What’s new in Wound Management?

Gary W. Ellison, DVM MS DACVS
University of Florida, College of Veterinary Medicine
Gainesville, FL

Vacuum assisted Wound Closure

Vacuum-assisted wound closure (VAC) is a non-invasive, active, wound management therapy exposing the wound bed to local sub-atmospheric negative pressure through a closed system in order to facilitate wound healing. Initially introduced in human medicine for the treatment of chronic wounds, VAC removes fluid from the extra vascular space, improving circulation and enhancing the proliferation of granulation tissue.

A VAC system consists of several elements. Sterile polyurethane open-cell foam is cut to conform to the surface of the wound. The foam is placed within the wound making sure the foam is in contact with the entire wound surface. An egress tube runs from within the foam to another tube, which is connected to a reservoir and a vacuum pump. A plastic sheet with adhesive on one side is placed over the sponge and around the tubing creating an airtight seal with the skin around the wound margin. Sub-atmospheric pressure then applies a controlled suction force uniformly to all tissues on the surface of the wound.

Beneficial effects on wound healing have been documented in several animal models. Reported benefits include increases in tissue blood flow, granulation tissue formation and skin flap survival when compared to conventional bandaging techniques. VAC wound dressings also demonstrate a significant increase in the rate of bacterial clearance in experimentally infected models.

Based on promising results in animal models, VAC has become a mainstay in human wound management. The successful treatment of acute, sub-acute and chronic wounds is well documented throughout human medical literature. Vacuum-assisted closure has been used to treat degloving injuries, compartment syndrome, dehiscence of surgical wounds with or without exposed orthopedic implants, bones, ligaments or tendons, and to prevent post-operative seroma formation. VAC dressings have gained wide acceptance as a bolster dressing for full and split-thickness skin grafts and to enhance re-epithelialization of skin graft donor sites. The utility of VAC has also been recognized in human emergency medicine for the treatment of abdominal compartment syndrome, damage control laparotomy, open drainage of both the abdominal and thoracic cavities and non-surgical treatment of enterocutaneous fistulas.

EQUIPMENT AND APPLICATION OF VACUUM-ASSISTED CLOSURE DRESSINGS

It is essential that basic wound care principles be applied to all wounds prior to the application of VAC therapy. Proper debridement of devitalized tissues is essential for
successful wound closure and to eliminate any potential nidus for bacterial growth. Inability to thoroughly debride wounds prior to the application of VAC may result in the proliferation of granulation tissue over necrotic tissues resulting in delayed wound healing and abscess formation.

The vacuum-assisted wound closure device and methodology are subject to United States and foreign patents, and applications assigned to Wake Forest University. A worldwide license for VAC has been assigned to Kinetic Concepts, Inc. (KCI), San Antonio, TX. The VAC is a trademark of Kinetic Concepts, Inc. A VAC system has several essential elements. Sterile open cell polyurethane foam, plastic egress tubes, collection reservoirs and an adjustable suction pump capable of intermittent or continuous negative pressures ranging from –50 mm Hg to –200 mm Hg are all available through Kinetic Concepts Inc. The open cell polyurethane foam is available in three sizes. Each foam dressing comes in a sterile package with two transparent plastic self-adhesive sheets. The foam can be cut to conform to the shape of the wound. The foam should be placed within the wound so that it is in contact with the entire wound surface especially the deep margins of the wound. Foam should be placed within the wound fully expanded and care should be taken to avoid tightly packing foam into wounds. Foam bandages available through KCI are often too large for dogs and cats. The foam can be cut to shape and excess foam utilized in future VAC bandages.

A plastic fenestrated egress tube is inserted into a hole cut into the foam or placed between 2 pieces of foam. Placement of the tube fenestrations directly on the wound should be avoided as this may cause pressure necrosis in tissues around the fenestration sites and result in clogging of the vacuum system. Once the foam and plastic tubing are in place, the two are then covered with an adhesive plastic sheet that extends several centimeters beyond the wound margins. In veterinary patients it is helpful to cleanly shave all hair surrounding the wound in order to facilitate adherence of the plastic sheet and establish an airtight seal. In areas with difficult bandage conformation, we have also found it helpful to apply stoma paste to the skin around the wound to aid in adherence of the skin to the plastic adhesive sheet. It is essential that an airtight sealed be established in order to maintain constant negative pressure and prevent desiccation of the underlying tissues. The egress suction tube is then attached to a collection reservoir and to the vacuum pump. When the bandage is properly placed, a closed system is created consisting of the wound, foam, suction tube, collection reservoir and suction pump.

