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Early Results of Negative Pressure Wound Therapy in Treatment of Chronic Wounds

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Abstract

Background: Chronic wounds may affect only the epidermis and dermis, or they may affect tissues all the way to the fascia. Chronic wounds seem to be detained in one or more of the phases of wound healing. For example, chronic wounds often remain in the inflammatory stage for too long. Negative-Pressure Wound Therapy (NPWT) devices are designed to apply controlled suction to a wound bed at continuous or intermittent pressure settings to stimulate wound closure.

Aim: Assess the effect of negative pressure wound therapy in management of chronic wound.

Methods: This is prospective study was conducted on 60 Egyptian volunteers participated; they were 40 males and 20 females, between the age of 20 and 60 years. This study was conducted from May 2017 to May 2018 El Sahel Teaching Hospital.

Results: VAC therapy, together with periodical surgical wound debridement and specific antibiotic therapy could be helpful to promote and accelerate wound healing of foot lesions after restoration of an adequate distal blood flow through surgical revascularization or angioplasty.

Conclusion: Negative-Pressure Wound Therapy (NPWT) devices are designed to apply controlled suction to a wound bed at continuous or intermittent pressure settings to stimulate wound closure. Negative pressure can result in numerous alterations in the wound environment, including removal of excess exudate containing high concentrations of proteases and inflammatory cytokines, stimulation of senescent cells, mobilization of macrophages, and stimulation of angiogenesis.

Keywords: Negative pressure wound therapy; Chronic wounds; Treatment; ROS

Introduction

A chronic wound is a wound that does not heal in an orderly set of stages and in a predictable amount of time the way most wounds do; wounds that do not heal within three months are often considered chronic [1]. Chronic wounds seem to be detained in one or more of the phases of wound healing. For example, chronic wounds often remain in the inflammatory stage for too long [2].

In addition to poor circulation, neuropathy, and difficulty moving, factors that contribute to chronic wounds include systemic illnesses, age, and repeated trauma. Comorbid ailments that may contribute to the formation of chronic wounds include vasculitis, immune suppression, pyoderma gangrenosum, and diseases that cause ischemia [3]. Chronic wounds may affect only the epidermis and dermis, or they may affect tissues all the way to the fascia. They may be formed originally by the same things that cause acute ones, such as surgery or accidental trauma, or they may form as the result of systemic infection, vascular, immune, or nerve insufficiency, or comorbidities such as neoplasia or metabolic disorders. The reason a wound becomes chronic is that the body's ability to deal with the damage is over whelmed by factors such as repeated trauma, continued pressure, ischemia, or illness [4].

Ischemia causes tissue to become inflamed and cells to release factors that attract neutrophils such as interleukins, chemokines, leukotrienes, and complement factors [1].

While they fight pathogens, neutrophils also release inflammatory cytokines and enzymes that damage cells. One of important jobs is produce Reactive Oxygen Species (ROS) to kill bacteria, for which they use an enzyme called myeloperoxidase. The enzymes and ROS produced by neutrophils and other leukocytes damage cells and prevent cell proliferation and wound closure by damaging DNA, lipids, proteins, the Extra Cellular Matrix (ECM), and cytokines that speed healing. Neutrophils remain in chronic wounds for longer than they do in acute wounds, and contribute

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to the fact that chronic wounds have higher levels of inflammatory cytokines and ROS. Since wound fluid from chronic wounds has an excess of proteases and ROS, the fluid itself can inhibit healing by inhibiting cell growth and breaking down growth factors and proteins in the ECM. This impaired healing response is considered uncoordinated. However, soluble mediators of the immune system (growth factors), cell-based therapies and therapeutic chemicals can propagate coordinated healing [5].

Though all wounds require a certain level of elastase and proteases for proper healing, too high a concentration is damaging. Leukocytes in the wound area release elastase, which increases inflammation, destroys tissue, proteoglycans, and collagen, and damages growth factors, fibronectin, and factors that inhibit proteases. The activity of elastase is increased by human serum albumin, which is the most abundant protein found in chronic wounds. However, chronic wounds with inadequate albumin are especially unlikely to heal, so regulating the wound's levels of that protein may in the future prove helpful in healing chronic wounds. Excess matrix metalloproteinases, which are released by leukocytes, may also cause wounds to become chronic. MMPs break down ECM molecules, growth factors, and protease inhibitors, and thus increase degradation while reducing construction, throwing the delicate compromise between production and degradation out of balance [6].

Negative-Pressure Wound Therapy (NPWT) devices are designed to apply controlled suction to a wound bed at continuous or pressure settings to stimulate wound closure. Negative pressure can result in numerous alterations in the wound environment, including removal of excess exudate containing high concentrations of proteases and inflammatory cytokines, stimulation of senescent cells, mobilization of macrophages, and stimulation of angiogenesis [7].

Although there was little clinical evidence of its benefit when this product was launched in the market, utilization has soared, initially fueled by clinical impressions of significant acceleration of wound granulation and closure, particularly in deep, complex wounds with large tissue defects requiring coverage. NPWT has been used over uncovered bone, tendon, and deep tissues, resulting in the clinical impression of a favorable response [8].

