Diagnosis and treatment

Handmade VAC® therapy applied for complex wounds

Sistema VAC® artesanal para el tratamiento de heridas complejas

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Introduction

Nowadays, with the progressively increased presence of industrial machinery, extreme sports, travel, etc., accidents causing extensive and severe wounds are more frequent. In general, they are extensive, slow, torpid-healing wounds with significant tissue loss that require local and prolonged therapies. Overall, this translates into more days of hospitalisation and higher health care expenses, resulting in a considerable emotional impact and important decrease in the life quality of patients and their families. Thus, the main objective is to implement techniques aimed at favouring wound healing, making it possible for patients to recover quickly in the shortest time possible.

The vacuum-assisted closure (VAC®) therapy system involves a training and supervision period throughout treatment that should be handled by specially trained staff. There are different VAC® therapy system units on the market, which are usually complex and highly priced. Our goal is to present an alternative to these systems that applies the therapy technique in a simple and inexpensive way, utilising easily acquired health care materials.

Principles and properties

To stimulate the formation and growth of wound granulation tissue, the wound needs to have an adequate perfusion ensuring correct oxygenation, nutrient contribution, and tissue growth factors. The importance of keeping a wound in optimum conditions, free of blood and serous fluid collection, are necessary principles that should be followed during the wound care therapy process. On the other hand, bacterial overgrowth and wound contamination, as well as wound devascularisation, are known factors that hamper healing.

Throughout the years, different methods have been designed and used to favour optimum conditions during wound care. Wound care by means of hydrocolloid dressings, topical application of growth factors, hyperbaric chamber treatment, keratinocyte cultures, among others, are some of those methods. An alternative method is the VAC® system, which consists of delivering local and controlled negative pressure on the wound bed, correctly prepared and debrided. Some of its most salient benefits are preventing wound contamination by eliminating the exudate and reducing wound manipulation, which diminishes granulation tissue damage and potential bacterial colonisation and infection in the wound. Additionally, it reduces local oedema by suctioning extravascular liquid from the wound, thus reducing inflammation and favouring perfusion, increasing local blood flow, nutrition, tissue oxygenation, cell growth and proliferation, and fibroblast and macrophage epithelial migration, thus shortening healing time. All of these elements jointly promote the formation and growth of granulation tissue, thereby favouring quicker healing, or enabling wound bed preparation for a subsequent surgical repair.

In addition, extending the time between wound care therapies reduces the number of hospital visits, the number of dressings needed, and hospital stay, facilitating patient discharge, either to their homes or to less expensive health care centres. Besides, considering the existing work overload seen in hospitals and clinics nowadays, with such an increased caseload, this therapy system makes it possible to improve management and optimise personnel, resources and work time towards the service of wound care and...
therapies. All of these aspects result in important advantages from an economic and cost reduction viewpoint, and even more so does the handcrafted VAC® therapy that we hereby propose.

The history of VAC®

The VAC® technique is a relatively recent procedure. The technique was first described by Argenta and Morykwas in 1997, although it had been developed some years before. They demonstrated the way in which an oedema decreased by delivering negative pressure to the wound and creating a closed space, favouring vascularisation, oxygenation and healing. It also promoted vascular proliferation and angiogenesis, with the subsequent formation of granulation tissue.

The VAC® system has been demonstrated to be beneficial and effective for wound healing and has a well-known positive cost/effectiveness relation for health care centres due to its speed in reaching results (estimated at 60% faster than that of conventional methods) and, as a matter of fact, its use was approved years ago by the Food and Drug Administration. Its effect on ischaemic wounds, where healing was altered due to limited vascularisation, has been studied and compared to other existing treatments, such as hyperbaric oxygenation. In these cases, the VAC® technique and the local microvascularisation that it promotes showed an increase in wound cicatrization, turning it into an option worth considering. Experimental studies have determined and quantified the granulation tissue increase and quality in relation to conventional therapy techniques, and they have also estimated the negative pressure level that must be steadily delivered to obtain better results with the VAC® technique. The ideal amount of negative pressure initially recommended was −125 mm Hg, which was to be delivered intermittently; later, the recommendation was to apply continuous treatment cycles to obtain better results and to decrease local wound discomfort.

Handcrafted VAC® treatment method

Patient's choice

This is a crucial step that determines future needs, progress, and potential success of the treatment.

