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EDITORIAL

Applying NPWT to bleeding open wounds after forefoot amputation in diabetic foot patients – a case report

Jacek Białecki, Przemysław Pyda, Anna Kołodziejska, Anna Rybak, Sebastian Sowier

CASE REPORT

***Abstract*— NPWT is increasingly used in patients with diabetic foot. The protocol for performing NPWT is subject to debate. Main concerns regard the type of suction to use (continuous, intermittent, or variable), the wound-packing material, or the exact pressure to apply. Typically, an optimum pressure range of –80 to –125 mmHg is indicated. Following bone resection in diabetic foot patients, the surgical wound is left open, which often entails bleeding from the resection site. In these cases, the start of NPWT was typically delayed by 24–48 hours – during that time a pressure dressing was applied – and NPWT was only started once bleeding had ceased. In order to initiate NPWT as soon as possible, we decided to start it at a higher negative pressure than usual, i.e. –180 mmHg, expecting that this would stop the bleeding. Only then would we reduce the negative pressure. This paper presents the course of NPWT with high negative pressure values after an amputation in 2 diabetic foot patients. In both cases, our assumptions were confirmed. The patients did not bleed, the drained volume did not exceed 30 ml (which seems clinically insignificant) in the first 40 minutes of treatment. Later, with negative pressure at –120 mmHg, no bleeding into the dressing was observed. Following the treatment (which lasted for 9 days), the wounds granulated normally, with no signs of inflammation. Applying VAC dressing using high negative pressure values to bleeding wounds immediately after surgery may stop the bleeding, enabling immediate initiation of NPWT.**

***Keywords*—negative pressure wound therapy, diabetic foot, amputation, bleeding**

I. INTRODUCTION

NEGATIVE pressure wound therapy (NPWT) is increasingly used in patients with diabetic foot, both in treating wounds caused by ulceration, and in healing surgical wounds following bone resection. NPWT assists in wound healing in a number of ways: it drains exudate, contracts the wound edges, alters blood flow in the wound edges, stimulates angiogenesis, reduces tissue edema, stimulates the formation of granulation tissue, creates a moist environment, and stimulates the wound bed.[1–3] Multiple studies indicate that NPWT is superior to other wound dressing methods in the treatment of diabetic foot.[4–6] The protocol for performing NPWT is subject to debate. Indications for when NPWT should and should not be used have been established quite clearly.[7, 8] However, indications regarding the type of suction to use (continuous, intermittent, or variable),[1, 9–11] the wound-packing material,[1, 12, 13] or the exact pressure to apply[14–17] are less definitive. Typically, an optimum pressure range of –80 to –125 mmHg is indicated, though other recommendations can also be found: Timmers et al. (2005) suggest, for instance, that the best wound healing outcomes can be achieved at pressures ranging from –250 to –300 mmHg.[18] Following bone resection in diabetic foot patients, the surgical wound is left open, which often entails bleeding from the resection site. In these cases, the start of NPWT was typically delayed by 24–48 hours – during that time a pressure dressing was applied – and NPWT was only started once bleeding had ceased. This was due to the widespread belief that applying NPWT immediately after the surgery might increase bleeding. However, in order to initiate NPWT as soon as possible, we decided to start it at a higher negative pressure than usual, i.e. –180 mmHg, expecting that this would stop the bleeding. Only after achieving hemostasis would we reduce the negative pressure. This paper presents the course of NPWT with high negative pressure values after an amputation in 2 diabetic foot patients.

II. CASE REPORT

A. Surgical interventions

Patient A (53 years old), suffering from type-2 diabetes, hypertension, and coronary artery disease, was referred to our hospital with necrosis of the fourth toe and extensive phlegmon of the right foot. Initial debridement of the wound was performed on an outpatient basis: an amputation of the fourth toe was performed and the drainage of the subcutaneous forefoot tissue was initiated (Fig. 1). Subsequently, the patient was admitted to our hospital for further diagnostics and therapy. A blood culture test was run and a targeted antibiotic therapy was initiated (Ciprofloxacin 2 x 400 mg i.v.). After 4 days of conservative treatment, clinical symptoms of ischemia in the distal parts of the limb were found. Therefore a computed tomography angiography of lower limbs was

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Figure 1. A wound after an amputation of the fourth toe. On the back of the foot, there are small incisions from drains placed in the outpatient clinic.