NPWT should be applied after the wounds are debrided and are clean of scar, slough, and nonviable tissue. Sterile foam is cut to the wound size and placed in a wound bed. Any areas of undermining or tunneling should also be filled with foam pieces. Skin sealant is used with padding of periwound area to prevent excessive pressure from tubing and skin irritation. The wound is covered with film drape to ensure an airtight seal. The tube clamps are opened, and the pump is turned on to allow wound fluid and bacteria to travel into the collecting canister. The dressing is left in place for 48 h to 72 h (12 h to 24 h, if infected). Most studies have used- 125 mmHg of pressure [9].

Three types of filler material are used over the wound surface: open-cell foam, gauze and transparent film, or honeycombed textiles with a dimpled wound contact surface. Foam dressings are used to fill open cavity wounds and can be cut to size to fit wounds. The foam dressing is applied, filling the wound and then a film drape is applied over the top to create a seal around the dressing. Open weave cotton gauze can be covered with a transparent film, and a flat drain is sandwiched in gauze and placed onto the wound. The film drape covers the wound and creates a complete seal, and then the drain is connected to the pump *via* the tubing [10].

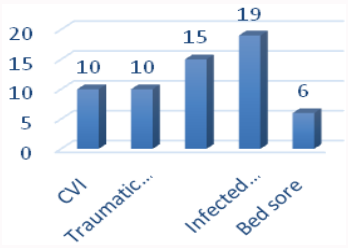

Figure 1: Distribution of the studied cases according to complaints (n=60).

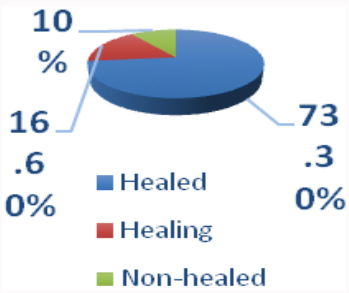

Figure 2: Distribution of the studied cases according to fate (n=60).

Table 1: Distribution of the studied cases according to demographic data (n=60).

sex	No.	%
Male	40	66.6
Female	20	33.3
Age (years)		
Min. - Max.	20.0-60.0	
Mean ± SD.	51.97 ± 12.11	
Median	54	

The aim of this study is assessing the effect of negative pressure wound therapy in management of chronic wound.

Materials and Methods

This is a prospective study in which 60 Egyptian volunteers participated; they were 40 males and 20 females, between the age of 18 and 60 years. This study was conducted from May 2017 to May 2018 at El Sahel Teaching Hospital.

Ethical consideration

- Informed consent was obtained written informed consent was taken from parents for participation the study. After being the aims and process of the study as well as applicable objectives.

- The study procedures were free from harmful effects on the participants as well as the service provided.

Prior to the study, all the volunteers were examined for peripheral arterial pulsation, presence of diabetes mellitus, swab for wound infection, chronic venous insufficiency and presence of neuropathy. The data collection procedure used in the current study was noninvasive, not potentially harmful, did not provoke pain and did not use any instrument or energy currently considered to be potentially dangerous to the present or future health of the participants or of his off springs. Additionally, great care was taken to use procedures provoking the minimal disturbance to the subject.

Statistical analysis

The data was analyzed using MedCalc© version 15 (MedCalc©

Table 2: Distribution of the studied cases according to complaints (n=60).

Complaints	No.	%
CVI	10	16.6
Traumatic amputation	10	16.6
Ischemia with ischemic amputated	15	25
MTA stump		
Infected amputated stump	19	31.6
Bed sore	6	10

Table 3: Distribution of the studied cases according to intervention before VAC (n=60).

Intervention before VAC	No.	%
No	46	76.6
Surgery	4	6.6
PTA	10	16.6

Software bvba, Ostend, Belgium). Values were expressed as mean and Standard Deviation (S.D.). The mean and S.D. for each nasal measurement were calculated. The normal measurements and indexes are those that fall between the mean and 2 standard deviations above or below the mean (mean _ 2S.D.). A small mean and a large standard deviation mean that there is wide variation, whereas a large mean and a small standard deviation indicates limited variation.

Results

Table 1 showed the distribution of the studied cases according to demographic data. There were 40 males, their ages ranged from 20 years to 60 years. The number of females was 20 and their ages ranged from 23 years to 59 years. Table 2 showed the distribution of the studied cases according to complaints, the patients were presented with either post traumatic wound, infected amputated stump (MTA) with intact peripheral pulsations, ischemic amputated stump (MTA), Chronic Venous Insufficiency (CVI) or bed sores.

