Case Report

“Low Cost” Negative Pressure Wound Therapy for Acute and Chronic Wounds: A Case Series

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Keywords

Acute wound · Chronic wound · Healing · Negative pressure wound therapy · Vacuum-assisted closure

Abstract

Negative pressure wound therapy (NPWT) is an alternative to standard treatment of acute wounds (such as traumatic or postoperative wounds) but also in that of chronic wounds (such as ulcers or stage 3 and 4 pressure ulcers). With cellular, extracellular effects and bacterial clearance, it leads to the rapid formation of healthy budding granulation tissue, which provides wound bed for directed healing or secondary coverage by skin graft or flap. However, the exorbitant cost of VAC (vacuum-assisted closure) devices for our limited resources health facilities and their unavailability led us to opt for a “low cost” solution using wall suction and disposable materials readily available in all surgical departments. We present the technique used in our department and its results through a series of 3 cases with both acute and chronic lesions evolving in septic environment and where NPWT enabled us to ensure a genuine care protocol until healing while reducing the cost of therapy, the number of dressings and the length of hospital stay.

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Introduction

The idea of using negative pressure (NP) to assist wound healing is not new. In the 1970s, pioneering Russian surgeons were already applying the principle of a vacuum chamber placed above the wound. And even if the widespread use of this technique in many surgical specialties is due to the commercial development of many innovative devices, the fact remains

that the principle of its use goes back further. In 1986, Kostiuchenok et al. [1] demonstrated, in a study of 116 patients, the superiority of NP dressing for infected wounds after surgical debridement compared to surgical debridement alone. Three years later, Chariker and Jeter published a method of NP dressing connecting wall suction via a drain to moist gauze pads covered with adhesive film, allowing a thin and dense granulation tissue. It was only in the early 90s that Fleischman et al. [2] successfully applied this new NP wound therapy (NPWT) to 15 patients with open fractures using foam dressing for an extended period of time in order to promote granulation and healing. It was Argenta and Morykwas [1, 2] who eventually popularized the technique using a combined system of open-cell polyurethane foam and NP applied in a controlled manner. The granulation tissue obtained through this new approach was thicker and more ventilated, but the financial costs of acquisition and operation of this device were higher, making it inaccessible to low-income countries. Working in a remote and limited resources hospital, access to such medical devices is not always easy task to manage (7,500 USD per unit and 75 USD for each dressing change) [3]. Therefore, we opted for a “low-cost” but yet effective alternative which requires both wall suction as described in the original technique but using a foam whose properties are similar to polyurethane or polyvinyl alcohol foams used in more modern devices. While some teams with a similar device to ours reduce the costs to 15 USD [4], in our experience the cost has never exceeded 4 USD for each dressing change. This adaptation allows us to set up a genuine care protocol for wounds, including complex ones, by supporting with NPWT the entire healing process up to the epidermization phase.

Materials and Methods

We report the case of 3 patients with acute and chronic wounds evolving in a septic context.

Case No. 1 (Fig. 3): A 22-year-old man presented late after having been treated by a bone-setter following a crushing injury of his right ankle. A “too tight” traditional immobilization device was made which led to the formation of a voluminous purulent collection of the medial surface of his right ankle and with a large cutaneous necrosis, subcutaneous detachment, and significant inflammatory signs.

Case No. 2 (Fig. 4): A 27-year-old paraplegic female patient was admitted for the management of stage 4 sacral pressure ulcer constituting deep ulceration with muscle and bone involvement and multiple areas of necrosis.

Case No. 3 (Fig. 5): A 58-year-old woman with insulin-dependent diabetes presenting ulceration of the dorsal surface of her right foot with loss of substance and purulent infiltration towards the superomedial part and towards the 2nd toe.

As a first step, all patients underwent flattening with surgical debridement, cleaning, excision of devitalized or necrotic tissues, elimination of fibrin, abundant irrigation using saline solution, and an antibiotic therapy adapted to the results of bacteriological findings. Debridement, which is a capital step, must be meticulous and repeated at each dressing change if necessary. In order to use our “low cost” technique (Fig. 1), we replaced polyurethane foam by that from surgical scrub brushes, the tubing, and its suction port by nasogastric tube or bronchial suction tube No. 14, 16, or 18, the hydrocolloid for the protection of wound edges by tulle gras (vaseline gauze), the adhesive film ensuring sealing by an incise drape and the therapy unit by wall suction and exudates collection bottle. We start our installation by protecting the surrounding skin using strips of tulle gras. Afterward, we cut up the foam to make it correspond to the wound, in size and depth (Fig. 2A), and then, using straight forceps, we create a tunnel in it, large enough to allow the introduction of the nasogastric tube (Fig 2B, C). We then carefully place the foam in the wound without covering healthy skin but

Fig. 1. Elements of the "low cost" negative pressure wound therapy (NPWT): **(1)** Tulle gras in place of hydro-colloid. **(2)** Nasogastric tube or bronchial suction tube No. 14, 16 or 18 in place of the suction port and its tubing. **(3)** Foam from surgical scrub brushes in place of Polyurethane foam. **(4)** Incise drape in place of adhesive film ensuring sealing. **(5)** Wall suction gauge connected to exudates collection bottle, set to -125mmHg, in place of therapy unit.

