Negative Pressure Therapy in Wounds Surgical Treatment

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The study aims to assess the significance of negative pressure therapy in the treatment of 1 January 2014 - 31 June 2017. The objectives intend to evaluate the healing time required after applying the method and the functional consequences for the patient. A prospective study was conducted on a sample of 31 patients with various tipe of wounds which were monitored their clinical course between September 2014 - February 2017, following negative pressure therapy. There were used vacuum assisted closure devices (VAC ™ - Hartman) in order to apply negative pressure to the wound, while complying with specified settings in accordance with patients' outcome. Healing was obtained in all cases, to an average hospital stay of 30 days and 12 days of therapy application.The negative result of microbial cultures was obtained after an average of 7.55 days by simultaneous application of negative pressure and antibiotic treatment according to the antibiogram. After basic treatment of the wound, auxiliary methods such as negative pressure contribute to the healing. Evolution was favorable with wound granulation in 95% cases, which allowed surgery under local anesthesia, and defect was covered with skin graft. VAC therapy falls into the last group of treatments by eliminating healing inhibitors. This regenerates the wound in a damp environment and essentially turns an open wound into a closed system.

Keywords: negative pressure, wounds treatment

The first experience in the use of negative pressure therapy occurred in 1987 when it was used in the treatment of soft tissue injuries and septic wounds.

Numerous articles were published in the early 1990s and the spectrum of indications was expanded for chronic wounds (leg ulcers, decubitus ulcers). In early 2000s a significant extension of indications of applicability of the technique was noted in severe dermatological syndromes, problematic vascular surgery wounds and also an increasing use in plastic surgery.

Fleischmann described the method of exposure to subatmospheric pressure of the wound to obtain debridement and wound healing in 1993 in patients with open fractures.The procedure was improved in Germany by Muller, who applied it to 300 patients with infected wounds, and in 1998 Kovacs et al. described using the technique in the treatment of chronic leg ulcers.

By applying negative pressure therapy in the surgical field in the last 20 years, it was promoted a new approach to treat infections of the surgical wound. Due to its benefits, this therapy is currently being introduced widely, becoming the method of choice in some pathologies, minimalizing surgical gestures.

In our country plastic and reconstructive surgery has been shaped and strengthened as a specialty due to a sustained activity carried out by medical, scientific and organizational development by Professor Agrippa Ionescu and his team. Plastic and reconstructive surgery may have been one of the most amazing advances, from the first rebuilding of a finger, to the entire human body. Over the last 20 years, an impressive number of people around the world have only gained from developing this important branch of modern medicine [1]. Over the past decade negative pressure therapy has emerged as an adjunct to the management of surgical wounds in a range of specialties including plastic and reconstructive surgery. NPWT is an effective method used for the management of acute and chronic wounds with a well documented efficacy in the adult population. The main indications are surgical wound dehiscience and skin grafting, but NPWT is also used in head and neck surgery, for example in anterior tracheal necrosis after total thyroidectomy used in malignant tumors of the thyroid and in huge multinodular goiters and in some types of thyroiditis[2,3].

The objectives of wound healing are represented by minimizing blood loss, replacement of defects with new tissue (granulation tissue followed by scar tissue) and to restore an intact epithelial barrier as quickly as possible.

Thus, auxiliary therapy such as ensuring local hyperbaric oxygen atmosphere, the administration of growth factors, skin-substitutes, grafts of cultivated keratinocytes, electrical stimulation and local drainage, with or without flushing by sealing the woundin negative pressure, may constitute the conditions for local healing. Increasing blood flow in the circulation and compromised or damaged tissue oxygenation enhance the ability of resistance to infection.

Successful healing of wounds, spontaneous or after surgery, is correlated with the bacterial load of the affected

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tissue which must be less than 10u bacteria per gram of tissue.Bacterial accumulations greater than 10u interfere with wound healing.The study aims to demonstrate the usefulness of the method and its clinical use, which is increasing the benefits it brings to both patients and medical establishment.The objectives of the study are to assess the healing time after applicating the method, the extent of the surgical procedure and the functional consequences for the patient.

