NEGATIVE PRESSURE THERAPY IN TREATMENT OF SEVERE COMPEX INJURIES OF UPPER AND LOWER EXTREMITIES

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Abstract: 34 cases of complex musculoskeletal wound involving lower and upper extremities were included in this study. In all patients, debridement and fasciotomy was done before the application of VAC therapy or conventional treatment of wounds. 18 patients were included to the investigated group with application of VAC-assistance. The conventional wound treatment with antiseptics and gauze dressings was applied for 16 patients of control group. Control checkpoints were on third and seventh day of the treatment. The evaluation of results included healing rate of the wound that particularly meant the difference between initial wound area and wound area on checked time points. There was significant decrease in average wound size attained by VAC therapy (1.6 cm2 after 3 days and 3.9 cm2 after 7 days) in comparison to the conventional one (0.8 cm2 and 3 cm2 respectively). VAC therapy using negative pressure promote wound healing by increasing local capillary perfusion and increased rate of granulation tissue formation, decreases the duration of wound healing and requires fewer painful dressing change. Key words: negative pressure wound therapy; wound healing; combat injury; wound closure.

Introduction Treatment of severe open limb injuries remains an urgent problem of modern surgery, despite the huge number of new developments in this direction. One of the methods of treating wounds that are widely used and used in various areas of surgery is the method of NPWT (Negative pressure wound therapy), VAC (Vacuum Assisted Closure) or BAC therapy. The method of treating wounds with negative pressure is used in the therapy of both chronic and acute wounds. These systems create an intermittent or permanent way of negative pressure inside the wound. This procedure helps in removing any secretions: the infected material or exudates from the wound, which leads to faster healing in comparison with the usual "dressing" method [1]. This method is one of the promising in the treatment of severe complex open limb injuries. The locally used vacuum dressings, in the most general form, consist of a hydrophilic polyurethane (PU) sponge, a transparent adhesive coating, a non-divergent drainage tube and a vacuum source with a collection container. Creation of negative pressure and drainage was carried out by the attached adhesive pad with a drainage tube and a vacuum source with a reservoir for collecting liquid. With the help of an external monitoring device in the vacuum system, a range of negative pressure values of about -125 mm Hg was maintained. Art. (possible values from -50 to -200 mm Hg) [2]. Vacuum therapy improves the course of all stages of the wound process: reduces local edema, as a result - promotes increased local blood circulation, reduces the level of microbial contamination of the wound, deforms the wound bed and reduces the wound cavity, leading to faster healing of the wound. Also, vacuum therapy reduces the severity of wound exudation, contributing to the maintenance of a moist wound environment, which is necessary for the normal healing of the wound. All these effects contribute to an increase in the intensity of cell proliferation, enhance synthesis in the wound of the main substance of connective tissue and proteins [3]. Severe complex injuries of extremities, especially high energy, are often accompanied by extensive necrosis of soft tissues, which subsequently leads to the risk of re-infection, the problem of lack of blood supply to bone fragments, delayed fusion of the fractures, the formation of gaping wounds, and the difficulty of closing the wounds due to lack of healthy skin [4]. The literature mentions the use of vacuum therapy for a variety of pathologies: acute trauma, various chronic wounds, burns and frostbites, osteomyelitis, necrotizing fasciitis, pressure sores, purulent wounds and trophic ulcers, diabetic foot, lymphostasis, maxillofacial, spinal, thoracic , plastic and reconstructive surgery, pediatrics, as well as peritonitis, intestinal fistula and abdominal trauma, intestinal anastomosis failure and concomitant pelvic abscesses [5]. The objective of the study was to demonstrate the advantages of early management of patients with severe open polystructural injuries of limbs, which are fragmental or fire-resistant, in comparison with conventional therapy. Materials and methods For the study, two groups were formed: the study group of patients, who used the VAC-therapy method, 18 people; the control group of patients, who used the traditional method of treatment - 16 people For the control group, a classic "dressing" method was used to treat open complex injuries of the limbs using daily dressings with solutions of antiseptics, hypertonic solution. After preoperative preparation, surgical treatment of the wound was performed. It included the disclosure of wounds, the removal of foreign

