VAC Therapy: Vacuum Assisted Closure Therapy

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INTRODUCTION

VAC Therapy also called vacuum therapy, vacuum sealing or topical negative pressure therapy, involves the use of vacuum assisted drainage to remove blood or serous fluid from a wound or operation site.

This is a simple technique where a piece of foam with an open-cell structure is introduced into the wound and a wound drain with lateral perforations is laid on top of it. The entire area is then covered with a transparent adhesive membrane, which is firmly secured to the healthy skin around the wound margin. The other end of the drain tube is connected to a vacuum source, fluid is drawn from the wound through the foam into a reservoir.

The adhesive membrane provides air tight seal and partial vacuum created in the foam within the wound, reducing its volume and facilitating the removal of fluid. The foam ensures that the entire surface area of the wound is uniformly exposed to this negative pressure effect, prevents occlusion of the perforations in the drain by contact with the base or edges of the wound, and eliminates the theoretical possibility of localized areas of high pressure and resultant tissue necrosis.

DEVELOPMENT OF VAC TECHNIQUE

First described by Fleischman et al [1] in 1993 following successful use of this technique in 15 patients with open fractures, he observed that negative pressure resulted in “efficient cleaning and conditioning of the wound with marked proliferation of granulation tissue”. Further Fleischman and Colleagues [2,3] described in the treatment of 25 patients with compartment syndrome and 303 patients with acute and chronic infections - average

ABSTRACT

Controlled application of sub atmospheric pressure has been shown to accelerate debridement and promote healing in different types of wounds. The optimum level of negative pressure is around 125 mm Hg and appears to be more effective when applied intermittently five minutes on and two min off. The negative pressure assists in the removal of interstitial fluid, reducing edema and thereby increasing blood flow. This in turn reduces bacterial levels. In addition, mechanical deformation of cells stimulate protein and matrix molecule synthesis and increase the rate of cellular proliferation resulting in growth of granulation tissue and accelerate angiogenesis. Despite its cost of treatment this advanced wound healing therapy can be used both inpatient and outpatient basis. This technique can be coupled with microprocessor controlled vacuum unit capable of providing controlled levels of intermittent / continuous negative pressure ranging from 25- 200mm Hg. The ultimate goal of wound healing either by secondary intention or by tertiary intention is achieved without any major surgical procedure like flap reconstruction either pedicled or free tissue transfer.

Keywords: Vacuum assisted closure, wound healing, topical negative pressure
duration of therapy-16.7 days with 3.1 times dressing change. The wounds were subsequently closed by skin grafts and secondary suturing.

Muller [4] reported the success of VAC in 300 patients with chronic wounds.

Kovac et al [5] 1998 described the usefulness of VAC in treating the chronic radiation ulcers

Mullner et al [6] applied VAC therapy in 45 patients with soft tissue defects including the post traumatic soft tissue defects with open fractures, following debridement and irrigation, showed decreased dimensions of the initial wound and also eradication of the pre-existing infection.

In the early studies, negative pressure is achieved by the conventional methods using wall suction and vacuum bottle suction apparatus. But the practical problems like delivery, control and maintenance of the required negative pressure are described by Banwell et al.[7].

To overcome these problems, equipment called VAC was designed in 1995, with microprocessor controlled vacuum unit, capable of providing controlled levels of continuous or intermittent negative pressure ranging from 25-200mm Hg.

Two types of VAC

- Mains operated system with canister of 300ml for patients with limited mobility and heavily exuding wounds.
- A battery operated with a canister of 50ml volume for fully ambulatory pts with minimal/moderate exudates.

MODE OF ACTION

Morikvas et al [8] studied the physiological basis of the clinical effects and the optimum pressure required for the clinical benefits. In his series, deep circular defect with 2.5cm diameter on the back of the pigs is studied. Laser doppler tech was used to measure the blood flow in the surrounding skin and soft tissues of the defect with increasing levels of negative pressure continuous/intermittent. Results showed 4 times increase the blood flow at 125mm Hg and the flow was inhibited at 400mm Hg or above. Rate of granulation production is determined by measuring the reduction of the wound volume over time and is compared with wound dressed with saline gauze pieces- pressures used are -125 to -75mm Hg. They observed that Intermittent Therapy is more effective.

