

Negative Pressure Wound Therapy (NPWT) to Treat Complex Defect of the Leg after Electrical Burn

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Rezumat

Terapia cu presiune negativă în tratamentul unui defect cronic complex al membrului inferior după arsura electrică

Terapia cu presiune negativă reprezintă un tip de tratament non invaziv, care utilizează presiunea sub atmosferică pentru a crește aportul de sânge la nivelul plăgii, stimulând formarea țesutului de granulație, angiogeneza, proliferarea de fibroblaști și de celule endoteliale. Terapia cu presiune negativă are, de asemenea capacitatea de a scădea încărcătura bacteriană, de a reduce edemul și exudatul în timp ce menține un mediu umed care facilitează vindecarea. Pacientul nostru, în vârstă de 17 ani a suferit arsuri electrice cu voltaj înalt, de gradul III și IV pe aproximativ 60% din suprafața corpului în Noiembrie 2011. După excizia țesuturilor necrozate (mușchi, tendoane), extremitatea inferioară a gambei drepte - tibia, fibula, maleola internă și cea externă au devenit expuse circular. Defectul de țesut moale a fost acoperit parțial, utilizând un lambou muscular din mușchii gemeni și piele liberă despăcată. Apoi a fost utilizată o tehnică reconstructivă de cross-leg acoperind parțial defectul cu un lambou muscular de pe coapsa contralaterală. Culturile bacteriene de la nivelul plăgii au fost pozitive pentru *Pseudomonas aeruginosa*. În Octombrie 2013, pacientul a fost transferat în secția noastră. Examenul clinic local: tibia expusă pe o suprafață de aproximativ 15/3 cm în extremitatea distală, maleola externă expusă. S-a practicat rezecția fragmentului de tibia expus, devitalizat până la țesut osos sângeros și avivarea

marginilor plăgii. Apoi, terapia cu presiune negativă a fost inițiată, utilizându-se presiune negativă intermitentă care grăbește formarea țesutului de granulație. Toaleta locală, avivarea țesuturilor moi și schimbarea pansamentului au fost realizate de două ori pe săptămână timp de 6 săptămâni. După 6 săptămâni de terapie cu presiune negativă și 11 kituri de unică folosință ce au fost schimbate sub anestezie generală, plăgile au fost pregătite pentru grefare. Țesutul de granulație format acoperea în totalitatea suprafețele osoase atât la nivelul tibiei cât și la nivelul maleolei peroniere. Ambele zone au fost acoperite cu piele recoltată de la nivelul coapsei ipsilaterale. A fost realizată sutura mecanică a grefelor și acestea au fost acoperite cu pansament. În acest caz, prin utilizarea terapiei cu presiune negativă a fost posibilă acoperirea unui defect cronic de țesuturi moi, evitându-se astfel amputația membrului respectiv.

Cuvinte cheie: presiune negativă, plagă cronică, efect antibacterian, vindecarea plăgii, pediatrie

Abstract

Negative pressure wound therapy is a non-invasive treatment that uses under atmospheric pressure to increase blood supply to the wound, stimulating the formation of granulation tissue, angiogenesis, proliferation of fibroblasts and endothelial cells. Negative pressure therapy has also the ability to decrease the bacterial load, reduce swelling and decrease exudate while maintaining a moist environment that facilitates healing. Our patient, a 17 year old male, suffered major third and fourth-degree high voltage electrical burns on 60% of the body surface, in November 2011. After the excision of the necrotic tissue (muscles and tendons), the lower extremity of the right leg- the tibial bone, the fibula, external and internal malleoli became

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exposed circularly. The soft-tissue defect was partially covered by using an internal twin muscle flap and free split skin. Then, a cross leg flap technique has been used, partially covering the defect with a contralateral thigh flap. Surface swab cultures were positive for *Pseudomonas aeruginosa*. In October 2013 the patient was transferred to our department. The clinical examination of the right leg showed that the tibial bone had been exposed on an area of 15/3 cm in the lower half. The peroneal malleolus had also been exposed. The resection of the devitalized, exposed tibia and the avivement of the wound edges were performed. Then the NPWT was started and performed by intermittent suction. Local cleansing, soft-tissue avivement and dressing changes were performed twice a week for 6 weeks. After six weeks of NPWT and eleven dressing changes under general anaesthesia, the wounds were ready for skin grafting. Granulation tissue was formed, covering the entire surface of both the tibia bone and the peroneal malleolus. Both receptor beds were covered with free skin graft harvested from the ipsilateral thigh. The mechanical suture of the skin grafts was performed and the grafts were covered with damp dressing. By using the NPWT it was possible to cover major chronic soft tissue defects, thus avoiding the amputation of the member.