The choice made by patients amenable to VAC® therapy treatment will be subject to their general state and to a more specific assessment of the cutaneous lesions they present. On the one hand, knowing patients’ different diseases and comorbidity, their functional capacity, and the source of their lesions is very valuable data. It is necessary to ensure appropriate nutrition for patients, adding nutritional supplements if needed to guarantee wound healing and to make a global assessment of patients’ capacity, motivation, social status and family support. Some of the data that will determine the recommended technique in each case are the exhaustive assessment of the wound type, shape, size, location, the presence of exudate and its characteristics (colour, smell, etc.), the state of the wound bed and edges, and the previous history and progress obtained through previous treatments and therapies.

Patient information and education

Providing correct information on the treatment technique and its objectives will help patients reduce the fear and anxiety they experience before the procedure, thus helping them better withstand the treatment and favouring their cooperation. Information on the hygienic–dietary habits that patients should follow and functional limitations associated with treatment are valuable data at the time of establishing a therapy treatment, and, more specifically, the VAC® therapy system. Patients will communicate with the health care personnel to clarify doubts about the therapy and to report any disorders or side effects that they might experience.

Necessary materials

To implement the handcrafted VAC® therapy system, only a few supplies present in most basic health care units are necessary: surgical wound cleaning supplies (gauze and physiological solution), a sterile sponge which could be replaced with sterile gauzes and compresses, a sterile aspiration tube (or nasogastric tube) and a waterproof plastic dressing (for instance: Steri-Drape®, OpSite®), to cover the wound, in different sizes, according to the wound size. In those cases where sterile sponges are not available, an alternative would be to use the small sponges that come with surgical cleaning brushes.

Preparation of wound and adjacent tissue

Once the wound bed is assessed by physicians or nurses, the area to be treated must be debrided so as to eliminate sloughing, traces of fibrin, necrotic and devitalised tissues covering the wound. Both the wound and its surrounding area should be adequately washed, avoiding topical antiseptics since they can be cytotoxic (Fig. 1A and B). The administration of physiological solution is a better option, by means of an irrigation pressure that makes it possible to clean the lesion without causing injuries. The skin adjacent to the wound must be cleaned with mild soaps or physiological solution, and it should be protected to avoid wounds and cracks, patting it dry; alternatively, protection patches could be applied on the surrounding skin (Fig. 1C and D).

Applying VAC® therapy

Once the wound and the surrounding tissue have been prepared, the sterile sponge or gauzes are placed, covering the entire wound but not exceeding, if possible, the wound area, so as not to create dead spaces or cavities (Fig. 2A). The sponges or gauzes must adapt to the wound size, thus, they can be cut by means of a scalpel or sterile scissors. The wound should not be over filled, since the opposite effect could take place and the wound may become enlarged (Fig. 3A and B). The aspiration tube (or nasogastric tube) should be embedded in the gauzes or sponge and covered once more with a new layer of gauze or compresses, or with a sponge (Figs. 2A–C and 3C–F). Occasionally, and considering that the length of the tube could be excessive, it is necessary to cut the terminal end of the tube, or to make little orifices in it, to adapt the perforated portion of the nasogastric tube (whereby the aspiration shall be performed) to the extension and size of the wound.

On top of this, an adhesive waterproof plastic film (Steri-Drape®, OpSite®) is placed to isolate and seal the wound and the materials utilised, creating a closed system (Fig. 2D). It is important to ensure that a significant portion of the nasogastric tube should not be in direct contact with the skin surface, since that could generate a decubitus ulcer and injure the skin in contact with it. Placing gauzes between the tube and the skin is an alternative that is commonly used to avoid the formation of decubitus ulcers.

Sealing can be difficult, depending on the anatomical area to be treated. Adhesive dressing tape may be cut according to the size of the wound, and if the seal is not complete, extra waterproof tape and dressings may be placed.