Philbeck et al [9] has shown in his study that rhythmic perfusion of the tissue which is maintained because the process of capillary auto-regulation is not activated. Cells which are undergoing mitosis must go through a cycle of rest, cellular component production and division, constant stimulation may cause the cells to ‘ignore’ the stimulus and thus become ineffective. Some authors [10,11] suggest that cyclical pattern should follow a 48 hour period of continuous vacuum which may exert a rapid initial cleansing effect. Bacterial Counts are also reduced after 4 days as shown in punch biopsy [8]. The final part of the study showed that it increases the flap survival rates by 21%[8].

Morykwas and Colleague [8] Postulated that multiple mechanisms might be responsible for these observed effects. In particular, they suggested that removal of interstitial fluid decreases localized edema and increases blood flow, which in turn decreases tissue bacterial levels.

It has since been proposed that the application of sub-atmospheric pressure produces mechanical deformation or stress within the tissue resulting in protein and matrix molecule synthesis [12] and enhanced angiogenesis [13].

Fabianet et al [13] using a rabbit ear model provided evidence for stimulatory effect of subatmospheric pressure on the production of granulation tissue enhanced epithelialization.

In experimental partial thickness burns, subatmospheric pressure was shown to prevent progressive tissue damage in the zone of stasis that surrounds the area of initial injury. The effect was demonstrable within 12 hours of injury [14].

Clinical experience with VAC

Following animal studies the same research group described the clinical use of VAC in 300 wounds of varying etiology [15]. These were treated until completely closed or could be covered with SSG or suitable for soft tissue reconstruction by rotating the flap on to the healthy granulating bed. 296 wounds responded favourably and authors concluded that VAC is extremely efficacious modality for treating chronic non healing wounds.

Numerous papers have been described the use of VAC in the treatment of variety of wound types including extensive degloving injuries [16,17], infected sternotomy wounds [11,18,19] and various soft tissue injuries prior to surgical closure [20], grafting or reconstructive surgery [21]. Many articles and case reports were published from various specialties reveal the usefulness of VAC. Open abdominal wounds that contained exposed bowel, fascia,
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muscle, subcutaneous tissue, flaps, fistulas and mesh were well managed by using either a vicryl mesh\textsuperscript{28} or non adherent dressing before the application of VAC. (Jakalyn A Barace). Silvia cresti observed the useful of vac following pelvic exenteration with high risk of infection and APR with omentoplasty with satisfactory results\textsuperscript{24}. Ann-Maria Barne\textsuperscript{29}, treated necrotizing fasciitis\textsuperscript{34} following air crash injury with favourable outcome.

Ludwig Lable illustrated the usefulness of V.A.C. therapy management of deep sub-fascial infection after dorsal spinal surgery. It has been proved that the role of VAC in the management of Grade IIIB injuries\textsuperscript{33} is worth mentioning as it decreases the morbidity . Aziz Nadar et al demonstrated that the V.A.C. Granufoam Bridge Dressing\textsuperscript{35} is effective in the treatment of diabetic foot ulcers as it promotes reduction of wound area, wound bed granulation, and microbial clearance. By allowing placement of the suction pad outside the foot, it allowed patients to wear protective shoes and to walk non-weight bearing with crutches during V.A.C. therapy.

This vacuum-assisted dressing seems to be a useful tool in accelerating the separation of the necrotic bones and stimulation of granulation tissue formation in burned calvarium. In patients who will be treated conservatively with a few surgical interventions and early debridement of burned skull, this combination may be considered as an alternative approach in the management of skull burn.

Smith et al\textsuperscript{22} in a retrospective review described the use of VAC over a four year period in 93 patients who required open abdomen management and recommended VAC as the method of choice for open abdomen management and temporary abdominal closure.

VAC has also been used in the treatment of donor sites, particularly in areas that are difficult to managed by conventional methods\textsuperscript{23} such as those on the radial forearm\textsuperscript{24}. As it has reported that as many as 1/3 of the patients undergoing radial artery forearm free flaps develop exposed tendon complications and these are likely to be benefited by VAC therapy\textsuperscript{25}.

VAC has been used in conjunction with SSG in the treatment of burns and claimed to be particularly useful for irregular/ deep body contours such as perineum, hand and axilla\textsuperscript{26,27}. In all these situations, vacuum helps to hold the graft on to the bed. Thus preventing accumulation of tissue fluid under the graft. Several studies have been described the usefulness of the VAC therapy in variety of non-healing chronic wounds include a recalcitrant below knee stump wound, pressure sores, leg ulcers and long standing wounds unsuitable for reconstructive surgery.