Experimental part

Materials and method

The prospective study was conducted on a sample of 31 patients hospitalized in the St. Spiridon Hospital Plastic and Reconstructive Clinic, Iasi. The period of the study was between 1 January 2014 - 31 June 2017. Data used were those related to the patients' demographic, history of the underlying disease, complications and markers of inflammation. All wounds were monitored by measuring the sizes and photographed during evolution.

Laboratory investigations carried out before the beginning of the negative pressure therapy have included laboratory tests (CBC, markers of infection), an antibiogram sampling from the wound or from secretions externalized prior to surgerical gestures.The above mentioned parameters were monitored throughout the whole treatment period in accordance with recordingthe data on the duration of negative pressure therapy, the number of surgical debridement between wound dressings and negative pressure values used. Patients were monitored until the wound has completely healed.

Prior to the application of the VAC ™ device for negative pressure, the appropriate surgical debridement of all wounds was applied, afterwards being cleaned and well irrigated by the jet lavage (H, O, , betadine and saline).

NPWT dressing has been designed according to the wounds, which are then sealed with a semi-permeable film from the kit.

Pressure level was set individually for each patient based on their needs, using continuous suction initially, and intermittent suction subsequently, ranged between 90 and 125 mm Hg.

Pressure settings were dependent on the local conditions of the wound and pathological conditions of the patientwere considered.

Dressing change was performed every 48-72 h by doctor.

Results and discussions

In relation to the admission of the patients in the hospital, their number was variable.

Demographic data revealed that 23 of 31 patients were male and 8 female, aged between 19 and 80 years. Depending on the age groups, there were registered between 18-25 years - 3 cases; 26-45 years old - 3 cases; between 46-65 years - 16 cases and over 65 years - 9 cases.

Regarding their living area, 65% came from the countryside.

The patients who came to the emergency unit represented 68% (21 patients) and 32% (10 patients) were admitted for various chronic complaints. The etiology of the defects was varied, being represented by trauma - 10 cases (32%), burns - 4 cases (13%), other mecanism - 17 cases (55%) (fig. 1).

Classification of defects according to localization: thoracic limbs - 6 cases, pelvic limbs - foot 5 cases, ankle - 2 cases, butt - 10 cases, thigh - 3 cases, other locations - trunk - 5 cases;

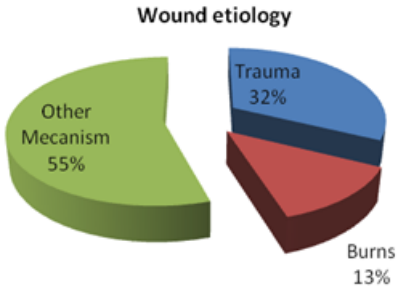

Fig. 1. Wound etiology

Soft parts interested : skin - 2 cases, subcutaneous cellular tissue - 29 cases;

Exposed structures: bone - 5 cases, tendon - 8 cases, vessel - 10 cases, nerve - 8 cases;

Presence of plate osteosynthesis materials - 1 case.

Another criteria that has been taken into account for the analysis of the casuistry was: initial injury through trauma (simple) - 4 cases ; complex (3-4 anatomically injured elements) - 8 cases ; by trophic ulcer - chronic venous insufficiency - 5 cases ; decompensated cardiac failure - 2 cases ; kidney failure - 1 case ; diabetes mellitus - 5 cases ; post-fall scars - 3 cases ; tumors +/- irradiation - 3 cases.

Most patients under observation had both associated diseases and aggravating factors such as: type 2 insulin-requiring diabetes mellitus - 9 cases ; chronic obliterative arterial disease - 5 cases ; chronic venous insufficiency - 4 cases; chronic edema of various causes (IRC, ICC, cirrhosis) - 6 cases; prolonged decubitus - 7 cases (fig. 2)

The number of days of hospitalization versus the number of days of VAC-applied therapy varied according to the general condition of the patient, the existing comorbidities and the favorable effect of negative pressure therapy over time.

Patients were admited for an average of 30 days , during which they received an average of 5 dressing kits.

