound and contribute to the immunologic response to foreign debris.

Proliferative phase: 3 to 12 Days After Wound Initiation

This phase is composed of 3 distinct processes, namely, fibroplasia, angiogenesis, and epithelialization (see **Fig. 1A2, B2**). The prominent cell types are fibroblasts, endothelial cells, and epithelial cells

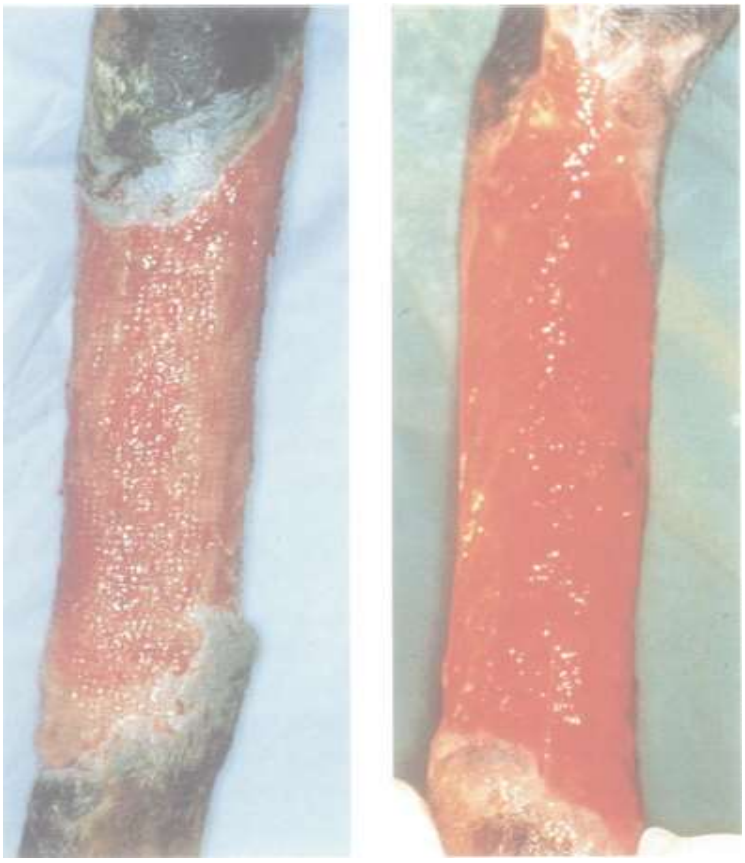
Early repair commences three to five days after initial insult Fibroblasts and endothelial cells predominate . Fibrin and fibronectin act as a scaffold for fibroplasia Epithelial cell migration Granulation tissue formation and epithelialization Commencement of wound contraction

Maturation Phase: 7 Days to Several Months after Wound

The main event during this phase is the strengthening of the newly formed collagen. Over time, collagen fibers become thicker and progressively more cross linked. They align with the tension lines of the body and nonfunctionally oriented fibers are degraded. Remaining fibroblasts in the wound differentiate into myofibroblasts under the influence of TGF-b. Myofibroblasts are contractile and therefore can continue to pull the wound edges together. The greatest increase in wound strength occurs in the first 7 days of this phase or approximately 1 to 2 weeks from the time of wounding, because this is the time of greatest collagen deposition . 6 The maturation phase may continue for months, eventually leaving a scar that is 80% of the tissue's original strength before wounding (see **Fig. 1A4, B4**) [(7)(6)]

Closure options for wounds

- **primary closure** of a wound is typified by the clean surgical wound where the tissues and skin edges are brought into apposition by sutures and healing is expected to be complete. with minimal scarring within 10 days



Chronic degloving injury of the right forelimb of a dog .with inactive granulation tissue far right) After debridement using) wet to dry dressings the wound has bright red active granulation tissue and is suitable for grafting or a reconstructive procedure

- **Delayed primary closure**. This is generally used for wounds with minimal contamination or those with questionable viability, oedema or skin tension, or in cases where early wound closure cannot be performed for other reasons . After initial open wound management, surgical closure is performed from day 2 to day 5
- **Secondary closure**. This is reserved for contaminated or dirty wounds. After open wound management, closure is performed between day 5 and day 10, when a healthy bed of granulation tissue is present