To obtain an air tight seal in the difficult areas such as sites near the anus and vagina or where the surrounding skin is moist, hydrocolloid dressing such as duoderm\textsuperscript{15} which is applied around the wound and used as a base for the adhesive membrane.

Philbeck et al\textsuperscript{9} claimed that this is very cost effective following a retrospective analysis and concluded that this is an effective treatment modality for variety of wounds producing healing in pressure sores 61% faster than saline soaked gauze, reducing cost by 38%.

**TECHNIQUE**

Negative pressure - The optimum pressure setting is 120mm Hg. This can be lowered by 25mm Hg in extremes of age, risks of excessive bleeding / circulatory compromise, surrounding bruising, excessive granulation tissue growth, pain / discomfort not relieved by analgesia. And it can be increased by 25 mm Hg in case of excessive drainage, large wound volume and in tunneled areas.

**COMPONENTS**

- Occlusive dressing to maintain vacuum at wound site.
- Sponge - open pore reticulated poly urethane foam (vac granufoam, vac Granufoam silver) or poly vinyl alcohol foam(vac white foam dressings) . or
- Honey combed textile with a dimpled wound contact surface. or
- Layers of non-woven polyester, joined by a silicone elastomer, has a non-adherent wound contact surface made up of numerous small semi-rigid dome structures.)
- Tubing and drape
- Suction pump for the application of negative pressure with a disposable canister.
Step I: Foam dressing cut to the size of the wound

Step II: Foam placed into the wound

Step III: Perforated drain tube placed into the sponge

Step IV: Transparent adhesive drape is applied making it air tight

Step V: Other end of the tube connected to the VAC unit which is programmed to deliver negative pressure.

Step VI: Once vacuum is switched on sponge gets collapsed creating negative pressure.
**TECHNIQUE OF VACUUM ASSISTED CLOSURE**

**Figure 2: Use of conventional VAC system**

- Post traumatic raw area
- Antibiotic application
- Air tight sponge dressing
- Connected to suction apparatus
- Pressure setting at 120 mmHg
- Pressure of 100 mmHg
- VAC using romovac 31, 40

**Mode of VAC**

Continuous therapy is applied for the first 48 hrs in all the wounds followed by intermittent therapy 5 min on 2 min off for at least 22 hours a day.

**Indications of continuous therapy**

- Patients with increased risk of bleeding
- Patients experiencing significant discomfort with intermittent therapy.
- Wounds with undermining and deep tunnels.
- Wounds with grafts or flaps to prevent shearing
- Highly exuding wounds.

**INDICATIONS for VAC therapy**

- Chronic wounds
- Acute wounds
- Traumatic wounds
- Sub-acute and dehisced wounds
- Partial thickness burns
- Ulcers- diabetic and pressure sores
- Flaps and grafts

**CONTRAINDICATIONS**

- Malignant wounds
- Untreated osteomyelitis
- Non-enteric and unexplored fistulas
- Necrotic tissue with eschar
- Sensitivity to silver (when VAC granufoam silver is used)
**GENERAL & SPECIALITY DRESSING GUIDELINES:**

<table>
<thead>
<tr>
<th>Wound type</th>
<th>Initial cycle</th>
<th>Subsequent cycle</th>
<th>Target pressure</th>
<th>Target pressure details</th>
<th>Dressing change interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute/chronic/partial</td>
<td>Continuous first 48hrs</td>
<td>Intermittent for the rest of the therapy 5 min on / 2 min off</td>
<td>125 mm Hg</td>
<td>Initially lowest negative pressure and gradually increasing under close monitoring</td>
<td>Every 48-72 hrs not less than 3 times a week.</td>
</tr>
<tr>
<td>thickness burns</td>
<td></td>
<td></td>
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<tr>
<td>Wound dehiscence</td>
<td>Continuous</td>
<td>Intermittent for duration of therapy Provides splinting effect in sternal dehiscence</td>
<td>125 mm Hg</td>
<td></td>
<td>Every 48-72 hrs not less than 3 times a week.</td>
</tr>
<tr>
<td></td>
<td>For duration of therapy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin grafts</td>
<td>Continuous therapy, Acts as a bolster</td>
<td></td>
<td>75-125 mm Hg</td>
<td>After 4-5 days</td>
<td></td>
</tr>
<tr>
<td>Pressure ulcers</td>
<td>Continuous for first 48 hrs</td>
<td>Intermittent for the rest of the therapy 5 min on / 2 min off</td>
<td>125 mm Hg</td>
<td></td>
<td>Every 48-72 hrs not less than 3 times/week</td>
</tr>
<tr>
<td>Diabetic foot ulcers</td>
<td>Continuous for first 48 hrs</td>
<td>Intermittent for the rest of the therapy 5 min on / 2 min off</td>
<td>50-125 mm Hg</td>
<td></td>
<td>Every 48-72 hrs not less than 3 times/week</td>
</tr>
<tr>
<td>Chronic wounds</td>
<td>Continuous for first 48 hrs</td>
<td>Intermittent for the rest of the therapy 5 min on / 2 min off</td>
<td>50-125 mm Hg</td>
<td></td>
<td>Every 48-72 hrs not less than 3 times/week</td>
</tr>
<tr>
<td>Flaps</td>
<td>Continuous therapy</td>
<td></td>
<td>125-150 mm Hg to provide bolster effect for bulky flaps</td>
<td>Remove dressing 72 hrs postoperatively</td>
<td></td>
</tr>
<tr>
<td>Abdominal wounds</td>
<td>Continuous therapy</td>
<td></td>
<td>125 mm Hg</td>
<td>Every 48-72 hrs not less than 3 times/week</td>
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</tbody>
</table>

