Negative Pressure Wound Therapy (NPWT) Using On-shelf Products for Treatment of Post-Traumatic Wounds: A Case Series

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Abstract

Objectives: To assess the efficacy of on-shelf products as a substitute for negative pressure wound therapy (NPWT) when commercial devices are not available and to explain the way those on shelf products can be used.

Material and Methods: On-shelf products that have been tried by the researcher as a substitute for the commercial expensive devices consisted of two suction tubes, a sterile plastic reusable canister, a dressing medium which is either foam sponge derived from a sterile scrubbing brush, or ordinary sterile gauze, adhesive sheet (e.g. Opsite), a nasogastric tube and the suction set with bacterial filter and a measuring gauge; to assess the suction power; fixed to the suction pipe in the room.

Case series: During the period from January 2008 till August 2012, Ten case were treated in Aseer Central Hospital, Abha, Saudi Arabia, using the on-shelf products (five cases with foam, four with gauze, and one in wich both types were used. Continuous suction mode was used in all cases.

Conclusions: Despite the fact that commercially provided devices for NPWT are quite expensive, it remains a cost-effective adjunct to wound healing. The use of on-shelf universally available substitutes for the expensive commercially provided NPWT devices proved to be effective, much cheaper and hence, more cost-effective.

Key Words: Negative pressure wound therapy (NPWT) – Cost-reduction – On-shelf products – Traumatic wounds.

Introduction

NEGATIVE Pressure Wound Therapy (NPWT) is the application of sub-atmospheric pressure to a wound using a dressing medium in a closed environment. It has become a recognized intervention for various types of wounds [1].

NPWT (traditionally named vacuum therapy) has been used for the treatment of open wounds for nearly a century. Beginning in 1908 with Bier’s Hyperemic Treatment [2], clinicians have applied vacuum suction to infections and all types of chronic, traumatic, and post-surgical wounds. More contemporary uses of vacuum suction were described in the 1970s in Russian literature and Fleischmann’s work followed by case studies described by Chariker, Jeter, and Tintle in 1989 [3]. In 1993, the FDA cleared “Vacuum-Assisted Closure (VAC) therapy” for marketing purposes and use in wounds. The system included a sterile, open-cell foam dressing that was placed into a wound, sealed with an adhesive drape, and then exposed to sub-atmospheric pressure applied through attached tubing. Evidence of improved wound healing, increased granulation tissue formation, and decreased bacterial load was noted [4].

A lot of commercial devices are available in the market nowadays. Their main idea is the use of open-cell polyurethane or polyvinyl alcohol foam sponge with a pore size mostly ranging from 400-600mm in diameter as the dressing medium and a suction pump; however, with comprehensive investigation of current clinical databases, evidenced-based research exists, which supports gauze as an effective interface for use with NPWT [5].

Those devices and their accessories are quite expensive. They are not available in most of the hospitals, especially in countries with low health annual budgets. Taking the vacuum assisted closure (VAC) system as an example, the average cost to supply equipment for therapy was USD 96.51/day [6].

To overcome this problem, the researcher applied on-shelf products, which are available in all hospitals, with the wall suction for treatment of
wounds in a series of cases, of whom the results were satisfactory. The daily cost of the substitute treatment using on-shelf products was around USD 4.00 or even less.

This case series aimed to assess the efficacy of on-shelf products as a substitute for NPWT when commercial devices are not available and to explain the way those on shelf products can be used.

**Material and Methods**

In this study, the on-shelf products that have been tried by the researcher as a substitute for the commercial expensive devices consisted of two suction tubes, a sterile plastic reusable canister, a dressing medium which is either foam sponge derived from a sterile scrubbing brush, or ordinary sterile gauze, adhesive sheet (e.g. Opsite), a nasogastric tube (Fig. 1A), and the suction set with bacterial filter and a measuring gauge; to assess the suction power; fixed to the suction pipe in the room (Fig. 1B).

Ten cases were treated using the on-shelf products, five cases with foam, four with gauze, and one in which both types were used. Continuous suction mode was used in all cases.

The objectives of the treatment was explained to the patients with details including the pain which will accompany the therapy and other possible pitfalls (e.g., leakage or obstruction and how to deal with them) as the patient’s or his escort’s participation is important for the success of treatment. Then, an informed consent for the treatment was signed by the patient or his substitute decision maker (e.g., parents).

The procedure was done either bedside or in the operative theatre according to pain tolerance, wound size, severity, need for sedation, especially in children; need for surgical actions and presence of other co-morbidities. The site was prepared and draped and the surrounding skin was dried. The sponge or the gauze was patronized to fit the wound without crossing over normal skin. If gauze, it must be socked in normal saline.