bodies, apparently nonviable tissues, fasciotomy, abundant washing with soap solutions and antiseptic solutions. Fixation of the fracture was carried out by an apparatus of external fixation of the rod type. The wound was loosely filled with gauze napkins with an antiseptic solution. Change of dressings was carried out once a day. Various solutions of antiseptics, such as Betadin, Dekasan, boric acid solution, Oktanisept, etc. were used. With the reduction of signs of the inflammatory process, the cleaning of the wound, and the decrease in the amount of exudates, closure was carried out with the help of local tissues or skin grafting. In the study group, VAC-assisted wound closure after traumatic wounds, primary and secondary fractures, bullet and fragmentation wounds of the limbs, and also after the performed fasciotomy were used. Indications for the imposition of VAC-dressings were traumatic wounds, including gunshot, primary and secondary open fractures, complicated surgical wounds after osteosynthesis. The technique of applying the dressing, its prevalence and submergence, had differences that were determined by the type, shape of the wound and its depth. The shape of the superimposed PU-sponge was formed by a sterile scissors just before application, so that it would fit exactly in shape to the wound. We applied some measures to prevent the sponge overlapping with the skin around the wound, since it could cause the formation of epidermal blisters at the points of contact just after three-day exposure of negative pressure of 125 mm Hg. In cases of blind wounds (6 patients) with a deep narrow channel, we applied the method of applying a dressing in the form of a "fungus" for better drainage and prevention of the formation of "blind tunnels". A sponge was formed along the width and length corresponding to the wound channel. After adequate anesthesia (or as the final stage of surgical treatment), up to anesthesia, a piece of sponge was inserted into the channel through the instrument. A fragment of the sponge was placed on the wound surface, which was located parallel to the skin surface, in such a way that a reliable contact between the immersed and superficially placed segment was provided. For through wounds (2 patients), the sponge was located throughout the entire course of the wound channel from the side of the inlet or outlet. On one side, often from the side with a smaller wound, the course was closed with an occlusive dressing in the form of a sterile film. On the other hand, a trackpad (a concave tube) was connected to the hole through which aspiration was directly performed. Results The results of treatment were analyzed in 34 patients hospitalized into the Dnipro Regional Hospital by urgent order with open extensive soft tissue injuries, complicated by compartmental syndrome; extensive necrotic wounds; open fractures Gustillo-Anderson II, III-A, B - damage accompanied by primary closure problems. All 34 patients were men, the average age of which was 30±12 years. Of these, 31 (91.18%) patients had fragmental wounds, while the remaining three patients (8.82%) had bullet wounds. 27 patients (79.42%) were delivered with wounds of the lower limb, another seven (20.58%) had injuries of the upper limb. In 26 cases (76,47%) there were open fractures of the limb bones, and the remaining eight cases (23.53%) of soft tissue damage without bone fracture. Five patients (14.7%) underwent a fasciotomy in the wound bed. In turn, 29 patients (85.3%) were treated with primary wounds. In the study group there was a decrease in perifocal edema after a 3-4-day session of VAC therapy (one continuous procedure) versus 7-10 days in the control group. The formation of fine-grained "juicy" granulations occurred on the 6th-8th day (after 2 procedures of VAC), in the control group the formation of granulations was observed from 11-12 days. The dynamics of the formation of granulations in the study group was significantly higher than in the control group. The wound area of the patients in the initial examination in the group that was planned for VAC therapy varied from 12.5 to 104.6 cm2, with an average value of 62.4 cm2. In the control group, the variation in the primary area of the wound was 8.4 to 112.3 cm2, with an average value of 56.8 cm2. After the first session of VAC therapy on day 3, the variable area in the patients under study was 11.8-101.7 cm2, with an average value of 60.8 cm2. In the control group, these values were 8.1111.8 cm2 and 56.0 cm2, respectively. Thus, on day 3, the wound area (Δ) decreased in patients with VACtherapy on average 1.6 cm2, while in the control group this figure was 0.8 cm2. After the second session of VAC-therapy on day 7 in the patients studied, variations in wound area were 10.2-99.6 cm2, with an average area of 58.5 cm2. In the control group, these values were 7.4-105.6 cm2 and 53.8 cm2, respectively. That is, on the 7th day of the study patients, the wound area was reduced by an average of 3.9 cm2 after the VACtherapy, compared to the initial one, while in the control group this figure (Δ) on the 7th day was 3 cm2 of the area decrease wounds (Table 1). Table 1 Dynamics of the area of the wound surface in the control and study groups

