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Vacuum Assisted Closure Therapy: Applications and Precautions

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Abstract:

Treatment of wounds has been the cornerstone of plastic surgery since its inception. Vacuum-assisted closure provides a new paradigm that can be used in concert with a wide variety of standard existing plastic surgery techniques. It was originally developed as an alternative treatment for debilitated patients with chronic wounds. It has rapidly evolved into a widely accepted treatment of chronic and acute wounds, contaminated wounds, burns, envenomations, infiltrations, and wound complications from failed operations. The ease of technique and a high rate of success have encouraged its adaptation by thoracic, general, trauma, burn, orthopedic, urologic, as well as plastic surgeons.

Keywords: Vacuum Assisted Closure, VAC, Wounds.

Introduction:

Vacuum Assisted Closure (VAC) therapy, also known as negative pressure, wound therapy (NPWT), is a medical technique used for wound healing. It involves the application of controlled negative pressure (vacuum) to a wound site to promote healing and manage various types of wounds, such as chronic wounds, surgical incisions, and traumatic injuries **(1).**

The basic components of a VAC system include a vacuum pump, a collection canister, and a dressing that covers the wound. The dressing is typically a sponge-like material that is placed over the wound and sealed with an adhesive film.

Vacuum Pump: The vacuum pump is the core component of the VAC system. It generates the negative pressure needed for the therapy. It can be a portable or stationary device depending on the specific system (**2**)**.**

Collection Canister: The collection canister is connected to the vacuum pump and serves to collect wound exudate, blood, and other fluids removed from the wound during the therapy. It helps prevent these fluids from entering the pump and allows healthcare providers to monitor the amount of drainage (**3**)**.**

Tubing: Tubing connects the vacuum pump to the wound dressing. It facilitates the transfer of negative pressure from the pump to the wound site (**4**)**.**

Dressing: The dressing is a key component that is applied directly to the wound. It usually consists of a sponge-like material that conforms to the wound shape and is covered by an adhesive film. The dressing creates an airtight seal over the wound, allowing negative pressure to be applied specifically to the wound site (**5**)**.**

Adhesive Film: The adhesive film covers the wound dressing, creating a seal to maintain the negative pressure and prevent air leakage. It helps to secure the dressing in place and maintain the integrity of the vacuum system **(1).**

Connecting Tubing and Adapters: Various tubes and adapters are used to connect the different components of the VAC system, ensuring a secure and airtight connection (**2**).

Control Unit: Some VAC systems may have a control unit that allows healthcare professionals to adjust and monitor the negative pressure settings (**2**).

Power Source: The VAC system requires a power source to operate. Portable systems may have built-in batteries, while stationary systems typically plug into an electrical outlet **(1).**

The vacuum pump then creates negative pressure, which helps in several ways:

Wound Drainage: The negative pressure helps to remove excess fluids, including blood and wound exudate, from the wound. This can reduce swelling and prevent the accumulation of harmful substances at the wound site (**6**).

The compression of tissue caused by negative pressure leads to tissue hypoxia due to reduced perfusion beneath the foam, which in turn stimulates angiogenesis and local vasodilation through the release of nitric oxide. This process occurs specifically during the "suction off" periods of VAC therapy. As a result, the intermittent mode of VAC therapy is more effective compared to the continuous mode (**6**).

Hypobaric interstitial pressure and increased vessel permeability following an injury contribute to the development of edema. Vacuum-assisted closure (VAC) therapy exerts increased tissue pressure, which compresses blood vessels and increases the velocity of intravascular fluid flow, as described by the principle of continuity. This acceleration in fluid velocity results in a reduction in intravascular hydrostatic pressure, as explained by Bernoulli's principle. Together, these mechanisms reduce the outward flow of intravascular fluid, leading to decreased edema. Additionally, the elevated blood velocity created by VAC therapy induces a suction effect, drawing extracellular fluid back into the blood vessels. Furthermore, the compressive forces generated by negative- pressure wound therapy physically push edema away from the injured tissues. These combined effects lead to reduced interstitial hydrostatic pressure and improved oxygenation of the surrounding cells. VAC therapy also immobilizes the wound, which provides additional benefits to the healing process (**2**).

