The article was received on February 20, 2021, and accepted for publishing on May 9, 2021.

ORIGINAL ARTICLES

Negative-pressure wound therapy - advantages and disadvantages

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Abstract: *The applications of negative-pressure wound therapy (NPWT) have achieved remarkable diversification. Initially used in the therapy of soft tissue wounds related to open fractures, this technique led to the understanding of the complex mechanisms underlying it. This paper aims to analyze the evolutionary scenarios of a group of patients with heterogeneous lesions under negative pressure aspiration treatment. We aimed to identify and analyze various associated pathologies that have the potential to negatively influence the healing process under negative pressure treatment and implicitly analyze the particularities of representative cases for the group whose evolution under treatment proved to be unfavorable. Retrospective, observational study, type series of cases focused on a group of 17 hospitalized patients, who received treatment by negative aspiration, between 2015-2019 in the Surgery Department of the University Emergency Hospital Bucharest. Regarding the obtained results, diabetes mellitus, obliterating arteriopathy, and anemia had a prevalent distribution in the group with unfavorable evolution. The glycemic value can predict 17% of the evolutionary scenario of a patient (favorable/unfavorable) being necessary an integrative therapeutic conduct. Concluding, although an extremely promising therapeutic option, NPWT can prove to be disappointing given its impact in the background of suboptimally managed comorbidities.*

Keywords: *negative pressure therapy, negative prognosis, comorbidities, amputation, wound complications, lower limb obliterative arteriopathy*

INTRODUCTION

The negative-pressure wound therapy (NPWT) method involves the application of a negative (subatmospheric) pressure to the wounds in a controlled manner [1]. Using a system consisting of a vacuum source, a porous material (filler) arranged inside the wound that respects its limits, a polyurethane adhesive film, which is transparent, permeable to water vapor, and impermeable to bacteria, this therapy method ensures tightness [2]. The first indications of negative pressure aspiration therapy cited in the literature were in the management of soft tissue lesions associated with open fractures and for closing dermatofasciotomy wounds [3]. Currently, after numerous studies have elucidated many complex gears underlying the mechanism of action and it was possible to understand how the overall therapeutic effect is influenced by these mechanisms, the range of therapeutic indications has gained remarkable proportion [4].

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There are many ways in which negative wound pressure suction therapy promotes healing [5]. The suction force acting on the lesion drains the exudate and causes mechanical stress at the edges of the wound [6]. This mechanical stress alters the local tissue perfusion, consequently stimulating angiogenesis and the development of granulation tissue [7].

The changes in tissue perfusion induced by NPWT are a consequence of multiple determinism. Angiogenesis is responsible for a part of the perfusion changes [8]. In addition, pressure modifications from the wound and the physical changes of the existing blood vessels, which in turn initiate alterations in blood rheology, are other important components of the angiogenesis process [9]. Various studies have concluded that these perfusion changes induced by NPWT depend on several factors [10]. The first factor is the regime of application of negative pressure (continuous or intermittent) [11]. Then, the pressure regime used (-50mmHg - -200mmHg), the condition of the tissue (healthy/ischemic), the type of tissue, as well as its proximity to the area on which the negative pressure acts [12].

The healing process can be influenced by modifying various functional and material parameters [13]. Thus, the pressure level, the application of the pressure regime (continuous/intermittent), the type of filler material (foam/gauze), the presence of additional layers in contact with the wound, installation, etc., represent the therapeutic variables that must be agreed with the patient's particularities. Respectively, the patient's pathology, the type of wound, even its shape are factors to consider [14]. All these data play a key role in the therapeutic equation, whose ultimate goal is to obtain the maximum therapeutic benefit and minimize the disadvantages as much as possible [15].

Numerous studies on different types of wounds have revealed that NPWT is a more economical treatment method compared to conventional ones [16]. This involves the use of fewer dressings, and the frequency with which other reconstructive options are used is lower [17]. The healing time of wounds is shorter, and the overall duration of treatment and hospitalization is remarkably reduced [18]. Although the materials used in NPWT are at the beginning more expensive than those required for conventional treatment, in the long run, the costs of conventional therapy outweigh those of NPWT [19].

NPWT was introduced as a preventing technique for post-cesarean delivery wound morbidity, especially for obese women. The reported results are controversial; the heterogeneity of the results being summarized in two suggestive meta-analyses [20]. The background for using preventive NPWT consists in the actual rising trend of obesity and cesarean delivery among pregnant women and the compelling data regarding the results of this therapy in non-obstetrical surgical specialties [21]. However, at this moment, there are no valid studies to demonstrate that the use of NPWT is beneficial as a prevention strategy for wound infections and complications in the obstetric population; it is also not justified in the matter of economical features [22].