Figure 2. A bleeding wound after a non-anatomical amputation of the fifth toe, and resection of the fourth and fifth metatarsophalangeal joints together with the distal parts of the fourth and fifth metatarsal bones.

performed. A critical constriction of the superficial femoral-artery of the left limb was discovered. A vascular reconstructive surgery was performed – reversed femoral-popliteal saphenous vein bypass. A proper blood supply was obtained, which was confirmed by a Doppler ultrasonography. In the first week post-operatively, an inflammatory progression occurred in the distal part of the limb. Extensive necrosis developed in the fifth toe and part of the subcutaneous tissue of the forefoot and sole. The patient underwent non-anatomical amputation of the fifth toe, and resection of the fourth and fifth metatarsophalangeal joints together with the distal parts of the fourth and fifth metatarsal bones (Fig. 2). A broad-spectrum antibiotic therapy was initiated (Tazocin 3 x 4.5g i.v.). Throughout the entire hospital stay the patient continued insulin therapy (Insulatard: 16 u – 0 u – 28 u; NovoRapid: 16 u – 10 u – 8 u) and Clexane was administered subcutaneously (1 x 40 mg).

Patient B (55 years old), suffering from Charcot foot and diabetic foot ulcer, previously managed on an outpatient basis, was admitted to our hospital with extensive phlegmon in the left crus and foot. Crural amputation was performed, with standard suturing of the stump. Despite targeted antibiotic treatment (Imipenem 500 mg/Cilastatin 500 mg x 4 i.v.), 3 days post-operatively massive phlegmon developed in the stump tissues, with inflammatory infiltration of the soft tissue of the thigh. Surgical wound revision was performed, which involved removing sutures from the skin and muscle, and dissecting the skin and subcutaneous tissue from the lateral part of the thigh along the inflammatory infiltrate. Pus was evacuated, and infected and necrotic tissue was removed (Fig. 3). Throughout the entire hospital stay the patient continued insulin therapy (Humulin N: 16 u – 0 u – 14 u; Humalog 14 u – 12 u – 10 u) and Clexane was administered subcutaneously (1 x 100 mg).

Figure 3. Revision of the crural stump following the amputation.

Figure 4. Foot after fourth and fifth metatarsal bone amputation, with the VAC dressing applied immediately after the procedure.

B. NPWT treatment

In both cases, despite parenchymatous bleeding from the surrounding tissue, a VAC dressing (Renasys-F, Ontario, Canada) was applied immediately after the surgery. A polyurethane foam dressing was cut to fit the wound (Fig. 4). The dressing was sealed and NPWT was started. A pressure of –180 mmHg was applied for the first 30 minutes after the procedure, then –140 mmHg for the next 10 minutes. Subsequently, the negative pressure was reduced to –120 mmHg and maintained until the end of treatment.

In both cases, our assumptions were confirmed. The patients did not bleed, the drained volume did not exceed 30 ml (which seems clinically insignificant) in the first 40 minutes of treatment. Treatment continued for 3 days, after which the dressing was changed. Then, NPWT was continued for the next two 3-day cycles, with the dressing changed again on the 6th post-operative day. Throughout the entire 9-day treatment the wound did not bleed. The VAC dressing drained a mean volume of 40 ml of serosanguineous exudate per day. Following the treatment, the wounds granulated normally, with no signs of inflammation (Fig. 5).

III. DISCUSSION

Figure 5. Wound site with VAC dressing removed after 9 days of NPWT.

NPWT is now commonly used in the treatment of diabetic foot. Though general indications for the treatment have been established, no single protocol has been developed. Reports from a number of centers indicate that in cases of open wounds following amputation or bone resection in patients with diabetic foot, early start of NPWT may trigger or exacerbate bleeding. Hence, treatment start was typically delayed by 24–48 hours, until after hemostasis had been achieved. This is also the protocol recommended by some authors.[19, 20] The standard method for the achievement of hemostasis is electrocoagulation. However, in cases of diabetic foot, this creates multiple new thermal necrosis sites, which is undesirable, particularly if infection exists. Another method for managing bleeding from the surgical wound involves applying a pressure dressing, which restricts blood flow to the tissues. However, this delays the start of NPWT, while the larger volume of secretions remaining in the wound increases treatment time. If the tissues surrounding the wound are infected, it is desirable to apply NPWT as soon as possible, which allows for early drainage of the secretions that inhibit wound healing due to the content of proinflammatory factors. To effectively remove the secretions from the wound, we decided to apply a VAC dressing onto the fresh wound, immediately after the surgery. Bearing in mind the concerns related to bleeding, we attempted to adjust the negative pressure in a way ensuring the evacuation of secretions without causing bleeding. Some studies on NPWT discuss the impact of the negative pressure in the dressing on blood supply to the surrounding tissue. (It should be noted that measurements to determine the optimum negative pressure value are performed on tissues with a specific compactness — therefore, their results should not be automatically used to prescribe pressure values for use in tissues with different properties. For instance, different pressures may be optimal for the abdominal wall and for the foot.) Wackenfors et al., studying the impact of negative pressure values ranging between –50 and –200 mmHg on microvascular blood flow around the wound in porcine models, reported that the use of NPWT may reduce microvascular blood flow in the tissues directly adjacent to the wound, and that the higher the negative pressure value, the greater the affected area.[21, 22]

Based on this report and our own experience with NPWT, we decided to apply a negative pressure of –180 mmHg for the first 30 minutes, to prevent bleeding. The negative pressure was then reduced to –140 mmHg for the next 10 minutes. After that, treatment was continued at the standard pressure of –120 mmHg. This allowed us to start NPWT immediately after the surgery without increasing the risk of bleeding. Further observations are required to develop a protocol for NPWT after amputations in diabetic foot patients.