A continuous negative pressure setting of 125 mm Hg is most commonly used. Initial animal studies showed improved blood flow and granulation tissue formation with intermittent suction; however, when intermittent suction was performed in the clinical setting on human patients, increased wound discomfort was noted. For weeping wounds and post-operative prevention of seroma and edema formation, a lower negative pressure setting of 50 mm Hg is used.

The frequency of VAC bandage changes depends on the characteristics of the individual wound. Vacuum-assisted closure bandage dressings are typically changed every 2 to 3 days. If VAC bandages are left in place over 4 to 5 days, granulation tissue may grow into the open cell foam requiring surgical removal of the foam bandage. Highly contaminated and infected wounds may require daily bandage changes and copious lavage. If a foul odor is noted while changing VAC bandages, bandage changes should be performed more frequently and hydrotherapy initiated. In veterinary patients, bandage changes can usually be performed under heavy sedation. If extended VAC therapy is to be performed, the foam can be cut out through the plastic adhesive sheets while leaving the portion of the sheet adhered to the skin in place. This reduces skin irritation and minimizes discomfort experienced during bandage changes. New adhesive sheets are placed over the previously applied bandage to avoid pulling the adhesive sheet away from the skin.
APPLICABLE HUMAN LITERARY REVIEW

Non-Healing Wounds

Vacuum-assisted closure was initially developed for the non-surgical treatment of chronic non-healing wounds in human patients. A report of 175 human patients suffering from chronic non-healing wounds attributed to pressure ulcers, dehisced wounds, venous stasis ulcers, radiation ulcers, vasculitic and diabetic ulcers. Of the 175 patients treated with VAC therapy, 171 responded favorably resulting in complete closure or closure following a less invasive skin graft or skin flap. In a study comparing VAC versus traditional wet-to-dry bandages for the treatment of 36 chronic non-healing wounds, VAC treated wounds decreased in size by 78% compared to a 30% size reduction in wounds treated with wet-to-dry bandages. Histologic evaluation of VAC treated wounds also showed marked granulation tissue formation and angiogenesis while the wet to dry treatment group showed inflammation and fibrosis.

Surgical Dehiscence

Vacuum-assisted closure has been used extensively in human surgery for the closure of surgical dehiscence’s. Closure of median sternotomies and various spinal and orthopedic procedures have all been reported. The use of VAC therapy has been shown to decrease the wound management time required before a delayed secondary closure could be performed as well as speed closure by non-surgical means when second intention healing is relied on alone. The human literature also supports the use of VAC therapy in cases of surgical dehiscence with exposed orthopedic hardware, bone or tendons. The VAC system maintains these wounds in a closed environment preventing further contamination and enhances the rate of granulation tissue formation over exposed bone, tendon or orthopedic implant.

Degloving Injuries and Skin Grafting

The ability of VAC to produce granulation tissue over exposed bone and tendon has made it an ideal form of wound therapy for appendicular degloving injuries and several human studies support such claims. In human patients, degloving injuries are treated with VAC therapy in a number of ways. Reports of appendicular degloving injuries treated with surgical reattachment of the skin and an overlying VAC bandage has resulted in skin survival rates between 60 and 100%. When skin reattachment is not a surgical option, degloving injuries are often treated with VAC dressing until a healthy granulation bed is formed. A split-thickness skin graft with an overlying VAC bandage can then be used as a bolster dressing. Human split-thickness skin graft survival is reported to be between 95 and 100% using this technique. The reported benefits of VAC bandages used as a bolster for human split-thickness skin grafting include evacuation of excessive fluid and removal of degradation products, immobilization of the skin graft to the recipient bed, bandage conformation to irregular surfaces, and enhanced neovascularization. In addition, VAC bandage application to graft donor site wounds re-epithelialized significantly faster than donor sites managed with traditional bandaging techniques.