Fig. 2. Example of applying NPWT device: **(A)** Cutting the foam according to the wound size and depth. **(B)** Creating a tunnel in the foam using straight forceps. **(C)** Introducing the nasogastric tube in the tunnel. **(D)** Protecting the tendons with tulle gras. **(E)** Placing the foam in the wound. **(F)** Applying the incise drape maintaining an airtight seal.

Fig. 3. (A, B) Purulent collection of the medial surface of the right ankle with a large cutaneous necrosis, subcutaneous detachment and significant inflammatory signs. (C) Appearance after debridement and conventional dressings showing the significant presence of fibrin. (D) Applying NPWT device after another debridement. (E) Budding granulation tissue, without fibrin. (F) Result after directed healing.

Fig. 4. (A) Stage 4 sacral pressure ulcer constituting deep ulceration with muscle and bone involvement and multiple areas of necrosis. (B) Appearance after debridement. (C) Applying NPWT device creating a “foam bridge”. (D) Reduction in the size of the pressure ulcer and installation of budding granulation tissue, without fibrin. (E) Placing a gluteus maximus flap. (F) Final appearance after healing.

exceeding wound surface by about 1 cm (Fig. 2E). After that, we proceed to careful application of incise drape to cover foam dressing, while respecting an additional edge of 5 cm or more if necessary in order to make it airtight (Fig. 2F). In our female patient with sacral pressure ulcer, we created a “foam bridge” by connecting different pieces of foam together, so we can shift tubing positioning to a location that makes it easier for us to connect the suction pipe with (Fig. 4C). It should be noted that noble nerve, ligament, or tendon structures must be protected by interposing an interface between them and the foam (Fig. 2D). In our case, the interface was tulle gras. All that remains is to connect the end of the probe to wall suction system via suction bottle where serous fluid will be collected. Therapy is initiated by setting vacuum gauge to a continuously delivered NP of -125 mm Hg (Fig. 1B). We authorized a

Fig. 5. (A) Ulceration of the dorsal surface of the right foot with loss of substance and purulent infiltration towards the superomedial part and towards the 2nd toe. (B) Appearance after debridement, exposed extensor tendons. (C) Applying NPWT device. (D) Installation of budding granulation tissue, without fibrin, covering the tendons. (E) Skin grafting. (F) Healing.

maximum of 1 h of suction interruption per day for ambulation, wash, and fulfillment of needs. The dressing is changed every 72 h. Wounds were carefully cleaned with saline solution during each dressing change, and a mechanical debridement using a curette was performed during the first dressings in order to minimize bacterial load by eliminating biofilm. All our patients benefited from this therapy for 3 weeks, which represents a total of 5 dressing changes.

Results

The size of all wounds reduced considerably and rapidly with the installation of budding granulation tissue which appeared as early as the first dressing change. Granulation tissue was clean, bright red, well vascularized, bleeding on contact, ventilated, without fibrin, or exudates. This granulation tissue offered good conditions for directed healing for the first case and allowed us to proceed with a secondary coverage using gluteus maximus flap for sacral pressure ulcer and skin graft for diabetic foot ulceration. It should be noted for the latter case that thanks to NPWT, exposed toe extensor tendons kept their physiological appearance, hydration, and white color, and were not subject to drying out or necrosis. Both patients who underwent secondary coverage were also put on NPWT immediately after surgery for 5 days, which promoted faster healing. No pain was reported neither during therapy hours nor during dressing changes for which the application of a little saline solution was sufficient to achieve smooth removal. The only notable disadvantage of this “low cost” NPWT adaptation was the limitation of patient movement due to the device connected to wall suction.

Discussion

NPWT systems are adjuvants to healing certain traumatic or surgical wounds with high risk of complications or certain chronic wounds that do not heal at first intention [5]. They boost the physiological healing process until granulation tissue is obtained, leading to directed healing or secondary coverage surgery. NPWT thus reduces the number of dressing changes, the cost of therapy, and the length of hospital stay and places the patient in both physical and psychological comfort to complete the healing process. Its indications concern all loss of substances, acute hollow wounds (post-traumatic, surgical, with or without