IV. CONCLUSION

Applying VAC dressing using high negative pressure values to bleeding wounds immediately after surgery may stop the bleeding, enabling immediate initiation of NPWT. Further observations are required to develop a protocol for NPWT after amputations in diabetic foot patients.

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New perspectives in the treatment of hard-to-heal wounds

Jarosław Cwaliński, Jacek Paszkowski, Tomasz Banasiewicz

EDITORIAL

***Abstract*— Hard-to-heal wounds continue to be a challenge in the everyday surgical practice. Their treatment is time-consuming, expensive and in many cases requires interdisciplinary assessment. Therapy option include properly selected surgical procedures and dressings combined with systemic antibiotherapy. Application of vacuum assisted closure (VAC) facilitates the evacuation of pathological discharge, reduces tissue oedema and eliminates bacterial biofilm. Complementary administration of antibiotics to control chronic infection relies today in most cases on vancomycin, ciprofloxacin or piperacillin with tazobactam, with good clinical effect.**

An alternative to antibiotics against MRSA, administered at hospitals might be dalbavancin, a new generation lipoglycopeptide, which belongs to the same class as vancomycin. Introduction of dalbavancin and VAC might be an alternative to traditional methods of therapy.

***Keywords*—NPWT, Dalbavancin, biofilm, chronic wound**

I. Epidemiology

EXTENSIVE hard-to-heal wounds represent a significant problem in everyday surgical practice. Despite many years of experience and a number of therapeutic standards effective cure is time-consuming, expensive and in many cases requires interdisciplinary involvement. Progress of surgical techniques over the last decades has contributed to an increase in total healing rate, however there is a large group of patients for whom lack of proper tissue regeneration leads to chronic organ dysfunction.

Hard-to-heal wounds are referred to as so-called “silent epidemic” which affects, according to various estimates, even 1-2% of the population in developed countries. In the US, the total number of patients hospitalized for this reason amounted to nearly 6.5 million and the total cost of treatment consumed 25 billion dollars. On the other hand, in Scandinavian countries, spending related to the treatment of chronic wounds accounts for 2-4% of the health care budget.[1, 2]

Multicenter experiences indicate that dealing with chronic wounds calls for a comprehensive approach and requires a holistic assessment of the problem. Adequate treatment strategy depends on the improvement of local conditions as well as on the general condition of the patient. Preventing infection and keeping the injured tissue in moist setting became the basic priorities.[3] The key issue is to separate the healing area from potential sources of pathogens, i.e. necrosis, gangrene or digestive contents in case of abdominal fistulas. Simultaneous coexistence of chronic diseases deteriorates general condition and additionally depletes the regenerative potential of damaged tissue. Cardiovascular, metabolic or renal failure as well as immunodeficiency syndromes can be a potential trigger responsible for worse healing. Other risk factors include older age, male sex, chronic steroid therapy, nicotinism and malnutrition. All but the first two can be modified in the course of treatment.[1, 4]

II. Pathogenesis of wound formation

However the pathophysiology of chronic wounds proves that lack of healing depends on many factors, three of them are crucial: local ischemia, infection and tissue swelling strongly inhibit wound regeneration. Most complicated cases are characterized by both synergy of these agents and their mutual enhancement. Following the microcirculation insufficiency, local inflammation and swelling occurred. Insufficient fluid supply and lack of gas diffusion facilitate bacterial colonization initiated primarily by opportunistic pathogens. As a consequence, necrosis is formed penetrating the skin, subcutaneous tissue and even deeper located structures. In addition pathological discharge accumulates on the bottom of the wound which additionally impairs its effective repair.[5, 6] The growth and survival of microorganisms within the infected area is stabilized by formation of a biofilm defined as a bacterial matrix supplemented by polymers (polysaccharides, proteins) and nucleic acids. It creates a local microenvironment that facilitates bacterial adhesion and protects colonies against adverse external factors including loss of moisture. In addition, it is a medium for signal transmission, transferring information responsible for drug resistance[6, 7]

The resorption of biofilm is crucial in the process of wound healing. As a barrier factor it hinders diffusion of respiratory gases and neutralizes penetration of antiseptics or anti-inflammatory solutions. By keeping the pH relatively stable, biofilm supports the electrochemical gradient and, due to its spatial structure, allows for the growth of both aero-