An important step in therapeutic conduct is the bacteriological examination of wound secretion. A series of microorganisms responsive to wound infection have been isolated from the assay. The prevalence of Gram-negative bacilli compared with other pathogenic microorganisms, such as bacilli gram positive and fungi (fig. 3)

The microorganisms found were sensitive to the following antibiotics:clindamycin, ciprofloxacin, colistin, cefort, metronidazole, amoxicillin, fluconazole.

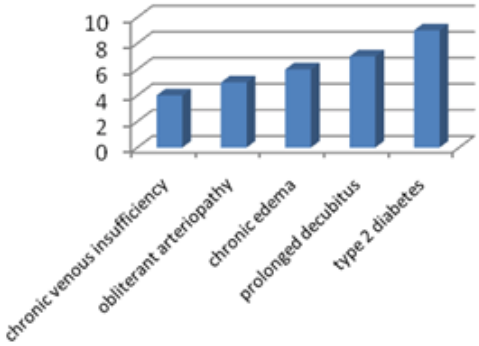

Fig .2. Associated Comorbidities

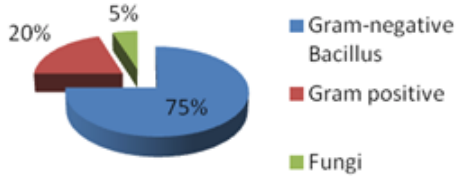

Fig.3. Pathogenic microorganisms present in wound secretion

A number of studies have demonstrated the benefits of negative pressure therapy in the treatment of infected wounds, showing superior efficacy compared to conventional dressings.

In the study, we obtained an average of 12 days of use of the technique to the closing time of the defect or grafting, with an average hospital stay of 30 days, as sustained byMcCallon.

The mechanisms of action of the negative pressure wound therapy may be quantified for generating micro and macrodeformation to the wound. The reduction in size of the wound due to the pores of the material used and the action of centripetal forces exerted on the entire surface of the wound by the sponge applied, determines its macrodeformation.

The cells are subjected to various mechanical forces, including the hydrostatic pressure of the extracellular fluid, stretching and compression transmitted over the entire cell array, all this joining the force of gravity determines microdeformations to the wound .

Analysis of the above mentioned elements has shown that the tissue in the vicinity of the sponge structure is subject to compressive forces. In general, regular microenvironment, but very variable created during this therapy is causing micro deformation. Microdeformations represent the result of the morphological integrated mechanics, the shape of the cells being an important determinant of their function [4]. Furthermore, it is known that cells can adapt to physical stress and thus the cell functions can be initiated by physical anddynamic changes. In children there si a limited experience with NPWT due to concerns about vascular compression and pain associated with treatment. However, studies in pediatric oncology patients showed that this method can be used as an adjuvant in wound healing and closure even in rare pediatric cancers [5].Small and dense LDLc (LDLcholesterol) particles seem to be the marker of a series of anomalies including HDLc (HDL-cholesterol) concentration decrease, apoB concentration increase, insulin sensitivity decrease, and procoagulant changes (PAI-1 increase) [6]. Numerous experimental studies prove the capacity of the vegetal polyphenols to diminish the lipid peroxidation and to reduce the LDL oxidation [7]. The macrophages, T cells and cytokines (Interleukin-1-beta) cooperate in synergy to destroy B cells. Insulin dependent diabetes mellitus is the result of this action [8]. Angiogenesis is initiated by the cell bed microdeformation that cause local hypoxia and thus leads to an increase in the vascular endothelial growth factor (vascular endothelial growth factor - VEGF). The temporary reduction of blood flow to the edges of the wound stimulates angiogenesis through hypoxia-inducible factor (HIF) -1alfa -> VEGF with an increase in density of microcirculation [9-11]. The superoxide radical is involved in various physiological and pathophysiological processes. It is produced in respiratory and cytochome P450 electron transport chain reactions as a by-product. A high amount of this product is also generated by activated neutrophils and macrophages during oxidative burst. The secondary immune isolated thrombocytopenia occurs in the context of some infectious diseases; in this regard, bacterial infection is involved in the etiology of moderate thrombocytopenia [12,13].