- Healing by second intention. This is generally reserved for dirty or infected wounds or large skin defects. Healing relies on the formation of granulation tissue, wound contraction and epithelialisation. Choosing which of these four basic methods to use depends on the aetiology of the wound, its size, location and the degree of contamination. Wound classification according to the degree of contamination is an important factor to consider when selecting a closure method

(Table1) Wound classification system

Class	**Description**
Clean	Surgical wound in which no inflammation is encountered and the respiratory, alimentary, genital, and urinary tracts are not entered. Most often closed primarily with or without appropriate drainage.
Clean-contaminated	Surgical wound in which the gastrointestinal, alimentary, genital, or urinary tracts are penetrated without unusual contamination, injury, or a breach in sterility.
Contaminated	Wounds that are open, fresh, and have occurred by chance. Significant sterile procedure breaks in a surgical cut. The gastrointestinal tract has a gross spillage. Acute nonpurulent inflammation in the incisions.
Dirty–infected	Old traumatic wounds with devitalized tissue that hasn't healed and/or an inflammation or perforated viscera.

Causes of complications

A wound's failure to heal can be caused by a single factor or a combination of factors, and good management necessitates the absence of these root issues. By following healthy, simple surgical rules, the surgeon will reduce the risk of complications.[14]

Infection

It's important to distinguish between a wound infection and wound contamination. Contamination is described as the appearance of microorganisms in a wound that have not elicited a response from the host; it may also involve gross debris. Infection is described as the presence of microorganisms in excess of 10^5 per gram of tissue[7]. Any infection that occurs in the operating site following an operative operation is referred to as a surgical site infection (SSI). Incisional and organ/cavity infections are examples of (SSI). Infection impedes wound healing at all times and can be the cause or result of wound dehiscence. Culture of deep tissue is the easiest way to confirm wound infection, and it's important to remember that surface pollutants don't indicate infection. At suture withdrawal approximately 3% of wounds are confirmed to be contaminated, although infection rates differ depending on the original degree of wound contamination[9] (table1) . The physical characteristics of a wound also influence the likelihood of infection. Since it prevents adequate drainage and forms a closed, hypoxic cavity, a puncture wound from a cut, for example, is an excellent environment for bacterial growth and infection. Hair removal is required in veterinary medicine due to the amount of hair our

patients have, and it should be performed with clippers right before surgery; razors should not be used on a regular basis.[10] When hair is trimmed around wounds, the wound can either be covered temporarily or lubricated with a clean, watersoluble lubricant to prevent infection. Maintaining normothermia, normal blood pressure, normoglycemia, and adequate tissue oxygenation are all suggested as ways to reduce the risk of (SSI).[11]

Nutrition

Since the healing of big wounds puts the animal in a catabolic condition, nutrition is essential in postoperative patients. Wound healing and strength can be reduced in malnourished animals or animals with comorbidities that allow their serum protein to be less than 2.0 g [12] . Protein deficient diets have been shown to slow wound healing. In animals with large or permanent wounds, it's important to make sure they get enough calories and protein. [13]

Abscesses

The development of an abscess is normal and normally occurs as a result of a puncture wound eg,(a bite). Localized erythema, oedema, humidity, incisional dehiscence, fever, and pain are all symptoms of abscesses. Many smaller abscesses react well to gentle excavation, flushing, debridement, and seven to ten days of systemic broad spectrum antibiotic support. Large abscess cavities can be handled by filling them with moistened gauze packs and changing them three times a day, hopefully. Closed vacuum drains can be used for several days to extract pus and infectious tissue fluids in certain deeper body abscesses, but only until necrotic tissue and foreign particles have been eliminated. Biopsies of the abscess wall are

recommended. Immunosuppression caused by multiple chemotherapeutic agents or disease (eg, feline leukemia virus, feline infectious peritonitis) should be treated in cases of unexplained or persistent abscess development. Cellulitis with gradual necrosis may be a symptom of autoimmune diseases and immune mediated vasculitis. epithelialization, however a biopsy of the tissue would be advisable to rule out underlying tumor recurrence. [14]

Neoplasia

Non healing wounds can be caused by a variety of skin and subcutaneous neoplasms (eg, squamous cell carcinoma). The wound is often caused by a tumor outgrowing its vascular supply, which leads to ulceration and necrosis. To diagnose such neoplastic lesions, a wound biopsy is needed. Following a diagnosis, the requisite medical, radiologic, or surgical treatment is provided, depending on the type of neoplasia. [15]

Chemotherapy and corticosteroids

Corticosteroids are anti-inflammatory drugs with a lot of strength. It's important to note that inflammation is a crucial part of the wound healing process. As a result, lowering it with corticosteroids during the early stages of wound healing will slow down the healing process. Steroids have the strongest benefit early in the healing process [2], but they can also be harmful later in the healing process. Corticosteroids block cyclooxygenase and 5-lipoxygenase. As a result, the arachidonic acid inflammatory pathway is shut down. Steroids inhibit angiogenesis, vascular permeability, phagocytosis, and lysosomal membrane stabilization. Glucocorticoids hinder collagen production by suppressing fibroblasts and have antimitotic activity on keratinocytes, slowing epithelialization.

