CHAPTER **34**

VACUUM-ASSISTED WOUND CLOSURE

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Despite recent advances, wound care continues to present a treatment challenge to healthcare professionals. Vacuum-assisted closure (VAC) devices are some of the newest clinical modalities now available to aid in the treatment of soft tissue defects, traumatic injuries, and post-surgical complications. These vacuum devices expose a wound to subatmospheric (negative) pressure, which applies a controlled force uniformly to all tissues on the inner surface of the wound. This negative pressure increases tissue perfusion, removes excess wound debris, exerts an inward mechanical stress on the tissues, and may decrease potential bacterial contamination.[1]

Galen first proposed the concepts of healing by primary versus secondary intention.[2] Healing by primary intention requires the wound edges to be opposed, which promotes the restoration of a continuous epithelial layer. Wounds in which the edges cannot be opposed must heal by secondary intention, requiring a deposition of matrix combined with revascularization to form granulation tissue. This will allow the migration of keratinocytes across the defect and eventual closure of the open wound. It was Thoma who first postulated that mechanical stress would result in angiogenisis and tissue growth.[2] This hypothesis is currently being supported by cases using soft-tissue expanders as well as the current Ilizarov techniques causing an increased cellular response and proliferation.

In 1996, Argenta and Morykwas embarked on a series of animal experiments to discover how pressure changes would modify wound healing by secondary intention.[2] They were studying the effects of continuous and intermittent negative pressure on blood flow, rate of granulation tissue formation, muscle flap survival, and the clearance of bacteria. They concluded that blood flow could be increased up to four times over baseline with a peak negative pressure of 125mmHg. Pressures of 400mmHg and above actually decreased blood flow levels. Granulation tissue formation was increased by 63% with continuous pressure and 103% with intermittent pressures. Intermittent pressure results in a repetitive release of activating second messengers causing a more rapid proliferation of granulation tissue when compared to the continuous pressure. Muscle flap survival was increased by 21% due to the improved nutrient blood flow. Lastly, they found that bacterial colonization of tissues decreased following the application of subatmospheric pressures to wounds. This study, although limited in size and scope opened the door for further research into this modality and eventually led to the engineering of a vacuum-assisted closure device.

The device that is currently available is called the V.A.C. (Vacuum Assisted Closure™). It is made by KCI based out of San Antonio, TX. Two units are under production, the "Stationary" and the "Mini" V.A.C. These systems consist of a computer controlled vacuum unit, canister, sterile foam dressing, plastic tubing, and clear adhesive drapes (Figure 1). One end of the tube is connected to the canister/vacuum unit while the other is embedded into the foam, which is lying inside the wound. The mini V.A.C. is a lightweight, fully ambulatory unit that allows the patient to be mobile while getting the benefits of the device (Figure 2). It has a battery life of 17 hours and is worn in a carrying case around the waist. This particular unit is for smaller wounds with minimal exudates.

Figure 1. The V.A.C. (Vacuum-assisted Closure) device (KCI, Inc.). System consists of a computer controlled vacuum unit, canister, sterile foam dressing, plastic tubing, and clear adhesive drapes.

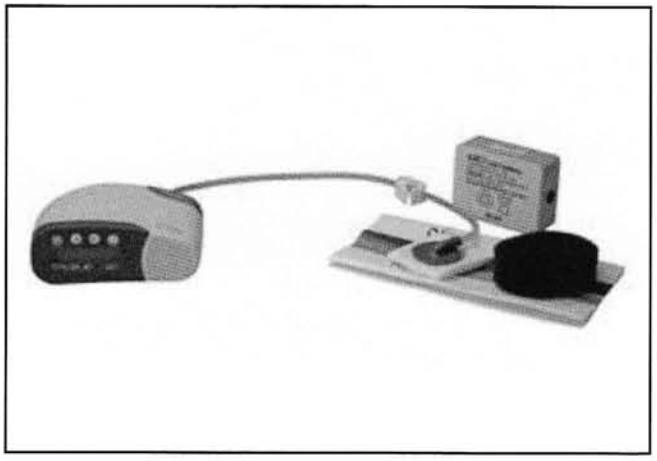

Figure 2. The Mini V.A.C. device (KCI, Inc). This lightweight, fully ambulatory unit allows the patient to be mobile.