The application of VAC therapy causes micro deformation or microstrain on the cells, which triggers a tissue expansion effect and the release of growth factors. This tissue expansion effect arises from the differential pressure created within the tissues due to the negative pressure applied. The internal pressure within the cells remains positive, while the external pressure beneath the dressing is negative. This pressure differential may cause cell expansion, promote the formation of granulation tissue, and draw the wound edges closer together, thereby reducing the overall wound size (**2**).

However, recent studies have indicated that the pressure in the underlying wound can paradoxically increase, resulting in hyperbaric conditions. The capillary perfusion pressure in normal tissue typically ranges between 10 and 35 mmHg. In cases where the vascular tree is intact, hyperbaric pressure is unlikely to cause capillary occlusion. On the other hand, in ischemic tissues, hyperbaric pressure may exacerbate ischemia and lead to necrosis. Consequently, negative- pressure wound therapy must be used cautiously on ischemic tissues, particularly when the affected area is circumferential (**7**).

Increased Blood Flow: The suction effect can stimulate blood flow to the wound, promoting oxygenation and nutrient delivery to the tissues. Improved blood circulation is crucial for the healing process (**8**).

Tissue Contraction: The controlled negative pressure can encourage the edges of the wound to come together, promoting the closure of the wound (**3**).

Reduced Bacterial Load: The vacuum helps in reducing the bacterial load in the wound, creating a more favorable environment for healing **(9).**

VAC therapy is often used in complex and hard-to-heal wounds, such as diabetic ulcers, pressure sores, and post-surgical wounds.

Indications for VAC therapy include diabetic foot ulcers, bedsores, skin graft fixation, flap salvage, burns, crush injuries, sternal or abdominal wound dehiscence, fasciotomy wounds, extravasation wounds, and animal bites or frostbite. Contraindications for VAC therapy include malignant wounds, untreated osteomyelitis, fistulae to organs or body cavities, the presence of necrotic tissue, and cases involving exposed arteries, nerves, anastomotic sites, or organs. Relative contraindications include patients with blood dyscrasias, patients with anticoagulants, or those with actively bleeding wounds (**2**).

During VAC therapy, red flag signs include active or excessive bleeding, surrounding invasive sepsis, increased pain, signs of infection such as fever, pus, or foul-smelling drainage, and allergic reactions to the adhesive. Complications associated with VAC therapy include failure of the VAC system, such as loss of seal, power failure, or blockage of the drainage system, wound infection, pain, bleeding, allergies to the adhesive drape, excoriation of the skin, restricted mobility, adherence of tissues to the foam, lack of patient compliance, and skin necrosis (**10**).

VAC therapy offers benefits, including a reduced rate of dressing changes, improved patient comfort, shorter hospital stays, reduced bacterial load, improved skin perfusion, reduced edema, and the provision of a closed, moist wound healing environment (**11**).