Group (patients count)	Wound area, cm2				
	Average wound area at admission	after 3 days		after 7 days	
		Average area	Δ	Average area	Δ
VAC (n=18)	62.4	60.8	1.6	58.5	3.9
Contol (n=16)	56.8	56.0	0.8	53.8	3.0

Discussion The most important problem of an open trauma treatment is the quickest restoration of the edges of the wound and the healing of the soft tissue of its bed. In order to accelerate the healing process of wounds of various types, different approaches of treatment have been developed, for example, topical application of antiseptics, hyperbaric oxygenation, and skin grafting. Vacuum-assisted closure of the wound (VAK) is a relatively new method of treatment with open wounds of the musculoskeletal system. The use of VAK to accelerate wound healing was first documented by Fleischman et al. [6]. In their work, Morykwas and co-authors postulated that negative pressure increases blood flow, as evidenced by increased hyperemia in the wound [7]. They found that the most optimal blood flow is achieved with negative pressure values of -125 mm Hg. Later, their hypothesis was confirmed by various studies [8,9]. Banwell et al. Showed good results after the direct use of VAC therapy with open lesions immediately after wound debridement [10]. The exact mechanism, due to which the wound healing is accelerated in VAK, is still not known, but several hypotheses have been proposed by various authors in recent years. The use of negative pressure removes the excess of edematous fluid, which, as is known, hampers microcirculation, reduces oxygen transport to the wound, and, moreover, prevents the wound from cleaning out from local accumulation of toxins. Removal of this excess fluid helps improve capillary blood flow and development of hyperemia [2]. Morykwas et al. found that wounds were less contaminated by microbiom after using VAC therapy compared to traditional methods [7]. Thus, it was proved that this method reduces the microbial load, which contributes to reducing the risk of infection of the wound. The present study also demonstrated the absence of any septic complications and improved microbial landscape in patients after the use of VAC therapy (data not included in the article). Urschel and co-authors suggested that negative pressure exerts a mechanical effect on the wound bed [11]. The effect of vacuum on the wound through the wound dressing leads to a decrease in the wound defect and, thus, to the rapprochement of the edges of the wound. In this study, there was a reduction in wound margins in BAC assisting, in which the original sizes varied from 12.5 cm2 to 104.6 cm2 with a decrease in the average wound area to 58.5 cm2 on the 7th day of patient management. Such results are completely correlated with the data of other authors. McCallon and coauthors demonstrated an average reduction in wound area by 28.4% locally using negative pressure [12]. Joseph et al. Showed a significant reduction in wound volume by 78% in the group of patients who were under local negative pressure, compared to a 30% reduction in wound size in the group with conventional wound management for 6 weeks [13]. On the other hand, in some studies, it was found that during the VAK treatment session, the surface layer of the granulation tissue is protruded from the wound, causing microdeformation and mechanical stress, which theoretically stimulates vascular growth and tissue regeneration [7]. Despite promising results, the main limitation for the widespread use of VAC therapy systems is their relatively high cost. Although on the other hand, VACtherapy significantly reduces the time of treatment of patients, providing early healing, and therefore saves money spent on management of the patient [14]. High-energy open trauma is often found with large tissue defects and the presence of microorganisms, which requires urgent sanitation and drainage of the wound. Wound healing is considered to be a priority and the most strategically important direction in the management of such injuries. The use of traditional dressings requires a long period of management, repeated debridement and is associated with a permanent disturbance of the granulation tissue and a more complex approach to managing the patient. The entire procedure for applying local negative pressure is the conversion of the open wound into a controlled and temporarily sealed medium with negative pressure, which is evenly distributed over the wound. Thus, VAC therapy provides a sterile, controlled environment that combines the benefits of open and closed type of treatment and wound healing takes place in moist, clean and sterile conditions [13-15]. Conclusion The results of the study showed a significant acceleration of the speed of the initial healing processes of complex fragmentation and gunshot wounds in patients with VAK-therapy, compared with conventional treatment in the control group. Primary application of the examined method of wound management is most effective, in our opinion, in the period corresponding to the second phase of the wound process (3-7 days).

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