INDICATIONS

A wide variety of both acute and chronic wounds may be treated with vacuum therapy. These include wounds secondary to trauma, dehisced wounds, diabetic or pressure ulcers, postsurgical skin grafts or flaps, and even fracture blisters. Numerous studies have been published on the use of negative pressure devices to assist with traumatic injuries such as compound fractures or degloving injuries.[3-6]

DeFranzo recently published research showing the successful use of a V.A.C. system on 71 out of 75 posttraumatic patients with injuries including exposed tendon, bone, and even orthopaedic hardware.[3] The majority of the participants in the study had their open wounds debrided in the operating room with placement of appropriate fixation at that time. Instead of packing the wounds with traditional methods, the V.A.C. system was implemented converting an open wound to a controlled temporarily closed wound. This was done even if internal fixation devices were exposed. The authors found that this device greatly reduced tissue edema, diminished the circumference of the extremity as well as the surface area of the wound, and enhance granulation tissue formation covering bone and hardware.

A more common use of vacuum-assisted closure in the podiatric community would be in the healing of postoperative diabetic foot wounds. A recent study by Valiulus compared vacuum therapy versus a saline-moistened gauze dressing following surgically debrided diabetic wounds.[1] This study, although limited in size, found the average date to satisfactory healing was 22.8 days for the VAC method compared to 42.8 days using saline-moistened gauze. This quicker wound resolution is important because it decreases the hospital stay for the patient, allows for a quicker return to normal activities, and also decreases costs associated with the treatment of these wounds.

Another indication for a total negative pressure device is to secure a skin graft or flap (Figure 3). It is critical for the survival of the graft to have appropriate contact between the recipient bed and the undersurface of the skin graft. In most cases the recipient site is a flat, well-granulated bed that will not experience excessive motion. In these cases a traditional tie-over bolster dressing is all that is necessary to secure the graft.[8] However, if the recipient site has irregular surfaces or will undergo repeated motion then a VAC device could be a more reliable method of securing the graft. It will ensure positive contact between the bed and the transplanted skin across the entire surface while preventing any fluid accumulation that may prevent revascularization of the graft.[8] The sponge should be cut to contour the defect while overlapping slightly around the edges of the bed. A porous, nonadhesive barrier is then placed between the sponge and graft to prevent adherence and damage of transplanted skin with removal of the dressing. The vacuum is applied at 125 mmHg on continuous negative pressure for 3-5 days before graft site is inspected.

CONTRAINDICATIONS

Currently it is not advised to use VAC therapy on wounds with necrotic tissue or untreated osteomyelitis, wounds with malignancy inside the margins, and wounds that communicate with fistulas or sinus tracts. It is also contraindicated to use these VAC dressings directly over exposed arteries or veins. It is still indicated to use negative pressure therapy on patients who are anticoagulanted as long as their lab values and wound drainage are closely monitored.

APPLICATION OF VAC UNIT

Debridement of necrotic tissue and aggressive cleansing of wound combined with appropriate hemostasis must be accomplished prior to application of the device. Patients should have the hair shaved around the border of the wound (if applica-

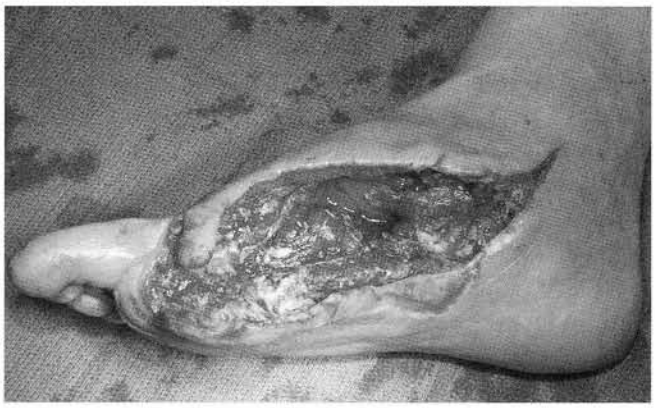

Figure 3A. A diabetic foot infection following surgical debridement.