Skin Avulsions

Increased survival of skin flaps and skin avulsion injuries have been reported in both human patients as well as various animal models. In veterinary patients, these injuries can be difficult to manage since any attempt to stabilize the orthopedic injuries often results in further vascular compromise of skin, which is relying primarily on the sub-dermal plexus for
survival. The increased anatomic dead space and avascular tissue created by these physiologic degloving injuries also create a favorable environment for bacterial growth.

**Prevention of Post-Operative Swelling and Seroma Formation**

The VAC system has been used in humans as a dressing for fasciotomy wounds after compartment syndrome. In a retrospective study comparing VAC to simple saline soaked dressings for fasciotomies, patients treated with VAC dressings had more rapid resolution of edema fluid from the tissue, allowing earlier definitive closure. In addition, a greater proportion of VAC treated wounds underwent primary closure rather than skin grafting for wound coverage. In human surgical wounds associated with a high risk of seroma formation or post-operative weeping, VAC dressings placed over the surgical incision at a low negative pressure (50 mm Hg) have resulted in the prevention of seroma formation and the successful transition to a dry wound that healed uneventfully with one 24-hour application.

**Abdominal and Thoracic Uses**

The VAC system has been used in human thoraces for the treatment of surgical dehiscence following median sternotomy and abdominal cavities after damage control laparotomy and for the treatment of abdominal compartment syndrome. Separation of the open celled foam from the abdominal and thoracic viscera was performed in some cases with fenestrated sheets of silicon. Enterocutaneous fistula formation has been reported as a result of foam eroding through the serosal surface of the intestines. These enterocutaneous fistulas were treated non-surgically with VAC using a series of progressively smaller foam pieces with finer pore sized until the fistulous tracts were sealed and healed by second intention.

**Complications and Contraindications**

Few complications exist in the human literature regarding VAC therapy. The most common is mild skin irritation from contact with the foam. The manufacturer has proposed several contraindications to VAC therapy. Though the VAC system will debride wounds to some extent, it will not remove grossly necrotic or devitalized tissue and should not be used in place of proper surgical debridement. The treatment of osteomyelitis with the VAC system alone is also contraindicated. Though VAC can be used over infected bone, resolution of osteomyelitis may be dependent on sequestrectomy were indicated and appropriate antibiotic therapy. VAC bandages are not recommended for the treatment of fistulas tracts to organs or body cavities in cases where the cause of the fistula is unknown, although reports exist in the human literature describing such techniques. The VAC system should not be used in wounds associated with known malignancies, since the application of the VAC bandage will likely increase blood flow and stimulate cellular proliferation within the wound bed. Finally, care should be taken when placing VAC dressings near exposed arteries and veins. It is possible for the foam to erode through vasculature resulting in extensive blood loss. Similarly, VAC dressings should be used with caution in patients with coagulation abnormalities or patients with active bleeding.

**New Silver Impregnated Dressings for the Practitioner**

Silver compounds have long been used as topical agents for wound care. In human medicine topical silversulfadiazine agents have been used for decades in burn units with the expressed aim of dealing with resistant bacteria particularly *Pseudomonas aeruginosa* and Methicillin resistant *Staphylococcus aureus* (MRSA) species. Silver-containing dressings are widely used to assist with management of infected wounds and those at risk of infection by Physicians and we are beginning to use them in veterinary medicine. These dressings have varied responses in clinical use due to technological differences in the nature of their silver content and release and in properties of the dressings themselves. Seven proprietary silver-
containing dressings in use for people include AQUACEL® Ag Hydrofiber®, nonwoven dressing; Acticoat™ Absorbent alginate; dressing, SILVERCEL™ alginate- carboxymethylcellulose nylon blended fibers; Contreet® Foam nonadhesive; foam PolyMem® ;Silver ;Urgotul® S.Ag gauze, and SilvaSorb® hydrogel. Of these we have clinical experience with Acticoat™ (Smith and Nephew Wound Care St Petersburg Fl 33716). This is a silver impregnated dressing that is placed in the wound and hydrated with sterile water before being covered with a water impervious outer dressing that can be left on for up to 7 days. The Ag alginate dressing not only has profound antibacterial properties but promotes granulation tissue formation. Case examples of the use of this dressing will be given during the lecture.