Table 3 showed the distribution of the studied cases according to intervention before VAC, in all cases NPWT procedures were not used unless the peripheral circulation is intact so in 7 cases presented with ischemic amputated stumps so these cases were managed to improve the peripheral circulation as following: 10 cases were treated by Percutaneous Trans-luminal Angioplasty (PTA) and 4 cases were treated by surgical arterial bypass. Table 4 showed the distribution of the studied cases according to fate, these cases were totally healed after using the NPWT and were ready for grafting by the plastic surgeons. They were as following: 10 cases presented with post traumatic wound, 19 cases presented with infected amputated stump (MTA) with intact peripheral pulsations, 4 cases were treated by surgical arterial by pass were complained from ischemic amputated stump. 10 of 15 cases were complained from ischemic amputated stump, were treated by PTA, and 10 cases were complained from chronic venous insufficiency. Non healed cases: 6 cases were not healed and dressing was used. These were as following: 4 cases were treated by PTA were complained from ischemic amputated stump and 2 case were complained from chronic venous insufficiency. The 6 cases presented with bed sores were admitted in the ICU and their wounds were healing but unfortunately the 6 cases died. Table 5 showed the Distribution of the studied cases according to different parameters.

Discussion

VAC therapy was initially developed to treat decubitus ulcers and

Table 4: Distribution of the studied cases according to fate (n=60).

Fate	No.	%
Non-healed	6	10
Healing	10	16.6
Healed	44	73.3

Table 5: Distribution of the studied cases according to different parameters (n=60).

	No.	%
Diabetes	25	41.6
Hypertension	22	36.6
Cardiac	15	25
Renal	9	15

wounds with vascular dysfunction; successively the indications for its use have gradually increased [11].

Recently, it has not only been used for chronic pressure ulcers but also prior to graft or flap treatments in cases of acute wounds, diabetic ulcers, burns and osteomyelitis [12].

VAC therapy exerts mechanical forces on the wound bed and has positive effects on both the contraction of the wound and the proliferation of granulation tissue. Moreover, it stimulates local blood circulation and it significantly reduces bacterial counts in tissues [13].

Armstrong et al. [14] carried out a study in 31 patients with diabetic foot ulcers and reported a 90.3% limb salvage rate without amputation, with an average length of stay of 32.9 days. Only 3.2% of patients were amputated below the knee, and the remaining 6.5% underwent transmetatarsal amputation.

Nather et al. [15] reported a 100% limb salvage in 11 patients with diabetic foot ulcers treated with VAC therapy, presenting Wagner grade 2 or 3 wounds with an average length of stay of 23.3 days.

Ulusal et al. [16] reported an amputation rate of 37%, with an average hospitalization of 32 days. The reason for this higher amputation rates in comparison to those in the literature is that 80% of the subjects had Wagner grade 3 and 4 wounds.

Beno et al. [17] reported efficient results in the management of venous ulcers and infected wounds, and they concluded that an appropriate revascularization is necessary prior to VAC therapy in patients with diabetic foot syndrome and peripheral arterial occlusive disease, while further studies are necessary to prove the efficiency of VAC systems in treatment of infected graft material after revascularization. However, because VAC therapy is a closed therapy system, it facilitates the safe removal of infected drainage, protecting health care personnel and other patients from nosocomial infections [11]. About the use of VAC therapy in the treatment of foot wounds after surgical revascularization of the lower limb, Nishimura et al. [18] reported a case of severe ischemic foot in a patient submitted to left axillopopliteal bypass and third, fourth and fifth digital amputation for gangrene, complicated with *Staphylococcus aureus* infection, in which VAC therapy markedly improved wound healing. Also, Clare et al. [19] reported their experience with VAC device in 17 patients with non-healing diabetic and dysvascular wounds, 6 of whom previously submitted to lower limbs revascularization.

The results of the current study showed that the cases were totally healed after using the NPWT and were ready for grafting by the plastic surgeons. They were as following: 10 cases presented with

post traumatic wound, 19 cases presented with infected amputated stump (MTA) with intact peripheral pulsations, 4 cases were treated by surgical arterial bypass were complained from ischemic amputated stump. 10 of 15 cases were complained from ischemic amputated stump, were treated by PTA and 10 cases were complained from chronic venous insufficiency. Non-healed cases: 6 cases were not healed and usual dressing was used. These were as following: 4 cases were treated by PTA were complained from ischemic amputated stump and 2 case were complained from chronic venous insufficiency. The 6 cases presented with bed sores were admitted in the ICU and their wounds were healing but unfortunately the 6 cases died.

The results of the current study support the usage of NPWT in treatment of chronic wounds.

Our study has several limitations that should be acknowledged. The small number of wounds studied could be a source of bias and we cannot draw conclusions from our data about the appropriate length of therapy.

Conclusion

Our results suggested that VAC therapy, together with periodical surgical wound debridement and specific antibiotic therapy could be helpful to promote and accelerate wound healing of foot lesions after restoration of an adequate distal blood flow through surgical revascularization or angioplasty.

Negative-pressure Wound Therapy (NPWT) devices are designed to apply controlled suction to a wound bed at continuous or intermittent pressure settings to stimulate wound closure. Negative pressure can result in numerous alterations in the wound environment, including removal of excess exudate containing high concentrations of proteases and inflammatory cytokines, stimulation of senescent cells, mobilization of macrophages, and stimulation of angiogenesis.

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