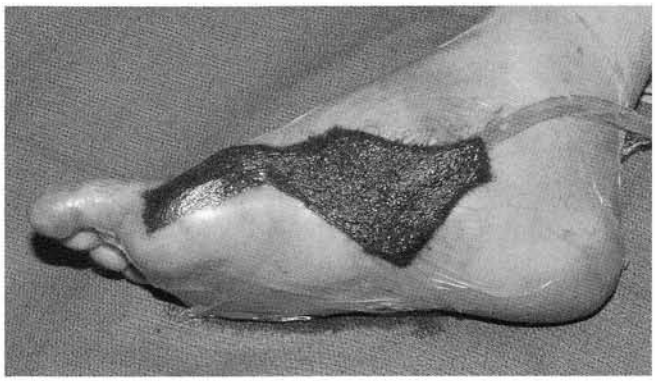

Figure 3B. Application of wound vacuum directly after surgery.

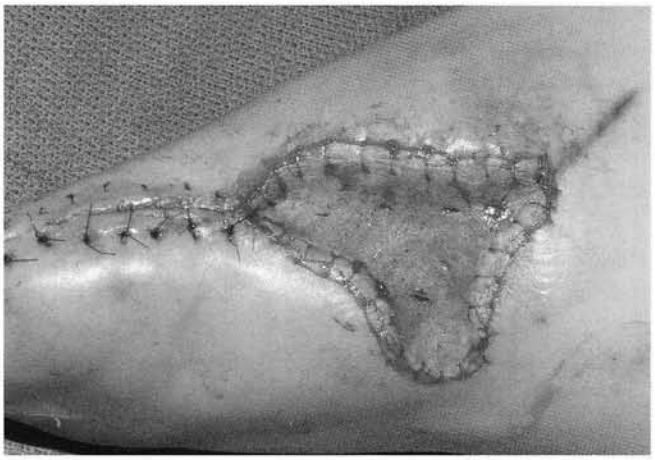

Figure 3C Two months of vacuum therapy after which patient returned to surgery for split-thickness skin graft. Another vacuum device was applied following skin graft.

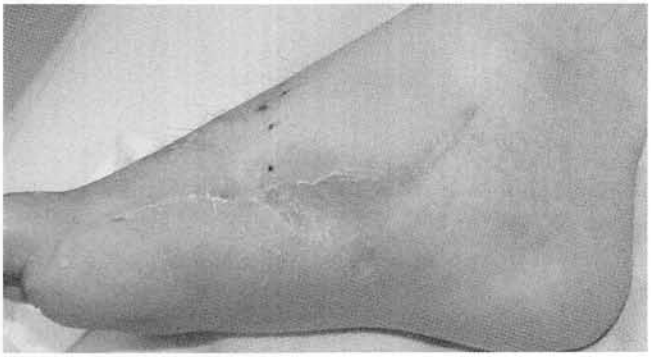

Figure 3D. Four month follow up with wound completely healed.

ble) and then you can apply skin preparation agents (Mastisol, Tincture of Benzoin, etc) for increased adherence of the clear film. Select appropriate size of sponge and then contour it to fit inside the wound without overlapping skin edges (Figure 4A). Make sure the sponge fills all areas of the wound including any tunnels or undermining. Place tubing into the sponge then apply the clear adhesive dressing over the wound and sponge allowing at least 3-5 cm of coverage onto healthy tissue to assure proper occlusive seal (Figure 4B). Lift the tubing and pinch 1-2cm of drape together below tubing to get a good seal at the skin to tube interface and to prevent irritation. Tubing should be positioned away from any bony prominences.

Turn on the V.A.C. device making sure all clamps are open to see if seal is intact. At this time the sponge should compress (Figure 5). If not compressed, listen for a whistling sound and patch leaks with more clear, adhesive film. The author has found the majority of leaks to usually be found at the tube/skin interface. If patient has multiple wounds, a "Y" connector can be used to allow one V.A.C. unit to be used for two separate wounds (Figure 6A). If the wounds are in close proximity to each other, a "bridging" technique may be used to necessitate the use of only one tube (Figure 6B). This uses a strip of a sponge to connect the two sponges sitting inside the two wounds. As long as all sponges are in physical contact with each other below a sealed occlusive dressing negative pressure will be achieved.