Key words: negative-pressure therapy, antibacterial effect, children, wound healing, chronic wound

Introduction

Negative pressure wound therapy has begun to play an increasingly important role in the global landscape of surgical treatment of traumatic wounds, both acute and chronic. This type of treatment intends to augment and improve the traditional methods of approaching these pathologies, bringing numerous benefits in morbidity, mortality as well as aesthetic benefits.

Traumatic wounds affecting a segment of a limb, can harm a patient, functionally and aesthetically, by themselves as well as by the type of treatment used (extensive reconstruction methods - muscle flaps, affecting another anatomical segment, the donor area). The use of negative pressure wound therapy can lead to minimizing these reconstructive surgery methods, reducing the surface of the soft tissue defect by covering it with granulation tissue, creating a skin graft receptor bed.

Negative pressure wound therapy is a non-invasive treatment that involves controlled application of sub atmospheric pressure to the local wound environment, using a sealed wound dressing (silver or silicone dressing and foam), connected through a drainage tube to a computerized vacuum pump. The continued vacuum increases blood flow to the area that needs to be treated and draws out fluid from the wound into an exudate container. (1,11)

Negative pressure wound therapy has the ability to increase blood supply to the wound, stimulating the formation of

granulation tissue, angiogenesis, proliferation of fibroblasts and endothelial cells. Negative pressure therapy also has the ability to decrease the bacterial load, reduce swelling and decrease exudate while maintaining a moist environment that facilitates healing. (2,11) However, its disadvantages include the need for prolonged treatment in order to obtain good results and the frequent friability and instability of the resulting granulation tissue. (6)

Negative pressure wound therapy uses a special foam dressing that supports the formation of new cells and promotes the renewal of granulation tissue in the wound. The foam can be combined with a silver wound dressing that reduces wound infections, decreases the frequency of dressing changes and pain levels and promotes wound healing in chronic wounds (4), or with a silicone wound dressing that reduces trauma and pain at dressing changes, prevents tissue from growing into the wound dressing, protects delicate wound structures and facilitates the formation of granulation tissue. (1)

Systemic (poor nutrition, associated pathologies etc) as well as local wound factors can contribute to a delay in wound healing. Local wound factors that interfere with wound healing could be tissue edema, poor tissue apposition, excessive wound exudate.(8) NPWT was the purpose to overcome many of these wound local factors.

Case report

The patient, a 17 year old male, was transferred to our department suffering from a chronic soft tissue defect, that could not be totally covered using classic plastic-reconstructive surgery techniques.

The patient's medical history shows that he suffered major third and fourth-degree high voltage electrical burns on 60% of the body surface, in November 2011. Free split skin was used to cover skin defects on both arms, forearms, anterior thorax. After debridement of the necrotic tissue, the distal extremity of the right leg - lower half of the tibial bone, lower half of the fibula, external and internal malleoli became exposed circularly (Fig. 1). In order to cover the defect, more plastic-reconstructive surgical techniques were used.

The soft-tissue defect was partially covered by using an internal twin muscle flap and free split skin. A cross leg technique was practiced, in order to cover the posterior defect, using a contralateral thigh muscle flap. The donor site of the flap was split skin grafted, and the flap was sutured over the defect. Both limbs were kept in position using a cast. Division of the flap was performed after 21 days.

*The distal anterior half of the tibial bone and the peroneal malleolus remained exposed. Swab cultures were positive for *Pseudomonas aeruginosa*.*

When the patient was transferred to our department the clinical examination of the right leg showed that there were two soft tissue defects, a major one, which left the tibial bone exposed on an area of 15/3 cm in the lower half, and a smaller one, which left the peroneal malleolus exposed and had a surface of 7/2,5 cm. (Fig. 2)



Figure 1. The right leg after debridement of the necrotic tissue



Figure 2. Aspect of the right leg when the patient was transferred to our department

The resection of the devitalized, exposed tibia and the avivement of the wound edges were performed. After the bone resection, the depth of the defect increased progressively from proximal to distal, reaching almost 1 cm in the most distal area. (Fig. 3)

After wound cleansing, the defect was covered with a nanocrystalline silver wound dressing to control the local *Pseudomonas* infection. A foam dressing was applied over the silver dressing to fill the wound, then a film drape was applied over the top to create a seal around the dressing. Because of the irregular shape of the defect, the foam dressing had to be cut to size to fit the wound. After that, the drain was connected to the pump via the port. In order to use a single vacuum port we had to create a foam bridge that linked the two defects. To protect the skin between the two defects, as well as the skin from the entire length of wound edges, we used hydrocolloid dressing during the entire process.

Then, the NPWT was started and performed initially by continuous suction. The first 12 hours after starting the NPWT, the patient lost almost 600 milliliters of blood, due to difficult hemostasis in the bone. In order to control the blood loss, we switched to intermittent suction. The patient was carefully monitored. Hemorrhage stopped gradually in the first 24 hours. We continued on variable suction during the whole therapy process.