Depending on the underlying pathology, chronic wounds and swelling are often concomitant, and accumulated excess fluids being accepted as a contraventionalhealing factor by the compression effect exerting locally on cells and tissues. Applying negative pressure in these situations reduces extracellular fluid accumulation resulting in a better blood perfusion by reducing compression on the microvasculature [14]. Toxins, bacteria and exudate may be removed from the wound site along with the fluids [15].

The dressing is impermeable to proteins and microorganisms, reducing the risk of contamination of wounds, having limited permeability to water vapor and other gases, thus helping to maintain a moistand stable environment at the wound.

The lack of a wound bed which could allow the extension and cell adhesion, prevents the development of isometric tension within the cell, thus leading to its spheronising and finally to apoptosis, a situation that was not found in chronic wound bed.

Before applying negative pressure therapy,patients were subjected to debridement excision involving changing of the dressing twice a day, under surgical stress, maintaining systemic inflammatory response syndrome (SIRS) and also an increased risk of septic complications, while the negative pressure therapy system allowed a few days between procedures, thereby increasing patient comfort and decreasing hospital costs (time in the operating room, workload, materials).

Microbiological surveillance of the wound after initiation of negative pressure therapy was shown to significantly improve the evolution, with an important reduction in the contamination of the wound. From a clinical point of view, necrosis was produced in a limited number of cases,obvious remission of SIRS and hipercatabolic syndrome was observed [16]. In cases with a large number of days of hospitalization during which surgery was performed that targeted the digestive tract there are studies which confirm the appearance of endogenous fungal endophthalmitis after recent surgery.

Negativity pathogen susceptibility was obtained in all patients studied, the mean being 7.55 days of use with results similar to those reported in the literature, where studies have certified decreased bacterial load of the wound for about 20% of patients in the four days of the establishment of negative pressure therapy and 60% of patients in 8 days after start of treatment. Studies of Morykwas and Argenta, Banwell et al. and Morykwas et al. have reported increased clearance of bacteria from the infected wound by using negative pressure therapy.

Measuring the surface or volume of evolving wounds is useful in documenting the results obtained or predicting them in the treatment of wounds.

Wound assessment can be done through several modes, the most commonly used are linear measurement, surface and wound volume estimation.

Linear measurement is a simple and reliable method, costs little to be implemented, and is portable. The method has its disadvantages, including the limited sensitivity of the method to changing wound dimensions and collecting information about its form.

Planimetry used for complex surfaces overestimates the defect by about 40% and in the case of circular wounds the defect is overestimated by about 25%.

Volumetry is used to evaluate all dimensional axes of a wound by giving the method superiority to planimetry in the case of irregular deep wounds. The peculiarity in the evaluation method used by us in the study of the volume of a wound is the superposition on the defect to be dimensioned of a geometric form that corresponds more real to the defect itself. In the case of large complex wounds, various such geometric shapes were summed up, thus calculating the volume of the defect.

Using the mathematical principle *the square-cube law* which describes the relationship between the volume and

the area as a shape's size increases or decreases we were able to implement our data in the definition relation where pressure (p) is equal to the ratio of force (F) applied to the surface (S) unit.

Conclusions

Evolution was favorable with wound granulation in 95% cases, which allowed surgery under local anesthesia, and the skin graft defect was covered.

VAC therapy falls into the last group of treatments by eliminating healing inhibitors. This generates the wound in a damp environment and essentially turns an open wound into a closed system.

The application of negative pressure reduces extracellular accumulation of fluid, leading to a better blood perfusion by lowering the compression to the microvasculature and bandage having limited permeability to water vapor and other gases helps maintain a moist and stable environment of the wound.

We recommend the use of intermittent suction technique whenever possible because in addition to the physical changes of the wound bed that lead to an increased bacterial clearance to this level, it also facilitates the association with local instillation of antibiotic.

The use of negative pressure not adapted to local conditions can lead to ischemia.

Volumetry of the wound is a means of accurately quantifying their evolution, the correlations between the applied force and the surface of the wound are oriented to the negative pressure applied.

Patient quality of life is improved by using negative pressure treatment, through the benefits of using this therapy, and by social reinsertion of patients within a short time interval.

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