The effect is slowed healing [1,16] . Exogenous steroid therapy, including topical steroids, should be stopped while other wound treatments are continued when treating slow-healing wounds. Steroid use raises the risk of new infection or resistance to infection, as well as the potentiation of an ongoing infection. Cortisone's symptoms are amplified in the presence of malnutrition and protein deficiency, and a low dosage effectively prevents fibroplasia. Healing is unaffected by single doses.[2] Chemotherapeutic cytotoxic agents can affect the rate of wound healing[2,16,17]. These medications have an effect on dividing cells, which may have an impact on wound healing. Wound healing is influenced by the mode of action, the dosage, and the timing of administration. Wound healing is influenced by the mode of action, the dosage, and the timing of administration. As a result, clinical and laboratory trials have been difficult to understand, and no general conclusions about the impact of these medications on wound healing can be drawn. There are no specific guidelines for the use of these agents in animals after surgery. High doses administered before or shortly after injury seem to have the strongest effect on recovery.[2]

Wound dehiscence

Impending wound injury is often shown by necrosis of the skin margins, extreme cutaneous swelling, the appearance of serum under the skin, and serosanguineous discharge from the suture line. Tension can be reduced by orientating the suture line parallel to the tension lines in the skin, and also by using undermining, skin stretching, relaxing incisions, tension-relieving suture patterns, and flaps or grafts. Staged debridement should be carried out until all nonviable and

questionable tissue has been removed from the wound, before closure is attempted . To keep animals from playing with injury, use a supportive bandage, basket-type muzzles, or Buster collars. Decubital ulcers at bony prominences may be caused by improper bandaging (Fig 2). Weak and sparsely haired skin, rubbing between skin and bedding or skin and bandaging, insufficient bedding content, and skin maceration from urine and feces are all predisposing factors.

Fig 2: Full-thickness pressure necrosis above the olecranon in a greyhound after improper bandaging

Complication of wound:

1- Bleeding. 2- Infection. 3- Emphysema.
4- Tetanus 5- Damage to nerve tissue. 6- Cellulitis
7- Thrombosis

The steps involved in treating complex wounds

- searching for and treatment of life-threatening trauma/conditions
- obtaining thorough history and physical examination
- examining the wound using aseptic technique to prevent further contamination
- anesthetizing the wound before cleansing
- performing hair removal, skin disinfection, hemostasis, surgical debridement and mechanical cleansing
- use of antibiotics and drains and open wound management. Prompt and thorough assessment and timely operative management are key to optimal treatment of complex wounds

MANAGEMENT OF THE WOUND

The aim of wound management is to optimise the conditions for wound healing. Depending on the wound, this may mean preparation for primary closure or temporary decontamination and debridement until closure is possible or healing has occurred. The first stage is decontamination as far as possible, given the state of the wound and the condition of the patient. The second stage is debridement of necrotic or devitalised tissue and removal of any foreign debris. Chronic wounds may result in granulomas and prolonged morbidity.

LAVAGE

The aims of lavage are to remove gross debris and to dilute bacterial contamination[18]. Gross infection or necrotic tissue may be washed away with a hand shower and soft tap water lavage. The wound is then lavaged more thoroughly. To avoid further infection, the wound should be cleaned sterilely, and

the clean area around the wound should be covered or rescrubbed as required.