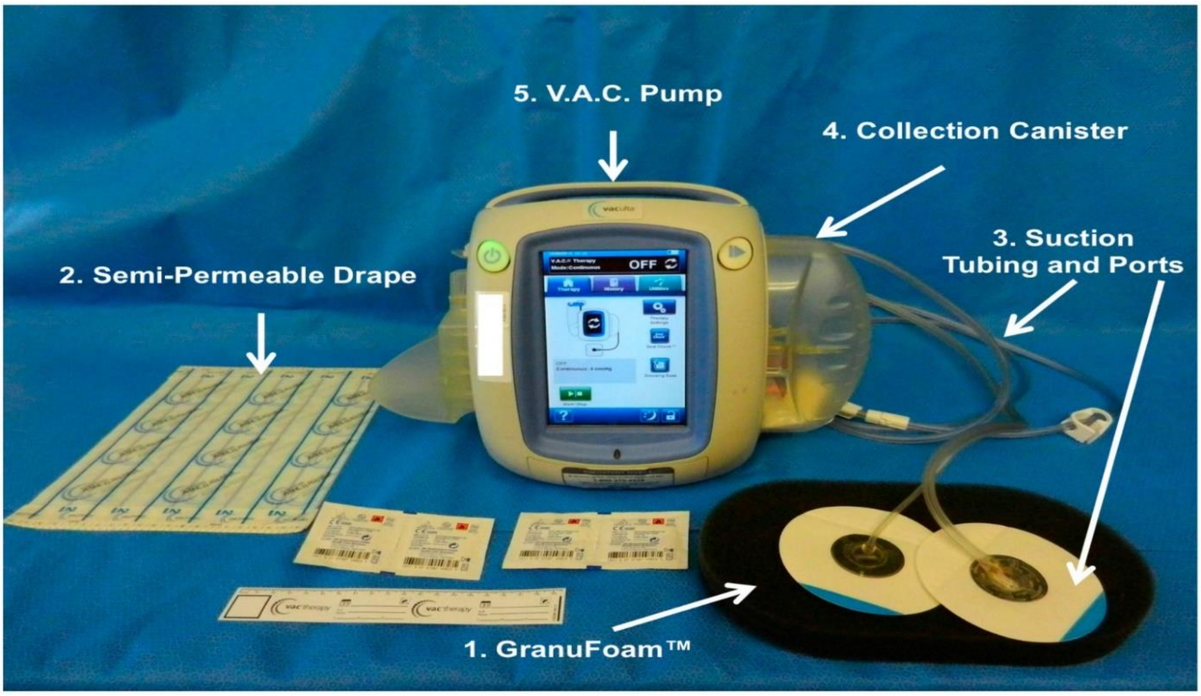

Figure 1: The basic components of a VAC system (**12).**

Application for VAC

Vacuum Assisted Closure (VAC) is used in various clinical settings to promote wound healing and manage complex wounds.

Chronic Wounds: VAC therapy is often used for chronic wounds that are difficult to heal, such as diabetic ulcers and venous stasis ulcers. It helps in reducing wound exudate, promoting granulation tissue formation, and accelerating overall wound healing **(13).**

Surgical Incisions: VAC can be applied to post-surgical incisions to enhance healing and minimize complications like dehiscence (wound opening) or infections. It helps in maintaining a clean and controlled environment around the incision site (**14**)**.**

Traumatic Wounds: VAC therapy is utilized for traumatic wounds, including those resulting from accidents or injuries. It aids in the removal of debris, reduces the risk of infection, and supports tissue regeneration (**15**)**.**

Pressure Sores (Decubitus Ulcers): Patients with pressure sores, commonly known as bedsores or decubitus ulcers, can benefit from VAC therapy. It helps in managing wound exudate, promoting tissue repair, and preventing infection in pressure-sensitive areas **(16).**

Burn Wounds: In certain cases of burn wounds, VAC therapy may be applied to promote healing and prevent complications. It assists in managing fluid drainage and can contribute to a better cosmetic outcome (**2**)**.**

Flap and Graft Surgery: VAC therapy is commonly used after flap or graft surgery to secure and enhance the success of the graft. It promotes graft adherence, reduces edema, and improves blood supply to the transplanted tissue **(17).**

Orthopedic Infections: VAC therapy can be employed in orthopedic cases where post-surgical infections occur. It aids in controlling infection, promoting tissue healing, and facilitating a clean environment around orthopedic hardware (**4**)**.**

Closed Incision Management: VAC can be used for closed incision management after surgery to reduce the risk of complications and infections. It assists in promoting optimal wound healing beneath the skin surface (**2**)**.**

Precautions

Intermittent negative pressure is preferred over continuous negative pressure because it generates more blood flow during the vacuum "off" phase. Studies have demonstrated that the rate of granulation tissue formation is significantly higher with intermittent negative pressure, at 103%, compared to 63% with continuous negative pressure (**18**).

Air leaks in the dressing should be avoided, as they allow continuous air flow over the wound surface, leading to tissue desiccation and the formation of eschar. This eschar can seal the wound with retained exudate, worsening the condition. Additionally, the pressure in VAC dressing gradually decreases over 48 hours, so dressings should be changed after this period. It is important to note that VAC therapy should not be abruptly terminated after a single session, as this could cause a rebound phenomenon and worsen the wound. To avoid this, 2–3 VAC sessions should be planned (**2**).