Afterwards, the drainage or nasogastric tube (or tubes, in the case that multiple therapies are being conducted simultaneously) is connected to a breathing tube (Fig. 2E–F). This tube is connected by means of an adjustable negative pressure and aspiration system to a vacuum pump that is, in turn, connected to a sterile reservoir where
the extracellular fluid and the oedema extracted from the wound will be stored after applying vacuum pressure. From time to time, nurses shall carefully check the waterproof adhesive plastic tape to detect possible leakages. A simple way to ensure that the wound remains watertight and does not lose any pressure is to observe whether the sponge wrinkles after connecting the suction tube to the negative aspiration. The fact that the sponge or the gauze is completely collapsed guarantees that the locally delivered vacuum pressure is sustained (Fig. 4A, B and D).

The negative pressure applied is variable. It is administered through mechanical, not compressive, forces applied on the wound bed by means of a vacuum pump. It might oscillate between −50 and −200 mm Hg, with a continuous or intermittent treatment pattern. Although these pressures are relatively low, they might be painful for patients since they are applied on open wounds or ulcers. Whenever pain is caused, the applied pressure should be reduced and then increased progressively according to patients’ tolerance to pain. In general, it is advisable to exert a continuous pressure of −125 mm Hg, although this pressure could be lower in cases where wounds exudate profusely.5,8

It is important to programme the cycle and pressure to be applied to the wound. Experimental studies have demonstrated

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**Fig. 1.** (A) Wound located in the posterior lower left limb. The wound bed presents traces of fibrin and sloughing, as well as tendinous tissues. (B) The wound needs to be debrided before applying the therapy. (C and D) Preparation of perilesional tissue, protecting it with patches (this step is optional and it must be carried out in accordance with the type of wound to be treated). Observe how negative pressure (VAC®) therapy was also applied to another wound in the proximity.

**Fig. 2.** Therapy by negative pressure vacuum (VAC®) system, with gauzes or compresses. (A–C) Coverage of exposed wound using sterile gauzes or compresses. The nasogastric tube is placed between the lower gauze layer (covering the wound directly) and an upper gauze layer, by the orifice area, where suction is applied. (D–F) Gauze and tube coverage with waterproof dressings, to create a closed space where vacuum may be applied. The tube (or tubes, in case of double cures) is connected to an aspiration tube; in turn, this is connected to a variable aspiration and negative pressure system.
Fig. 3. Therapy by negative pressure vacuum (VAC®) system, using a sterile sponge system. (A–C) Preparation of therapy materials. As can be seen, the sponge may be obtained from a sterile surgical cleaning brush. Sponge is cut in half using a sterile scalpel. (D–F) Placement of drainage tube in its thickness in the area that has the orifices, for suctioning. Drainage remains in the middle of the sponge.

Fig. 4. (A) Final view of the therapy without performing aspiration or negative pressure. (B) Delivering vacuum pressure on the wound. The fact that gauze or sponges are completely collapsed confirms and guarantees that the vacuum pressure is being delivered correctly. In case the material failed to collapse, it would be necessary to check the wound in search of possible leaks, which prevent the vacuum from being maintained. (C and D) Therapy by negative pressure vacuum (VAC®) on a wound with difficult healing, after amputation of the second and third toes on the left foot as a result of necrosis and peripheral arteriopathy. Initial appearance of the wound following the amputation, and the subsequent application of VAC® therapy. The wound presents traces of fibrin at the edges, as well as more tissue loss. (E and F) Wound progress after 5 and 10 days of treatment, respectively, with a significant improvement in terms of healing and wound appearance.
the effectiveness of applying an intermittent pressure pattern, but pressure variations applied on wounds might be painful. On the other hand, for patients to have a better tolerance, mobility and autonomy, aspiration could be suspended occasionally by simply pinching the aspiration tube with a Kocher pinch, so as not to lose applied negative pressure. Dressings should be changed every 48–72 h or more, depending on the type of therapy and the wound healing state. In cases of very suppurative lesions, therapies should be carried out more frequently. As the wound closure progresses, the treatment configuration may be adjusted ([Fig. 4C, E and F]). Physicians and nurses may monitor wound progress and choose an adequate therapy according to the healing process stage of patients at a given time.

Removing therapy materials

Whenever therapy dressings need to be changed or removed, the first step is to disconnect the wound from the negative pressure. Before removing the adhesive dressings and sponges, it is necessary to bear in mind that this process might be painful, particularly in extensive wounds, since the sponges or compresses are adhered to the wound. Therefore, analgesic treatment might be necessary before changing the dressings. The materials must be removed slowly, while applying physiological solution if necessary to help remove the adhesive layer and the sponge. Excessive traction should not be applied to minimise epidermal breakage and damage to the granulation tissue generated.