Choice of solution

Isotonic saline or lactated Ringer's solution are the best lavage solutions. This is used in large quantities to dilute and wash out bacteria and debris while causing no physiological harm to the wound bed's normal cellular processes. Copious gentle lavage using isotonic solutions, together with careful wound debridement, is the perfect. Antiseptic solutions can have a role in the treatment of badly infected wounds, where necrosis and lysis are more important than host cell proliferation, as well as in immunocompromised patients that are more susceptible to infection. Antibiotics have also been applied to lavage solutions, especially in wounds that have been anaerobically contaminated. Antibiotics that are soluble, such as metronidazole, penicillins, and neomycin, but it is questionable whether the antibiotic will reach a sufficient concentration for long enough. Antiseptics or antibiotics should never be used in place of proper surgical debridement. Both compounds applied to a lavage solution have the ability to harm the bacteria as well as the cells of the host. As a result, antiseptic liquids must be used at the proper dosage. In very necrotic or purulent wounds, repeated lavage will be necessary to gain the benefits of the bactericidal action of the antiseptic.[(19)]

SOLUTIONS SUITABLE FOR LAVAGE OF OPEN WOUNDS		
Solution as supplied	**Concentration (%) for lavage**	**Indications**
Sterile saline	0.9	Any wound
Lactated Ringer's solution	As supplied	Any wound
Chlorhexidine 4% (Hibiscrub ; Mallinckrodt)	0.05	Contaminated or infected wounds
Povidone-iodine (Pevidine; BK Veterinary Products)	1	Contaminated or infected wounds

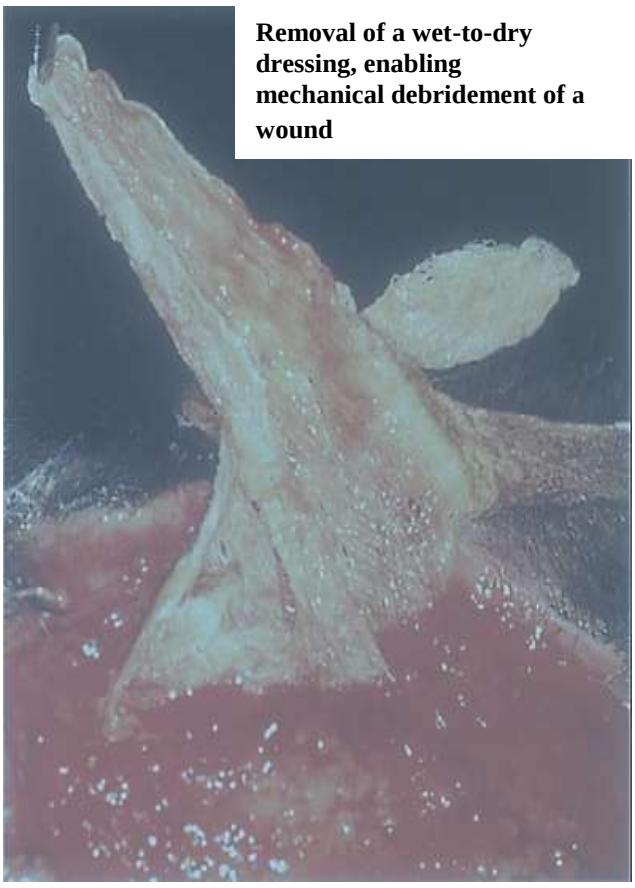
DEBRIDEMENT

The purpose of debridement is to remove devitalised, contaminated or damaged that may delay healing tissue ,and foreign material from the wound This allows rapid onset of the proliferative phase of healing ,will enable the veterinarian to investigate the extent of the injury to the underlying structures. In order to turn the wound into a surgically clean wound, good wound debridement will require a variety of approaches and procedures. If there is some doubts about the quality of the tissue, the wound can be debrided in stages over a few days.

Surgical debridement is the most effective way to clear grossly infected tissue before suturing a wound, whether as part of a staged process of partial debridement of non-viable tissue. Incisions can be made with a small scalpel, and lavage can be repeated as debridement progresses. Fat should be resected liberally with selective surgical debridement; however, caution must be taken not to injure the subdermal plexus or the vascular supply to the skin. Surgical debridement should be used for both initial and delayed closures, as well as second-intention recovery. Skin hooks should be used to protect the edges of the skin. Retractors should not be used. Haemostasis is important to prevent haematoma formation and the separation of wound surfaces . The exploration should be thorough enough to determine the wound's boundaries without contaminating surrounding tissues or disrupting the fascial planes of tissue, which serve as natural barriers to bacterial invasion.