Local cleansing, soft-tissue avivement and dressing changes were performed twice a week for 6 weeks. In the purpose of controlling the local infection with *Pseudomonas aeruginosa* we used silver wound dressing (3,4), intermittently with the silicone wound dressing.

The patient received intravenous treatment with antibiotics Colistine, Gentamycine.

On the sixth day of using the NPWT the contraction of the wound edges could be observed.

After ten days of using the NPWT local extension of the granulation tissue was observed, thereby, slowly reducing the soft tissue defect. We applied a silicon based dressing to the wound site in order to stimulate the formation of the granulation tissue. We continued by using variable negative pressure 115 mmHg for 2 minutes, followed by 50 mmHg for 4 minutes.

After 15 days of using the NPWT granulation tissue covered the proximal and the distal ends of the wound. Local cleansing,



Figure 3. After the bone resection, the depth of the defect increased progressively from proximal to distal, reaching almost 1 cm in the most distal area

avivement of the wound edges and dressing changing were performed. The negative pressure wound therapy continued and the bone has been progressively covered by newly formed granulation tissue.

In the last stage of the negative pressure wound therapy, in the middle area of the defect, a small surface of bone, about 1/0.5 cm, was not covered with granulation tissue. To cover this area we used both silicone dressing, to facilitate the formation of the granulation tissue on the bone, and silver dressing on the surfaces that have already been covered by granulation tissue, to eradicate the infection with *Pseudomonas aeruginosa*. Unfortunately, swab cultures remained positive for *Pseudomonas aeruginosa*. At this stage, the peroneal malleolus has been completely covered by the granulation tissue. (Fig. 4)

After six weeks of NPWT and eleven dressing changes under general anaesthesia, the wounds were ready for skin grafting. Both receptor beds were covered with free skin graft harvested from the ipsilateral thigh. The mechanical suture of the skin grafts was performed and the grafts were covered with damp dressing. (Fig. 5)

Results and Discussions

In this case we used the Negative-pressure Wound Therapy as the last solution in limb salvage. After all the classical reconstructive techniques have been depleted, NPWT was used to cover the major soft-tissue defect and to prepare the



Figure 4. In the last stage of the negative pressure wound therapy a small surface of bone was not covered with granulation tissue



Figure 5. Three days after grafting signs of skin graft healing could be observed

wound bed for skin grafting.

In the process, we used silver impregnated dressing and intravenous antibiotics in order to control the local *Pseudomonas aeruginosa* infection. According to the literature the “addition of a silver dressing to NPWT effectively reduces bacteria in contaminated wounds and is more beneficial on the gram-positive bacteria”. (3,4) Unfortunately, swab cultures remained positive for *Pseudomonas aeruginosa*. We also used silicone based dressing to the wound site in order to stimulate the formation of the granulation tissue. The use of a silicone dressing as a contact layer between the foam and the wound bed, reduces pain (11) and has mechanical non adherent properties, not allowing the granulation tissue to grow into the foam.

The contraction of the wound edges could be observed on the sixth day of therapy and, after ten days of using the NPWT, local extension of the granulation tissue could be seen in the proximal and the distal ends of the wound. According to the literature, tissue deformation is an important factor in wound healing at cellular level. So the wound deformed, drawing the edges of the wound together, decreasing wound size and volume. (8) After six weeks of NPWT and eleven dressing changes under general anaesthesia, the wounds were ready for skin grafting.

We used variable negative pressure because, according to the literature, the granulation tissue formation is more pronounced than when using continuous NPWT. (10) “This may be the result of both mechanical stimulation of the wound bed (a massaging effect) and enhanced blood flow to the wound edges”. (5) There was only one complication during the treatment, the bleeding on the bone area at the initialization of the NPWT which was manageable and the hemorrhage stopped progressively. There were no clinical signs of active infection despite the fact that swab cultured were positive for *Pseudomonas aeruginosa* before and after the use of NPWT.

Conclusions

The basic principles of using negative pressure wound therapy

are: a proper debridement of the devitalized tissue (to facilitate healing and reduce the risk of infection), maintaining a constant negative pressure at the wound site - continuous or variable negative pressure (therefore removing the accumulated fluids from the extravascular space of the wound surface) and monitoring healing in a controlled environment, with due regard to vital anatomical structures, hemostasis and wound hygiene. (9)

Deep and extensive wounds are very difficult to treat, particularly if the patient's overall condition is severely negatively impacted.(7) By using the NPWT it was possible to cover major chronic soft tissue defects, thus avoiding the amputation of the member. After the skin graft was healed, the patient had an acceptable standing, walking function of the leg. He also became better socially integrated, improving his quality of life by being involved in light sports and other activities. (Fig. 6)



Figure 6. Three months after grafting the whole skin graft site regained full skin integrity

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