infection) and chronic hollow wounds (leg ulcer, diabetic foot ulcer, stages 3 and 4 pressure ulcers), exuding wounds, 2nd degree burns, before and after skin graft surgery. Its contraindications are mainly represented by malignant wounds, areas of necrosis before their debridement, untreated osteomyelitis, unexplored fistula, exposed blood vessels, pyoderma gangrenosum, uncooperative or agitated patient, patient with hemostasis problems, or on anticoagulant therapy. NPWT appears to be a complete solution with multiple virtues: it preserves a moist and warm environment favorable to granulation, ensures effective protection of bone and tendons, prevents cross infections by ensuring airtight separation from external environment, drains serous fluids, and prevents their stagnation, thereby achieving bacterial load reduction [6]. It also mobilizes interstitial fluid and reduces tissue edema improving blood flow [7]. All this contributes to the elimination of harmful components such as cytokines and proteases [8], the stimulation of neoangiogenesis process (in particular by increased concentration of local interleukin-8 and vascular endothelial growth factor [9]), promotes cell migration and proliferation, thus leading to the formation of well-vascularized granulation tissue. At the cellular level, NP induced microdeformations by elongation cause a change in ionic concentration and permeability of the cell membrane [10], stimulate metabolic activity (in particular that of cell growth and immune defense factors), induce increased mitosis, fibroblast migration, and formation of expanding extracellular matrix [11]. NP also leads to contraction of wound edges (macrodeformations) and mechanical stimulation of wound basement. In our patients, NPWT enabled us to obtain granulation tissue from the 1st dressing, performed on D4, which is a very short time given the nature of lesions and their septic nature. One of the challenges we faced was the ideal NP to be applied as our wounds were of a different type. Indeed, some authors have shown that low-pressure suction (25 mm Hg) results in decreased drainage of fluid from wound, decreased removal of toxins, and decreased formation of cells. This results in reduced rate of granulation tissue formation. In the other hand, the high suction pressure (500 mm Hg) can cause an increased mechanical deformation of tissues which can lead to localized decrease in perfusion and reduced granulation tissue formation also [12]. However, as the wall suction, we used in our technique is not very precise, we decided not to modify this NP according to the type of wound but to apply the average pressure of 125 mm Hg which is considered as an optimal pressure. The other question to be addressed was whether we should use continuous or intermittent mode. The intermittent NP is what it's recommended as it generates more blood flow during vacuum “off” phase. Studies have shown that rate of granulation tissue formation is twice with intermittent NP compared with continuous NP (103% with intermittent vs. 63% with continuous) [1]. However, given the difficulty in mobilizing the necessary human resources and the technical complexity of carrying out a regular and very numerous on/off cycles per 24 h, we preferred to choose the continuous mode for the simplicity of supervision. Subsequently, a check could be done every 3–4 h to confirm good depression of the dressing and assess the nature of the sucked fluid. Concerning the foam used, in the commercialized NPWT systems, 2 types of foam are commonly used: black (polyurethane ether, lighter, hydrophobic with a pore size of 400–600 microns) used for deep and irregularly shaped wounds and white (polyvinyl alcohol, dense, hydrophilic with a pore size of 250 microns) used for superficial surface wounds. As we did not have these at our disposal, we used the foam of surgical scrub brushes which is sterile, much less expensive and in polyurethane, thus with technical specificities close to the commercialized black foam. For the coverage of a larger area, we put several of these foams side by side, keeping them attached to each other with stitches made with sutures, we then cut their edges until obtaining the desired shape and surface. We could also in the same way and by creating a “foam bridge” shift the placement of the suction probe to a more appropriate or more accessible location with less constraints (Fig. 4C).

In our diabetic patient with ulceration of the dorsal surface of her foot and exposed extensor tendons, NPWT enabled us to cover part of these tendons with healthy granulation tissue constituting a favorable basement for the reception of our skin graft. It has also been used immediately after skin graft surgery by setting vacuum pressure gauge to -75 mm Hg, in continuous suction, in order to stabilize the graft, avoid shearing movements and secure its engraftment. Clinical benefits of NPWT in the management of diabetic foot and its complications, even wounds healing after amputation, were clearly established with faster budding and healing [13, 14]. It was the case with our patient with sacral pressure ulcer where NPWT promoted reduction of wound size and formation of granulation tissue, enabling us to use gluteus maximus flap under the best possible conditions. Although systematic reviews of international literature contain many methodological shortcomings and significant biases, just as our study may include, particularly due to our small sample, the general trend as well as the reality of our daily practice objectively demonstrate that “low cost” NPWT constitutes a reliable, reproducible, safe, economical solution and an alternative to the purchase of expensive equipments and disposable materials, particularly for health structures in low resource countries [15].

Conclusion

In this “low cost” NPWT, the NP produced by wall vacuum promotes effective management of acute and chronic wounds, including complex ones, by rapidly “producing” good quality granulation tissue enabling subsequently the best possible conditions for directed healing or coverage procedures (skin graft or flaps), while reducing the cost of therapy, the number of dressings and the length of hospital stay.

Statement of Ethics

The study was approved by the Scientific Committee and the Medical Council of our establishment (EPH Beni Abbes) under registration No. CM31-2020. Written informed consent was obtained from the 3 patients for publication of this case report and any accompanying images in accordance with the principles of the Declaration of Helsinki.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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Author Contributions

N.S. performed the device placement, the surgeries and wrote the article. B.R. and K.L. participated in the surgical interventions and in the postoperative management of the patients. All the authors read and approved the final manuscript.

Data Availability Statement

All data generated or analyzed during this study are included in this published article.

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