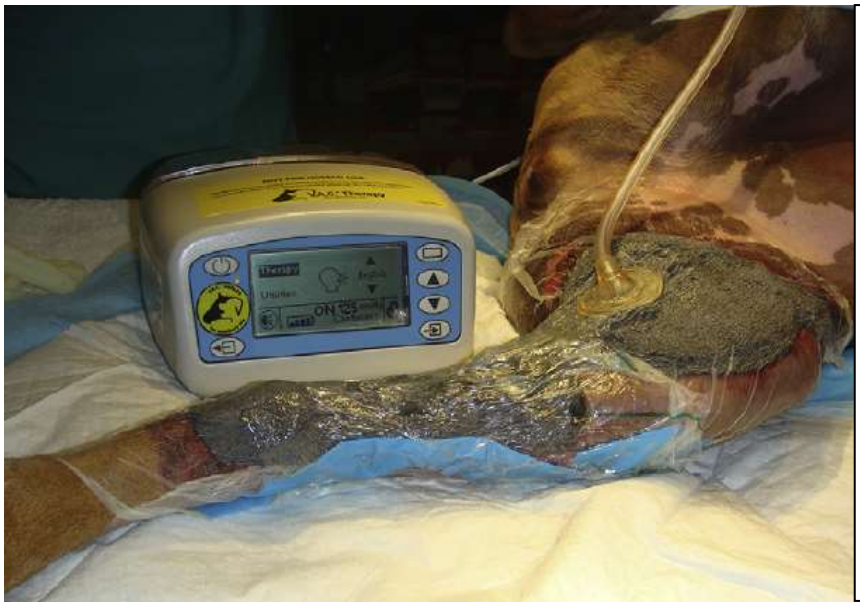
Dressings debridement. These allow further debridement of the wound after surgical excision of grossly devitalised tissue has been completed. They are especially useful in encouraging rapid establishment of granulation tissue in the management of

wounds healing by second intention and also allow debridement of contaminated or infected wounds.



Removal of a wet-to-dry dressing, enabling mechanical debridement of a wound

The primary dressing layer is an adherent open weave mesh (sterile surgical swab), which is protected by standard secondary and tertiary bandage layers. This mesh traps debris and necrotic tissue which is then removed at each dressing change. A 'dry-to-dry' dressing (dry mesh gauze) is occasionally indicated where there is a profuse low viscosity exudate. For a 'wet-to-dry' dressing, the gauze is applied wetted with sterile saline and removed once dry. Wet-to-dry dressings can be useful for gently debriding excessive granulation tissue, or restimulating chronic granulation tissue. Additionally, any wound that is purulent, malodorous or slow to heal, with retreating epithelial edges, may benefit from one to three days of wet-to-dry dressings. Adequate debridement in this way often controls bacterial infection in the wound more effectively than high dose antibiotic therapy. Wet-to-dry dressings are not used on exudative wounds, as they can macerate the tissues and cause more damage. It is vital that these dressings are changed daily, in order to prevent desiccation or maceration of the wound. (20)



(Fig. 3) NPWT , Tubing connects the dressing to a programmable vacuum pump and wound exudate is collected in a canister attached to the pump. maintained at a pressure of approximately 125 mm Hg

NEGATIVE PRESSURE WOUND THERAPY

Negative pressure wound therapy (NPWT) has been shown to increase granulation tissue formation, minimize bacterial load, improve blood flow, reduce hematoma and seroma formation, and boost cytokines and growth factors.[21] Some of these factors have been investigated in randomized, blinded, prospective studies and others are based more on clinical observation than scientific data. NPTW was originally investigated in veterinary medicine for use over traumatic wounds; however, studies have shown use with grafts and flaps as well as in cases of primary closure.[22][23] NPWT can be used as a temporary measure in wounds that heal by second purpose or in wounds where the ultimate target is delayed primary closure.[24] Lavage and necrotic tissue debridement are used to treat the wound at first. The NPWT system is then placed and maintained at a pressure of approximately 125 mm Hg. Specialized access tubing connects the dressing to a programmable vacuum pump, which subjects the entire wound to an evenly distributed negative pressure. Wound exudate is collected in a canister attached to the pump **(Fig.3)** Ideally,

NPWT is used in the inflammatory and early repair phases. Once granulation tissue is present, NPWT may delay wound epithelialization and contraction [25] Management benefits of NPWT include less frequent bandage changes than traditional bandages. When used in less tolerant animals, general anesthesia may be required for NPWT bandage changes, but at a minimum, sedation is necessary for most animals. The cost of an NPWT system and the cost of the materials should be taken into account when planning wound management.

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