MATERIALS AND METHODS

The retrospective study used data collected from the computer database of the hospital, respectively the discharge summaries of the patients. The data collection process focused on the following: demographic data, hospitalization duration, and the main diagnosis. Special attention was given to the associated pathologies that may influence the evolution of lesions of interest under treatment with negative pressure (lower limb obliterative arteriopathy – LLOA, anemia, atherosclerosis, type II diabetes). In addition, other factors were registered, such as laboratory tests (complete blood count, biochemistry analyses, laboratory tests for hemostasis), general clinical examination data, paraclinical investigations (radiography, Doppler ultrasound, angiography, CT (computed tomography), angio-CT), the nature of the primary and subsequent intervention, clinical evolution on the period of hospitalization under negative pressure therapy, the post-vacuum aspect of the lesions, the clinical condition of the patient and the aspect of the lesions of interest at the post-discharge controls.

The centralized data were analyzed descriptively using Microsoft Excel 2019. SPSS Statistics software was used to perform logistic regressions. After the first session of NPWT, the division of patients into the two groups reflecting the general evolution (favorable/unfavorable) and the post-vacuum aspect of the lesions of interest was considered.

Objectives

We aimed to analyze the prognosis of a group of patients with heterogeneous lesions undergoing NPWT. Our objectives included the identification and division of cases according to the favorable/unfavorable evolution of lesions of interest. It also included the appreciation of the distribution among patients of various associated comorbidities significant for the targeted population; according to literature, they have the potential to negatively impact the healing process, even under NPWT (diabetes, obliterating arteriopathy, anemia). We also looked into the analysis of the particularities of the representative cases from the study group whose evolution under treatment

proved to be unfavorable.

RESULTS

According to the inclusion criteria, a group of 17 patients was identified (5 female patients and 12 male patients), aged between 47 and 80 years, the average age being 62 years between 01.01.2015 - 31.12.2019, within the General Surgery III Department of the University Emergency Hospital of Bucharest. The situation of inpatient diagnoses, as well as the prognosis balance, are presented in a more schematic framework in Table 1.

Table 1: Inpatient diagnoses of the studied group

Diagnosis at admission	Patients no.	Prognosis
Gangrene in the lower limbs with various locations	7	Favorable – 5 Unfavorable – 2
Foot trophic ulcer	2	Unfavorable
Secondary purulent peritonitis	2	Unfavorable
Local complications of postoperative wound	5	Favorable – 4 Unfavorable – 1
Necrotizing fasciitis and cellulite of the abdominal wall	1	Favorable

Regarding the prognosis scenarios under NPWT, 7 patients (2 women and 5 men) showed an unfavorable course, the remaining 10 patients (3 women and 7 men) presenting an improved aspect of the lesions of post-vacuum interest (Table 2) (Figure 1).

Following the centralization of the number of hospitalization days, it was possible to outline a distribution of patients, respectively, the minimum number of hospitalization days (six), as well as the maximum number of days of hospitalization (seventy-five). Intuitively, the minimum duration of hospitalization was recorded in the favorable outcome group. Somewhat more edifying, it turned out to be the average number of days of hospitalization, calculated for each group. Therefore, an average of 22 days of hospitalization corresponded to the group with a favorable outcome, while for the group with an unfavorable prognosis, the average number of days of hospitalization was 40 days, with an increase of approximately 45% of the average time spent in the hospital and all its related costs.

Regarding the associated pathologies studied, respectively type II diabetes, anemia and LLOA, were identified in both groups, but overall there was a greater aggregation of these comorbidities within the group with an unfavorable prognosis.

Figure 1: A. Myxofibrosarcoma of the thigh; B. Wound dehiscence after hip disarticulation; C. Wound dehiscence treated with NPWT; D. improved lesion post vacuum therapy

Table 2: The detailed situation of the study group situation regarding the evolution of the diagnosis and the number of hospitalization days.