The nasogastric tube was put with the holes lying over the sponge or gauze and the wound was sealed by the adhesive sheet to be air-tight. Then, the integrity of the dressing was checked by connecting the tube to the suction piece and the pressure was adjusted to -125mm Hg in case of sponge or -60 to -80mm Hg in case of gauze. The sponge (or gauze) was sucked in, and the gauge showed how much negative pressure has been created, then the pressure was adjusted. The dressing was auscultated for air leakage, then checked once daily by the treating team during the daily ward round and two times every nursing shift for integrity.

The patient was instructed to drink plenty of oral fluids, kept on prophylactic anticoagulants if bed-ridden, allowed to ambulate for up to 30 minutes. The patient is usually allowed to ambulate every two hours after disconnection and sealing of the tube, which will be reattached when he is back to bed. The patients were taken for grafting and wound closure after removal of the last dressing once they became ready for grafting.

In this series, the researcher will present four cases; two of them were sponge-based, one was gauze-based and the last one in which both techniques were used.

**Case 1:**

A male-6 year old Saudi child was admitted to Aseer Central Hospital, Abha City, as a case of degloving injury of the dorsum of the right foot and ankle due to a run-over by the tire of a car. The injury resulted in loss of the skin over the lateral part of dorsum of the foot, lateral side of the ankle and lateral side of the lower leg. There was exposure of part of the extensor tendons on the dorsum of the foot and the lateral malleolus (Fig. 2A). The patient was taken to the operating room (OR) for debridement and hemostasis by the orthopedic team, treated conservatively by dressings and referred to the plastic surgery department one week after the accident. Foam-based NPWT, with pressure -125mm Hg, was applied to the wound (Fig. 2B) and was continued for 13 days till the wound became clean and ready for skin grafting (Fig. 2C). A graft then was applied with success (Fig. 2D).

**Case 2:**

A 32-year old male Saudi patient, a victim of road traffic accident that resulted in crush injury with extensive degloving of the dorsum of the right foot with multiple open fractures and dislocations of the metatarsals and metatarsotarsal joints (Fig. 3A). The patient was taken to OR, where debridement and joint and bone fixation has been performed using K-wires. The distally based degloved flap was only approximated with loose sutures due to the edema of the foot and the compromised circulation of the flap. Ten days after the injury the distally based flap became necrotic and blackish. The patient was taken to OR again for debridement,
hemostasis and then NPWT was applied using sponge with -125mm Hg continuous mode (Fig. 3B). The dressing was changed every 3 days and the wound became ready for skin grafting 19 days after the start of the treatment (Fig. 3C), then skin graft was applied to the wound with success (Fig. 3D).

Case 3:
A 43-year old female Saudi patient was admitted to the hospital as a victim of road traffic accident, resulting in open fracture of the upper part of the lower third of the left leg with severe anterior dislocation of the knee joint. The patient was primarily treated by the orthopedic team where plate and screws were applied to the fracture leg and the wound was closed by clips. The severely dislocated knee was reduced and immobilized with an external fixator. The patient was referred to the Plastic Surgery Department when necrosis of the skin over the fracture site was obvious (Fig. 4A). The patient was taken to surgery where tangential excision of the necrotic skin was done, then the wound was dressed for a week in an attempt to make the wound granulate, but unfortunately the wound did not improve that much and one of the screws was exposed (Fig. 4B). NPWT was then applied for 9 days; gauze-based with pressure of -80mm Hg (Fig. 4C), after which the wound improved and became ready for coverage. The exposed nail was covered with enough granulation (Fig. 4D). Skin graft was applied to the wound successfully, without the need for flap coverage (Fig. 4E).

Case 4:
A 57-year old female Saudi patient, diabetic and hypertensive, was referred to the Plastic Surgery Department, Aseer Central Hospital from another hospital as a casualty of road traffic accident. As a result of the accident, the patient had fractured pelvis, (which was fixed by the orthopedic team at the referring hospital) and extensive degloving of the upper two thirds of the right thigh that extended upwards into the pelvis and the lower part of the back (Fig. 5A). The degloved skin was retracted on both anterior and posterior sides of the thigh with partial skin loss exposing the lateral aspect of the thigh and lower back, which was lined with granulation tissue. The patient was kept on dressings for around one week in an attempt to make the degloved flaps adherent and prepare the base of the wound for skin grafting. However, these efforts went in vain. A decision was made to take the patient to OR for approximation or closure of the wound with the application of the NPWT. After cleaning and draping, the degloved flaps wear examined and pulled to approximate the defect’s edges. No undermining was done as the flaps were hardened due to edema, so as not to compromise the circulation. The approximation was done using vessel elastic loops as it was not possible to close the defect directly (Fig. 5B). Under the elastic loops, sponge was inserted (Fig. 5C), then over it another layer of sponge to preserve the elastics (Fig. 5D). Sponge-base was selected as high negative pressure of -125mm Hg was needed to make the flaps adherent to the underlying surface. The first dressing was left undisturbed for 3 days after which two more dressings were applied on alternate days with tightening of the elastic bands to approximate the edges of the wound, just before application of the adhesive sheet. Six days later, the wound edges were near to each other, thus allowing closure of the wound by direct sutures, except for an elliptical area which needed elastic bands approximation and gauze suction which has been continued for about two more weeks till it became closed (Fig. 5E).