Once a sealed environment has been accomplished, the unit is set to the desired pressure (usually 125 mmHg) on intermittent or continuous mode. The intermittent therapy has shown to stimulate more rapid granulation tissue formation, however, the continuous subatmospheric mode has

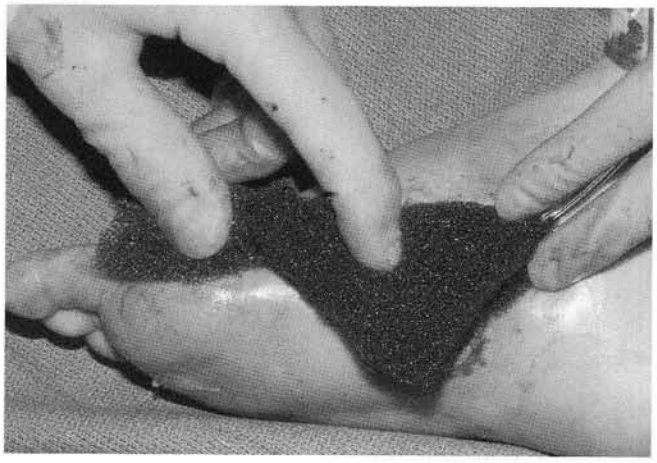

Figure 4A. Select appropriate size sponge and contour it to fit inside the wound without overlapping skin edges.

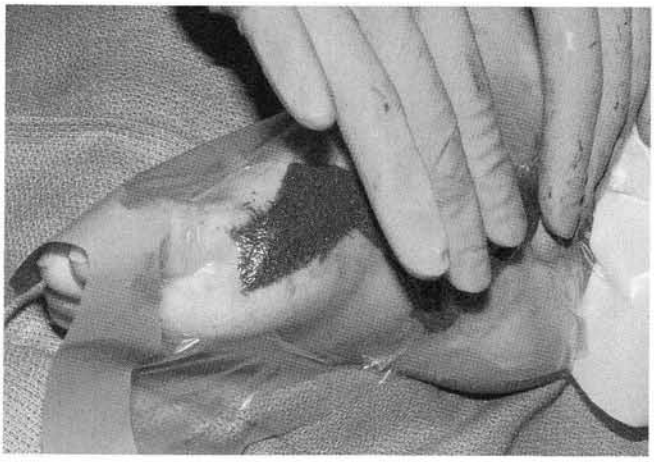

Figure 4B. Place tubing into sponge then apply the clear adhesive dressing over the wound and sponge allowing at least 3-5 cm of coverage onto healthy tissue to assure proper occlusive seal.

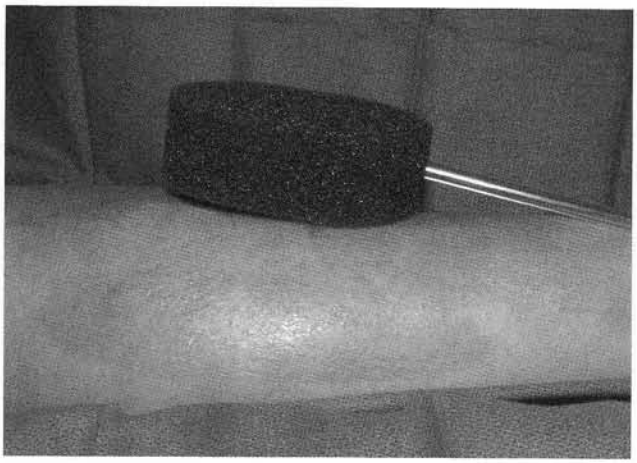

Figure 5A. Sponge application

Figure 5B. Adhesive film applied over sponge

Figure 5C. Compression of sponge once wound vacuum is started.