Treatment of wounds containing MRSA

Although the presence of MRSA in a wound may influence certain important aspects of a patient's care, it will still be necessary to manage the wound in the most appropriate manner. An open wound colonised or infected with MRSA, or any other potentially pathogenic bacteria, represents a serious potential source of cross-infection. When managing such a wound, it is the duty of the veterinarian to ensure that at all times the treatment provided is in the best interests of the animal concerned and is not likely to create a potential risk to other patients or members of staff. While elimination of the infective agent is clearly the primary aim, this process may be prolonged so measures must be taken to prevent the spread of contamination during this period.

Dressings that readily permit strike-through or shed fibres on removal should be avoided as they may transmit contaminated particles that could easily be carried around the room on air currents, contaminating adjacent surfaces. The use of irrigant solutions to remove adherent dressings may also increase the potential for infected material to be transferred from the wound to the surrounding area, either in droplets that bounce off the wound surface when a jet of solution is applied with force by means of a syringe or even in a gentle trickle that runs down the patient's leg. Semi-permeable dressings such as films, film-foam combinations and hydrocolloids, which effectively seal off the peri-wound area, may go some way towards addressing these issues as they help to prevent the passage of contaminating organisms both into and out of a wound. However, the use of these products depends on whether their fluid-handling characteristics and performance are appropriate to the condition of the wound and the amount of exudate produced. Having to apply an ointment to a wound several times a day does not fit well with most owners which would prefer to apply a dressing system that may remain undisturbed for several days. It might be argued, however, that because of the potential problem of developing resistance to this antibiotic it should be reserved for use in circumstances in which other dressings or pharmaceutical agents may not be appropriate.

For the initial management of MRSA infected wounds the following topical antibacterial agents may be considered:

- Silver sulfadiazine and chlorhexidine (Silvazine), which has been shown to be effective against MRSA in vitro when tested against 50 strains of MRSA.
- The above mentioned silver dressings
- Preparations containing povidone-iodine, including Betadine Solution (10% povidone-iodine; PVP-I) and Betadine Cream (5% povidone-iodine). One study, however, suggests that the antimicrobial activity of Betadine against MRSA was eliminated on dilution to one-quarter strength. These results are at variance with others which showed that povidone-iodine, when diluted 1:100, was bactericidal against both MRSA and MSSA, killing all organisms within 15 seconds.
- The use of honey for infected wounds is increasing in popularity and a number of dressings or preparations containing it are now available, some of which have been
shown to possess good antimicrobial activity against a wide range of pathogenic organisms, including resistant strains

**Honey**

- **Advantages**: Anti-bacterial, debridement, enhance granulation tissue formation and epithelialization, cheap. Easier to use than sugar.
- **Disadvantages**: Need frequent bandage changes (sometimes >2 times/day) No adverse effects reported, although pain may be noted on removal of dressing.
- **Method of action**: Same as sugar. Additionally, has an antibacterial property due to production of H2O2 in honey. High levels of amino acids, vitamins, minerals, and anti-oxidants contribute to improve healing. H2O2 stimulates angiogenesis and fibroplasias. Low pH accelerates wound healing and enhances anti-microbial effects.
- **Indications**: Same as sugar
- **Contraindications**: Same as sugar
- **Techniques of application**: MUST USE UNPASTURIZED HONEY Manuka honey may have best anti-bacterial effect. Do not heat honey. Apply approximately 30 ml of honey to a 10 x 10 dressing (soak sterile gauze with honey) and place gauze/dressing over wound and into pockets. Cover with absorbent dressing and tertiary layer. Change dressing when strike through occurs—initially this will be at least 1 time/day. Lavage wound at each dressing change. Discontinue treatment with healthy granulation bed present.