Diagnosis at admission	Post NPWT	Hospitalization days
Post-operatory wound suppuration	Improved	6
Leg gangrene	Improved	11
Gangrene at the level of the stump after amputation of the toe	Gangrene at the level of the stump	11
Forefoot gangrene	Improved	12
Post-operatory wound seroma	Improved	15
Stump gangrene after amputation of fingers II-V	Improved	15
Post-operatory wound suppuration	Improved	19
Secondary purulent peritonitis (strangulated eventration)	Wound seroma	24
Finger V gangrene	Improved	25
Calf gangrene	Improved	27
Post-operatory wound suppuration	Wound suppuration	31
Necrotizing fasciitis, abdominal wall cellulite	Improved	36
Heel trophic ulcer	Trophic ulcer	40
Leg gangrene	Gangrene at the level of the stump	52
Secondary purulent peritonitis (perforated gastric ulcer)	Wound dehiscence	53
Post-operatory skin necrosis	Improved	56
Toe trophic ulcer	Gangrene at the level of the stump	75

The particularities of the distribution of comorbidities in the studied group of patients are as follows:

• 5 patients diagnosed with LLOA; 4 belong to the group with unfavorable evolution;

• 9 patients diagnosed with anemia; 5 belong to the group with unfavorable evolution;

• 12 patients diagnosed with type II diabetes; all 7 patients constituting the group with unfavorable evolution had type II diabetes.

Regarding the blood glucose values at admission, out of the 12 known patients with type II diabetes, the only values corresponding to the normal range (70 - 110 mg/dl) were recorded in 2 patients belonging to the group with favorable outcome, respectively 85 and 93 mg/dl. The rest of the patients, more precisely the 3 remaining patients of the group with favorable outcomes and the totality of the patients that formed the group with unfavorable prognosis registered glycemic values higher than the normal range.

The tendency was of aggregation of high glycemic values, with small exceptions, in the group with unfavorable evolution.

Upon admission, 9 of the 17 hospitalized patients presenting with the inflammatory syndrome. Of these, 5 patients had a favorable follow-up.

DISCUSSION

The heterogeneity of the studied group lies both in the variety of types of lesions for which vacuum therapy was chosen, and their pathological personal history.

It was noted that the shortest duration of hospitalization, as well as the lowest value of blood glucose at admission, were found in patients belonging to the group with favorable evolution, while their maximum values belonged to patients in the group with unfavorable evolution. This similar pattern of distribution of maximum and minimum values can offer a prediction of the number of hospitalization days based on blood glucose at admission. However, the result obtained was not statistically significant, the value of blood glucose at admission explaining only 0.5% of the number of days of hospitalization and the hypothesis that the value of blood glucose at hospitalization is a predictor of the prognosis of patients has not been confirmed. On the other hand, the statistical results obtained suggest that the glycemic value explains 17% of a patient's evolution.

For a better understanding of the factors involved in guiding the evolution towards a favorable or unfavorable outcome, the second part of the study focused on a succession of 5 case presentations. All the selected 5 patients presented lesions with persistent or even worse follow-up under NPWT, the evolution as a whole of each case lying on the

background of various comorbidities.

Regarding the first 3 cases, we present the outcome of 3 male patients with the ages of 53, 58, and 47 years, respectively. All these cases presented chronic lesions located in the lower limbs, as well comorbidities with significant resonance on blood perfusion: type II diabetes, LLOA, anemia (case 1 and case 3). In all 3 cases, the presence of LLOA is an important issue in the healing process of the lesions, which is why its solution by intervention or surgery plays a crucial role in the management process along with other surgical interventions and NPWT.

Unlike the cases presented above, case 4 is characterized by the vital risk of the associated pathology with which the patient presents, namely generalized peritonitis secondary to a revived, imprisoned multisacular eventration, complicated by strangulation, torsion, and necrosis of the intestinal loops. The patient's prognosis is impacted by the purulent post-operative wound, with a dragging character despite the NPWT applied. Regarding the unfavorable outcome of this case, we have to mention that in addition to the multiple comorbidities (type II diabetes, stage II hypertension, osteoporosis, bilateral gonarthrosis) and multiple personal pathological surgical histories (thyroidectomy, appendectomy, myomectomy, intestinal occlusion) in this case, the particularity emerges from the coexistence of short bowel syndrome and anorexia nervosa. Short bowel syndrome is the prerogative of an extensive surgical bowel section that involved subtotal enterectomy [23]. Anorexia nervosa is a complex behavioral and psychiatric pathology [24]. It is impressive how the two pathologies are intertwined and maintained an altered biological status of the patient, burdened by dehydration and electrolyte and acid-base disorders. All these overlapped with metabolic disorders caused by an unbalanced type II diabetes lead to a status of severe malnutrition. This context, associated with anemia, deprives the whole body, including the postoperative wound of nutrients needed for healing. One mechanism by which NPWT promotes the healing process is by increasing local blood flow, so implicitly the supply of oxygen and nutrients, but the beneficial effect is canceled if the blood flow to the wound is poor in oxygen and deprived of nutrients [25].