**PRE AND POST VAC IMAGES:** VAC1 and VAC2 during the course of VAC therapy.

**Figure 1:** Avulsion injury foot after debridement

![After debridement](image1)

![VAC1](image2)

![VAC2](image3)

![VAC3](image4)

**Figure 2:** Post cellulitic raw area thigh

![Before VAC](image5)

![after VAC1](image6)

![after VAC2](image7)
RISKS OF VAC

Bleeding is likely in

- Patients who have friable / weakened vessels or organs as in cases of vascular anastomosis, infection, trauma or radiation
- Patients without adequate wound hemostasis
- Patients on anticoagulants or platelet aggregation inhibitors.
- Patients with soft tissue defects over the vessels.

PRECAUTIONS

PROTECT VESSELS AND ORGANS

Foam dressing should not come into direct contact. Should be covered with muscle or fascia, if not multiple layers of fine meshed, non adherent material or bio engineered tissue is another alternative. Tendons, ligaments and all the vital structures are to be protected.

When Hemostatic agents applied at the wound site:

Bone wax, gelatin sponge, spray wound sealants – may get dislodged.

Loose Fragments or Sharp Edges:

Possible migration of tissues lead to damage to the adjacent neurovascular bundles or VAC system.

SIGNS OF SYSTEMIC INFECTION

Should be addressed with systemic antibiotics and debridement of the wound before VAC therapy

FOAM PLACEMENT

- Foam should be patterned so that optimal contact to the wound is possible and uniform negative pressure is delivered.
Should always be sterile.
Date of placement should be noted.

Fom Removal
In growth of the granulation tissue may occur if foam is left in place and may lead to bleeding on removal and sometimes infection.
If the vac therapy is off for more than 2 hours, it should be removed.

WOUND MONITORING
- Depends on the goal of therapy, wound pathology and size, and management of co-morbidities.
- average length of the treatment is 4-6 weeks.
- discontinued if the wound shows no progress for one to two consecutive weeks. Or if the patients is unwilling to medical plan of care.

SIGNS OF EFFECTIVE VAC TREATMENT
- gradually decreasing exudate, changing to serous to sero-sanguinous discharge due to possible disruption of capillary buds as a result of negative pressure.
- slight increase in the size of the wound initially, later gradually decreasing size of the wound.
- wound color may change to deep red.

VAC INSTILL THERAPY SYSTEM
Combines the benefits of VAC therapy with instillation therapy to promote wound healing. Topical cleansers, topical antibiotics and topical antiseptics can be used. This can be used with continuous mode only.

CONCLUSION
VAC therapy is advanced medical therapy that can be applied in the management of many chronic and infected wounds resulting in wound healing either by secondary or tertiary intention. Though VAC therapy unit is expensive, the studies showed that in the treatment of chronic wounds it is cost effective in terms of decrease in the overall morbidity of the patient. And also it decreases the need of surgical intervention in many cases. Even in cases of post traumatic soft tissue defects with exposed bone or implants, wound can be managed with a simpler procedure like SSG following VAC therapy. And also reduces the rate of infection following surgery with better results. This can also be used in largely exuding wounds even with lymphatic involvement effectively.

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