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bic and anaerobic bacteria. In hard-to-heal chronic wounds biofilm is constantly regenerated with reimplantation after 2-3 days from its primary removal. This property explains why current healing concepts recommend as a priority the permanent removal of pathological exudate from the surface of an infected wound.[7, 8]

III. Clinical management

The evaluation of wound healing is carried out through clinical observation focusing on detection of hematoma and inflammatory or purulent discharge. The next step is to surgically examine the wound edges and fundus in search of infected or necrotic tissues. Furthermore, if necessary, a culture is collected as well as inflammatory markers in blood serum are monitored which allows to control the effectiveness of treatment or gives an early sign that the local infection starts to develop into sepsis.[9, 10]

Wound treatment includes properly selected surgical procedures combined with systemic therapy. The key is mechanical debridement of the wound edges with removal of any pathological discharge or necrotic changes and use of appropriate antibacterial prophylaxis or even, if valuable, antibiotic therapy. Treatment of hard-to-heal injuries carries the risk of septic complications, therefore in addition to surgical procedure the use of selected systemic antibiotic should be considered. Crucial is not only the antibacterial effect of a given substance, but also the mechanism of its distribution that determines the effectiveness of penetration in the healing site. Final decision should be based on the antibiogram and must comply with clinical practice and local guidelines.[9, 11]

IV. Hard–to—heal wounds and NPWT

One of the key achievements of the last decade in the field of hard-to-heal wound therapy was the use of negative pressure as a factor able to accelerate tissue regeneration. NWPT (Negative-pressure wound therapy) or VAC (vacuum-assisted closure) is done by placing a special polyurethane sponge with a hole diameter of 500 to 600 μm inside the wound and covering it with foil. Finally negative pressure is generated within the dressing reaching the value from -50 to -200 mmHg.[12]

VAC therapy results in the separation of pathological discharge and reduction of residual edema. Decompression of tissues significantly improves blood perfusion and lymphatic drainage. Negative pressure effectively helps to eliminate biofilm and inhibits also its new formation. As a result of contraction of intercellular spaces and following reduction of wound surface the use of a vacuum leads to so-called micro- and macrodeformation. VAC therapy restricts local inflammation, reduces tissue hypoxia and boosts cell proliferation.[13, 14]

Some authors also suggest its beneficial antibacterial effect, especially the limitation of Gramm-negative germs growth. Application of negative pressure favors the mechanical elimination of bacterial cells and also improves local pharmacodynamic and pharmacokinetic features of drug penetration.[14]

In practical terms the effectiveness of vacuum therapy is mainly determined by two elements, i.e. the value of the generated under-pressure and its proper distribution. The value of pressure advisable in the literature ranges from -50 to -200 mmHg and depends on the type of wound, its location, dimensions and the degree of tissue damage. It is generally accepted that pressure from -80 to - 125 mmHg is a compromise between sufficient removing of pathological discharge and the potential mechanical destruction of the wound surface. The problem of proper pressure distribution within the dressing is still the subject of research. There is no answer to the question about the possible difference between the value of pressure detected on the generator and its real value in different parts of dressing. The advantage of commonly used systems is the ability to individually adjust the sponge to the shape of the wound. Thereby the dressing covers the entire surface of the wound and protects it from the outside environment. Finally, the NPWT significantly minimizes the need for hospitalization, enabling further treatment in outpatient clinic.[15, 16]

V. NPWT vs antibiotherapy

There are a number of studies evaluating the effectiveness of systemic antibiotic therapy used jointly with negative pressure therapy in the treatment of complicated wounds. The results of many analyses, although based on a relatively small group of cases, indicate that NPWT augments the therapeutic activity of intravenous injection. Rowan et al. Assessing the efficacy of vancomycin, ciprofloxacin, and piperacillin with tazobactam in the treatment of hard-to-heal wounds showed that by using a vacuum dressing, the concentration of antibiotic within the wound reaches a value of not less than 80% of plasma concentration.[11]

The beneficial interaction of NPWT with systemic antibacterial treatment prompts to define a clinical algorithm allowing more effective use of both methods of therapy, especially in outpatient care. In this context, dalbavancin, a lipoglycopeptide antibiotic classified to the same group as vancomycin can increase the efficiency of wound healing. In preliminary clinical trials dalbavancin has been shown to be highly effective in the treatment of acute skin and soft tissue infections, including the elimination of methicillin-resistant S. aureus (MRSA). An additional advantage is its unique pharmacodynamic profile limiting the dosage for single administration or in two doses repeated one week apart.[11, 17]

VI. Conclusion

In conclusion a strategy based on surgical debridement, followed by NPWT and a single dose of dalbavancin in prophylaxis and therapy may be beneficial in a treatment of complicated wounds.However final recommendation requires further evaluation in a wider group of patients.

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