Indications

VAC® technique applications are diverse, and they may be applied in different situations:

- Complex wounds where either soft tissues have been greatly affected or open fractures, skin flaps or skin grafts are associated.
- Infected or not infected acute or chronic wounds, when bacterial colonisation decreases.
- Dehiscent wounds or wounds where a primary surgical closure has not been viable due to significant tension in the surgical wound edges. Applying VAC® therapy and the ensuing negative pressure on this type of wounds reduce the oedema by suctioning it, making it possible to bring the surgical wound edges closer together and close the wound more rapidly. In this way, on occasions, skin grafts will not be needed for coverage because wound closure will be achieved more quickly.
- Abdominal wounds and enteric fistulas; VAC improves wound condition and patients’ overall situations.
- Wounds where skin grafts have been placed; applying vacuum favours a better fixation of skin grafts to the surface area and reduces oedemas and exudate material, thus reducing mobilisation and, therefore, providing better foreseeable healing.
- Chronic, traumatic or spontaneous ulcers, caused by vascular disorders (either arterial, venous, or mixed), blood pressure, diabetes, vasculitis, etc.
- Elderly patients or patients with significant comorbidity, presenting extensive wounds, where surgical treatments are not indicated.

Complications and contraindications

Identifying adverse reactions to the treatment, as well as monitoring and detecting abnormal wound healing progress, are key elements since early detection of complications will influence a better future prognosis.

Patient intolerance to therapy materials may generate some complications, such as a skin reaction or irritation of the areas in contact with the plastic or adhesive dressings used to create a vacuum, or an irritation generated by the sponge used. This therapy is contraindicated in patients with hypersensitivity to this type of materials, or whose cutaneous fragility or allergy predisposition does not tolerate the therapy. To reduce this type of reaction as much as possible, the sponge should be placed away from the wound edges and the minimum area possible of healthy tissue should be covered to create the closed system.

Small decubitus ulcers have been described as having appeared in the perilesional skin, resulting from contact with the drainage tube. These lesions could be prevented by placing the tube in a different direction each time the therapy supplies are removed or changed.

In addition, particularly at the beginning of the treatment, patients may, on occasion, experience discomfort in the wound site or mild pain, stemming from the debridement performed on the wound before the treatment starts and from the aspiration pressure generated by the vacuum pump on the wound. This pain tends to be controlled once the aspiration pressure is reduced. In general, the intensity of this pressure is not as high as to make it necessary to suspend treatment.

Small haemorrhages may occur in the wound, mainly as a result of debridement, which has to be performed before applying the technique, as well as a result of hypervascularisation and granulation tissue generated by vacuum pressure. Furthermore, these patients tend to receive anticoagulant treatments due to their condition (antithrombotic prophylaxis in prolonged post-surgical and recovery periods). In general, these little haemorrhages subside when pressure is applied or when vacuum is generated, although they may hamper the implementation of the technique in a reduced number of cases.

In general, it is contraindicated in wounds with extensive necrotic tissue areas, fistula wounds, abscesses and complex osteomyelitis, since its complete resolution would require resectioning the affected bone material. However, recent publications indicate its benefits even in abdominal wounds presenting infections or abscesses.

Comments

One of the growing problems seen in hospitals is that patients presenting extensive wounds or significant tissue loss require longer hospitalisations, thus raising treatment costs in terms of both time and materials. Among the different possible treatments, the technique based on the implementation of VAC® is an effective and non-invasive method, with few associated risks. However, its implementation has been low due to the treatment complexity and its cost. In our group, after applying the handcrafted, protocolised VAC® therapy system, we have managed to obtain a significant increase of granulation tissue in the treated wound area, reduce signs of local infection and shorten healing time. It has functioned as a bridge to other treatments, reducing the size of the skin defect and improving the wound state in preparation for complementary wound coverage procedures. The proposed handcrafted VAC® technique is a simple, inexpensive and effective alternative. Its protocolisation, disclosure of its properties and implementation make it possible for these therapies to easily be applied in primary care facilities, aimed at reducing costs, promoting early healing and improving patient autonomy.

Conflict of interest

The authors declare that there are no conflicts of interest.
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References