Results and Discussion
The results were of applied on-shelf material for NPWT were satisfactory in all cases. Minor leakage occurred 7 times and was easily managed by the nursing staff through reinforcement of the dressing with more adhesive sheets.

Major leakage was reported twice which necessitated removal of the dressing and reapplication. The first one was due to excessive discharge from the wound bed and the other was due to dressing removal by the patient (child) as a result of negligence of his escort. The dressing was covered by cotton roll and crepe bandage to prevent the child from removal of the dressing.

Blockage was reported in three cases. The first one was due to kinking of the tube under the patient. The second and third ones were due to disconnection of the device for long periods more than 3 hours. These were managed by clearing the blockage by injecting saline and reconnection, after which it started to work properly. Pain was more tolerable in case of gauze suction as the pressure was less. It was managed by NSAIDs.

The direct effects of the NPWT system are to stimulate the formation of granulation tissue. It was observed that the granulation tissue that has been formed with sponge dressing was smoother than that formed with gauze dressing. However, in both cases, the graft take was almost similar.
Fig. (1A): The components of the Vacuum set used.

Fig. (1B): The suction set with measuring gauge fixed to the room pipe system.

Fig. (2A): Extent of trauma.

Fig. (2B): The NPWT applied and fixed to the wound.

Fig. (2C): The wound on the day of grafting.

Fig. (2D): The wound 4 days after skin grafting.

Fig. (3A): Crush injury with extensive degloving and open fractures and dislocations of the right foot.

Fig. (3B): The NPWT is applied to the right foot after debridement.
Fig. (3C): Wound became ready for Grafting.

Fig. (3D): The wound 6 days after grafting.

Fig. (4A): The necrotic skin over the fracture site, the arrow points at the fracture site.

Fig. (4B): The wound 2 weeks after tangential excision, the arrow points at the exposed nail.

Fig. (4C): Gauze based NPWT applied to the wound.

Fig. (4D): The wound on the day of grafting.

Fig. (4E): The wound one week after skin grafting.

Fig. (5A): The extent of the trauma on the day of first surgery.
Capobianco and Zgonis [7] stated that the negative pressure applied to a wound removes interstitial fluid high in cytokines, collagenases and elastases, which are known to inhibit fibroblast development and proliferation. Furthermore, this interstitial fluid has been shown to decrease tissue perfusion through its mechanical occlusion of local capillary blood flow. The negative pressure that is applied to the wound decreases the wound dimension by stimulating cellular proliferation and protein synthesis.

Othman [8] stated that ministries of health are trying to save money and yet provide the same quality of care. Wound management is a potential field where this could be addressed, through a wider use of NPWT. There is a substantial body of clinical and economic evidence supporting NPWT in wound management, including early discharge and faster healing, fewer readmissions, better patients’ quality of life, and improved cost effectiveness.

The popularity of NPWT as an adjunct to wound healing has been attributed to worldwide marketing, assumed safety, and overall cost-effectiveness. NPWT is estimated to cost approximately USD100 per day. This includes the cost of dressings, a canister and rental of the vacuum pump. NPWT has higher material costs than traditional wound treatment therapies (i.e., gauze); however, the cost may be offset by the benefits of reduced healing time, reduced nursing staff time and expense, decreased length of hospital stay, and facilitation of patient transfer to lower-cost care settings [9]. Nevertheless, this relatively high price is certainly far beyond the capacity of most centers in developing countries to apply NPWT.

Several authors reported that less-expensive devices were tried. Barnes et al. [10] evaluated the cost-effectiveness of NPWT using reticulated open-cell foam as delivered by a VAC in patients with complex wounds in a long-term acute care settings. They concluded that the lower cost per cubic centimeter volume reduction suggests that the reticulated open-cell foam produces a more favorable cost-effective solution.

In the present study, the researcher applied available on-shelf products as a less expensive
substitute for the highly expensive commercially provided NPWT products. The estimated cost for the on-shelf products for applying the NPWT to a wound is less than 4 USD/day.

In conclusion, despite the fact that commercially provided devices for NPWT are quite expensive, it remains a cost-effective adjunct to wound healing. The use of on-shelf universally available substitutes for the expensive commercially provided NPWT devices proved to be effective, much cheaper and hence, more cost-effective.

References