**Larval (maggot) therapy**

- **Advantages**: Very effective debridement while sparing viable tissue, antimicrobial, enhancement of wound healing.
- **Disadvantages**: Need to have shipped in overnight; psychological (i.e., “gross”). May cause tickling, itching or pain.
- **Method of action**: Mechanical debridement: maggots eat non-viable tissue and leave viable tissue. Secrete proteolytic enzymes that liquefies tissue—they then consume this. Can debride a large wound in 2-4 days. May molt during this time and increase in size. Antimicrobial effects also due to maggot secretions and proteolytic enzymes or digestion by maggots. May be effective against MRSA. Enhance wound healing maggot secretions stimulate growth factors and cytokines.
- **Indications**: Debridement of large amounts of necrotic/non-viable tissue, contaminated wound. Non-healing pressure ulcers, large contaminated wounds, osteomyelitis.
- **Contraindications**: Open body cavities, dry, non-exudative wounds; healthy granulation tissue or epithelial tissue.
- **Techniques of application**: Medical maggots (usually green blow fly) are used and are FDA approved. These are sterile and should be ordered when needed as they have a short shelf life. Change out maggots every 2-3 days. Replace with new maggots if necrotic tissue remains. Cover with a “cage” dressing that allows oxygen to wound/maggots but prevents maggots from “falling” out.

**Laser (low-level or cold laser)**

- **Advantages**: Inflammatory phase is sped up (progress to proliferative phase more quickly), enhanced cell division and collagen deposition, increased tensile strength of wound.
- **Disadvantages**: Cost of equipment ($1500-30,000); potential for eye injury
- **Method of action**: Light (photons) is absorbed by chromaphores in mitochondria leading to increased cellular metabolism, ATP production. Cell membranes are stabilized (pumps are restored and electronegativity restored within cell). Causes
vasodilatation (through NO, serotonin, histamine) and decreased production of reactive oxygen species (free radicals). Also enhances lymphocyte activity. During proliferative phase, fibroblast and keratinocyte proliferation and differentiation are enhanced. Angiogenesis is stimulated. Increased collagen deposition can occur leading to increase wound tensile strength.

- **Indications:** Any wound healing: post-operative, open wounds, mastitis, lick granuloma; decrease inflammation, increase circulation, pain relief.
- **Contraindications:** Tumor or potentially “unclean” margins. Over pregnant uterus. Over eyes.
- **Techniques of application:** Will differ depending on laser power and wavelength. Typical dose recommendations are 5-10 J/cm². A clear, plastic bag should be placed over the laser wand to protect it from the wound. The laser should be held several millimeters to centimeters off of wound (will depend on laser power and wavelength). Recommended to give increased dose to periphery of wound and less to open wound. Can administer in grid or scanning pattern. Optimal dose and treatment intervals are not known for small animals, but treatment every other day until wound closure.

**Leeches**

- **Advantages:** Restore venous circulation
- **Disadvantages:** Need to order leeches to be shipped over night or maintain “leach colony”. Psychological (“gross”). Possibility of infection with Aeromonas. Reported in 20% of humans treated with leeches. Can treat prophylactically with 3rd generation cephalosporins. Disease transmission is possible if used on multiple patients. Potential for loss of significant blood volume.
- **Method of action:** Leeches inject an anti-coagulant and local anesthetic at the site of attachment. This site continues to bleed for up to 10 hours after the leach has dropped off. Up to 150 mls of blood are reported to possibly ooze from each site.
- **Indications:** Venous congestion; skin grafts or flaps, microvascular surgery.
- **Contraindications:** Arterial insufficiency (ischemic wound)
- **Techniques of application:** Clean skin and rinse with water to remove any substances with taste or odor. Apply an adequate number of medicinal leeches (Hirudo medicinalis) to the area of interest (usually 2-5 in small animals). Use tongue depressors to guide leaches to area of interest. The leech will attach to an area that has blood flow (will not attach to ischemic areas) and venous congestion. If it will not attach, can make a small prick in skin to produce blood. Once the leech is attached DO NOT REMOVE IT. This could result in a portion of the mouth becoming lodged in the skin or spontaneous “vomiting” of stomach contents, including the bacteria Aeromonas from the leech. Leeches will drop off when satiated, typically after 30-60 minutes. It is important that someone monitor the patient and leaches until all have fallen off. Leeches should not be re-used, particularly on another patient. Leeches will not be “hungry” for months after feeding, so it is recommended to dispose of them by immersion in alcohol. The bite site should be cleaned and any accumulation of exudates removed to allow continued bleeding. Monitor the site for infection.
References