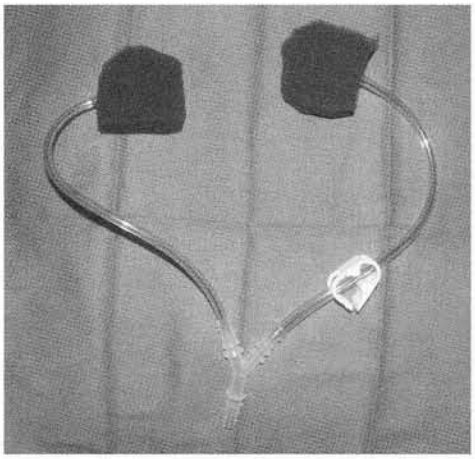

Figure 6A. If the patient has multiple wounds, a "Y" connector can be used to allow one V.A.C. unit to be use for two separate wounds.

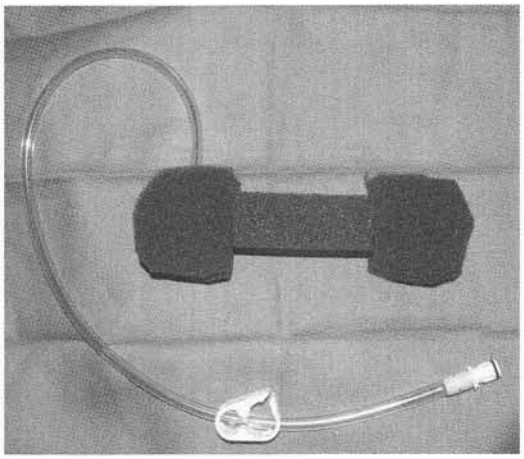

Figure 6B. If the wounds are in close proximity to each other, a "bridging" technique may be used to necessitate the use of only one tube. This uses a strip of a sponge to connect the two sponges sitting inside the two wounds. As long as all sponges are in physical contact with each other below a sealed occlusive dressing, negative pressure will be achieved.

a number of benefits that often make it a better choice. Patients tend to have less discomfort when the sponge is not contracting and expanding. High levels of drainage in the first few days of treatment lend itself to a constant suction. Difficulty maintaining an airtight seal is another reason to choose the continuous versus the intermittent therapy.

COMPLICATIONS

Complications with vacuum-assisted closure can be kept to a minimum if wound patients are properly selected and treated. Inadequate surgical debridement of necrotic tissues or nonviable bone can result in further continuation of the infection. If this necrotic tissue is not removed, the wound will not improve no matter what postoperative dressing is applied. Most guidelines suggest a dressing change every 12 hours if there is a high probability of continued infection. Once the wound has stabilized a dressing change every 48 hours is suggested.

Bleeding is another complication of using this type of dressing. Excessive growth of granulation tissue into the sponge has been observed after 48 hours of dressing placement.[3] This is especially true in children and young adults who may require dressing changes every 24 hours if this persists. This bleeding will become evident with the bedside dressing changes and does responds to pressure. Although anticoagulation treatment is not a contraindication, close monitoring of wound drainage and laboratory values are recommended.[7]

Pain may be associated with these dressing changes, especially if the sponge adheres to the wound bed. It may also be felt when the suction is reconnected to the new sponge. This pain should last no longer than 20-30 minutes. Often an intravenous or oral analgesic will help manage any pain. Stasis ulcers and lesions associated with chronic vasculitis are the most painful. Pressures may be lowered to 50-75 mmHg from the usual 125 mmHg to ease the pain. Beneficial effects will still occur, just at a slower pace.[3]

Skin integrity may be of concern in some instances. Patients receiving corticosteroids or who have had recent radiation may have difficulties maintaining intact skin layers. Peri-wound maceration is another problem that can arise. These complications may be avoided by 1) cutting the sponge to fit inside the wound without overlapping the surrounding skin edges; 2) applying a skin barrier product; 3) applying a non-adhesive plastic wrap directly surrounding the wound and then use adhesives and tapes to gain an air tight seal in an area with better skin layers; and 4) making sure the tubing exiting the sponge is not laying directly on the skin so as to cause pressure damage to the skin.[7]

DISCUSSION

The use of vacuum-assisted wound closure is a new modality that should be added to the list of products available in the treatment wounds. It is currently being successfully used in a range of acute and chronic wounds, as well as in the securing of skin grafts. Although promising studies have been completed showing an improved blood perfusion and rate of granulation tissue formation, further research using larger sample sizes is warranted to evaluate wound volume data, cost analysis and, long term follow up.

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