In selected case 5, the patient presents for a parietal suppuration in the right inguinal region after surgery with alloplastic materials for the right inguinal hernia. The patient's personal history includes an evacuated inguinal parietal abscess, which occurred after the surgical correction of the right inguinal hernia. In terms of comorbidities, the pathologies representative for the group with unfavorable evolution, respectively diabetes and anemia were noted. In addition, cardiovascular abnormal findings and a prostate adenoma were diagnosed. In the management process, an abscess underlying the pubic symphysis is identified. Surgical treatment aimed to remove all the debris and a cartilaginous fragment, subsequently applying NPWT to the semi-open wound. The patient was discharged healed and in good general condition.

At the first follow-up visit, the patient presents with a dehiscent wound with a visible granulation process and with a good general condition. However, at the second reevaluation, the biological and clinical condition of the patient was significantly worse (presence of fever and inflammatory signs), the right inguinal region appeared pasty and edematous, with the suppuration area located at the inferior area of the wound. Imaging results (inflammatory phenomenon extended to the muscle groups adjacent to the suppurative process, multiple lymphadenopathies, densification of subcutaneous inguinoscrotal and bilateral gluteal tissue, the osteolytic appearance of pubic bones) corroborated with other clinical and paraclinical investigations outlined the diagnosis of pubic osteitis. This diagnosis placed the case on a higher hierarchy in terms of gravity. It is to note that under conservative treatment the symptomatology diminished.

In an attempt to understand the unfavorable evolution of the patient, certain aspects should be discussed. First, the patient was the oldest from the study group (80 years) and the specialty literature mentions the alteration of healing processes in the advanced senescence process [4, 20, 21]. Secondly, there were various comorbidities, of which poorly controlled diabetes, which is responsible for the management difficulties of traumatic wounds. In addition, the infectious factor must be brought into question - staphylococcus aureus was isolated from the patient's wound – a virulent pathogen that causes treatment difficulties, even in people without a significant amount of comorbidities.

There are several limitations of this study that should be mentioned. One of these is the small number of patients included. Also, the study was retrospective and the data were collected from indirect sources, namely the computer database of the hospital, with no information available regarding the materials (filler material, wound contact layers) and the functional parameters applied (pressure level, pressure regime, vacuum source). Certain biological parameters crucial for documenting the prognosis of the case could not be identified, for which reason it was not possible to include them in the statistical analysis.

CONCLUSIONS

According to our study results, the majority of patients for which negative pressure wound treatment was applied presented a favorable outcome.

In order of frequency, the diagnoses at admission for patients included in our study were as follows: gangrene with various localizations in the lower limb, local complications of postoperative wound, legs trophic ulcers, secondary purulent peritonitis, necrotizing fasciitis, and parietal-abdominal cellulitis.

The average number of hospitalization days for the group with unfavorable outcomes was almost double compared to that of the group with favorable evolution, which engaged higher costs.

Pathologies such as diabetes, lower limb obliterative arteriopathy, and anemia had a prevalent distribution in the group with unfavorable evolution. According to the statistical analysis, the glycemic value can predict 17% of a patient's prognosis scenario (favorable/unfavorable).

The cases presented in the study mean to highlight the importance of an immediate, integrative and exhaustive therapeutic approach. Although an extremely promising therapeutic option, NPWT can prove to be disappointing, given its impact in the background of suboptimally managed comorbidities.

Acknowledgments

Professional editing, linguistic and technical assistance performed by Irina Radu, Individual Service Provider, certified translator in Medicine and Pharmacy (credentials: E0048/2014).

Funding: No funding was received.

Authors' contribution:

GP - design of the paper; CIM - drafting of the paper; VAB - analysis of data; NT - interpretation of data; MMC - revising of the paper; BC - final approval of the paper; CC - final approval of the paper All authors read and approved the final manuscript.

Ethics approval and consent to participate:

The study was done following the ethical standards stipulated by the Helsinki Declaration.

Patient consent for publication: Not applicable.

Competing interests:

The authors declare that they have no competing interests.

Availability of data and materials:

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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