One randomized controlled trial (RCT) provides objective evidence supporting the use of VAC for various indications. The evidence for traumatic wounds is graded as "C," while VAC as a bridging therapy between multiple debridement is graded as "B." However, a strong recommendation (Grade "A") is given for its use in managing skin grafting procedures (**15**).

Optimal application of negative pressure in wound therapy: Studies conducted on animal models have shown that granulation tissue formation is enhanced with a vacuum pressure of 125 mmHg, compared to both low (25 mmHg) and high (500 mmHg) vacuum suction. The use of low-pressure suction (25 mmHg) leads to reduced drainage of fluid from the wound, diminished removal of toxins, and less cell deformation. This results in a slower rate of granulation tissue formation. On the other hand, high suction pressure (500 mmHg) causes excessive mechanical deformation of tissues, which can lead to localized reductions in blood flow, impairing perfusion and hindering the formation of granulation tissue. As a result, a negative pressure of 125 mmHg is considered the optimal setting for most wounds (**2**).

Further studies on different levels of negative pressure (ranging from 10 to 175 mmHg) across various types of wounds have demonstrated that the level of negative pressure should be adjusted according to the specific characteristics of the wound. For acute traumatic wounds, a negative pressure of 125 mmHg is required, while for chronic non-healing venous ulcers, the ideal pressure is 50 mmHg, applied in intermittent cycles (**15**).

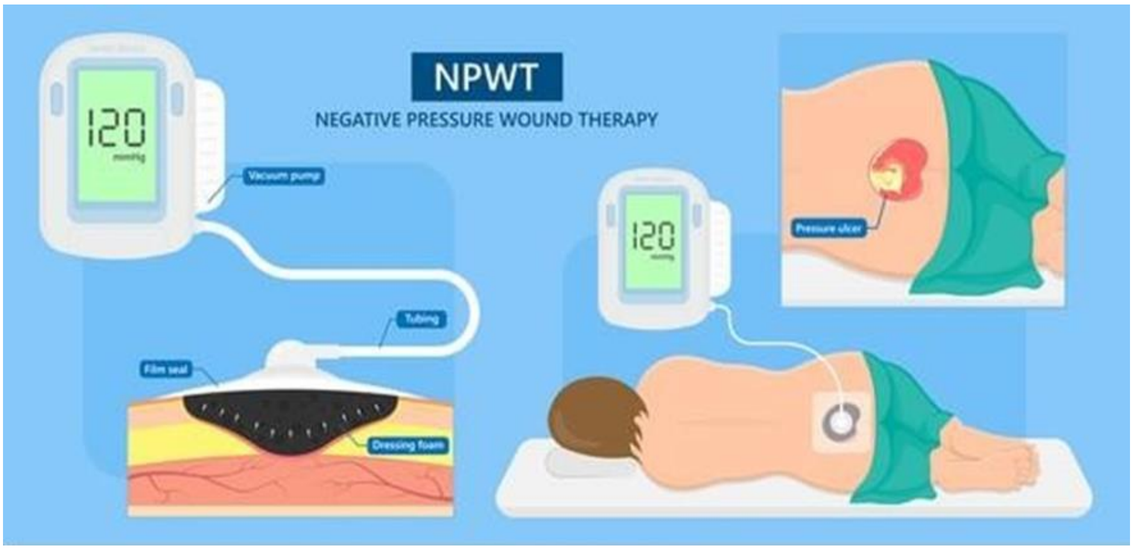

Figure 2: Negative pressure wound therapy.

Cost

Numerous studies conducted on various types of wounds suggest that vacuum-assisted closure (VAC) therapy may be more economical compared to conventional wound care methods. This is attributed to its requirement for fewer dressing changes and reduced need for extensive reconstructive procedures to achieve wound healing. Additionally, VAC therapy is associated with faster wound healing, a shorter overall duration of treatment, and decreased hospitalization time. While VAC dressings are initially more expensive than conventional dressings, the long-term overall cost of treatment is lower with VAC therapy due to these cumulative benefits (**2**).

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