The negative pressure wound therapy in the treatment of diabetic foot ulcers was used successfully for many years. In the case of complications associated with infection by this type of wound treatment to give very good results. From many years of sustained research on a device that could combine the advantages of the negative pressure wound therapy and drainage flow. Finally, in the last year, the first V.A.C. Ulta (KCI, USA) devices were included to the Polish hospital departments.

In this paper we present a case of a patient of successfully using a negative pressure wound therapy with installation via a set of V.A.C. Ulta in the ischemic diabetic foot syndrome complicated by phlegmon and tissue necrosis. The patient was treated in stages. In first stage was performed angioplasty of critically stenosis of the superficial femoral artery segment. Secondly, the resection of the necrotic bone revised fingers and forefoot was conducted, and in the third step the negative pressure wound therapy with installation was used. Finally, the wound was closed by the intermediate thickness skin graft. The total duration of treatment was 21 days. The patient in good general condition with a completely healed wound was discharged. Currently, after the supply with orthopedic equipment, patient regained full mobility.

**Key words:** negative pressure wound therapy with installation, V.A.C. Ulta, diabetic foot, phlegmon of the foot, insulin

The mechanism of negative pressure wound therapy (NPWT) action is providing a continuous negative pressure, through a specific pump connected to the foam dressing. The dressing protects the tissue from injury, improves blood flow and causes a decrease of the swelling. Furthermore, it stimulates granulation, tissue formation, cell proliferation, resorption of local healing inhibitors and dissolution of infectious material (1). The particular utility of NPWT had been demonstrated in the treatment of complications associated with diabetic foot (DF) (2).

DF syndrome often leads to the formation of non-healing ulcers or necrotic changes, especially when was created by ischemic etiology. Treatment of ulcers associated with DF is particularly difficult and expensive. The incidence of amputation in DF patients with lower limb ischemia and infected ulcers of the foot or shin reaches 85% (3).

It is difficult to identify an effective treatment approach of patients with necrotic changes after DF ulcers. The most important way of treatment, seems to be the performance of surgical revascularization. In the next step, it was used the surgical debridement or resection of necrotic tissue.

Another serious problem in the treatment of DF syndrome was the infection of the wound. In these patients often developed phlegmon of the foot. Mainly detected pathogen in swabs collected from patients with DF ulcers are polymicrobial, and the most common pathogen was streptococcal infections (4). The treatment was based on intravenous, targeted antibiotic therapy and surgical debridement allows drainage of pus. At this point, the treatment
was based on negative pressure wound therapy, recently enriched with the option of simultaneous drainage flow (Negative Pressure Wound Therapy with installation – NPWTi).

This therapy is possible to carry out by using the V.A.C. Ultra (KCI USA) (5). Currently, normal saline (0.9% sodium chloride) being used for NPWTi, but solutions such as insulin, phenytoin, sodium hypochlorite, biguanides and sulphonamides have been proposed as potentially useful agents (6). Many literature data also report a positive impact of topical application of insulin in the treatment of non-healing and infected wounds. However, NPWTi with solution of insulin was used rarely in clinical practice (7).

We are introducing the first in Poland case of a patient with DF syndrome complicated by phlegmon and tissue necrosis, in which we used successfully NPWTi with the infusion of insulin solution.

**CASE REPORT**

74-year-old man was treated because of infection and phlegmon of the foot in the course of ischemic DF syndrome, after amputation of II-IV left foot fingers and 2/3 distal side of II-IV metatarsal bones of left foot (due to necrosis) (fig. 1). The patient was treated at the Department of General and Vascular Surgery using NPWTi (V.A.C. Ultra, KCI USA).

Type 2 diabetes mellitus patient was diagnosed in 1995 and has been treated according to the following scheme: after each meal injection of 6-8 IU fast-acting insulin and in the evening 7 IU of long-action insulin (at 10 pm). The fasting plasma glucose was 120-150 mg/dl, postprandial glucose levels was 200-220 mg/dl and HbA1c level was – 6.4%.

Complaints from the left foot were started in 2010. The small, recurrent ulcer on the sole of the left foot around the fourth finger was appeared. Although in February 2013 a profound ulcer was created, which after conservative therapy has cured. However, in June 2013 there was a recurrence of the wound at the same location, and it was also found numerous fistula between the toes. The observed changes are cleansed and healed. Suddenly, in October 2013 wound in the foot renewed again. The patient reported a strong pain across the foot and ankle with associated edema and purulent leakage from the wound. Due to clinical features and X-ray of the foot the decision about emergency amputation of altered structures was taken. In November 2013, after consultation the patient was transferred to the Our Department in order to continue treatment. The patient pulse was found only in the groins and ankle-brachial index (ABI) on the left side was 0.2, and 0.6 on the right side.

The angiography was showed a hemodynamically significant stenosis in 1/3 lower left superficial femoral artery (AFS), numerous of atherosclerotic narrowing in the tibiofibular trunk, and total occlusion in the anterior tibial artery (fig. 2a). The angioplasty with stenting was taken on the left side of AFS, and significant improvement in limb blood flow was achieved. ABI on the left side was 0.7 (fig. 2b).

An infectious etiology of foot inflammation was confirmed on the basis of positive blood culture and locally obtained swab. The following pathogens were detected within the wound: Staphylococcus epidermidis, Enterococcus faecalis, Prevotella spp. In contrast, the blood cultures from the duration of hospitalization were negative. The intravenous antibiotic therapy compatible with antibiogram was used – ciprofloxacin (2x300 mg) and clindamycin (2x200mg) for a period of 7 days.

The V.A.C. Ultra with dressing V.A.C. VeroFloTM was applied, and after the first dressing change was observed a significant improvement in the appearance of the wound, increas-
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...ing granulation tissue and improving blood circulation in the limb (fig. 3a, 3b, 3c).

The duration of V.A.C. therapy was 10 days, at this time the dressing was changed 3 times. NPWTi was used in the following scheme: 10 minutes of saline infusion enriched with fast-acting insulin (in a dose of 2 IU per 0.5 l liquids). Secondly, the saline was aspirated. The volume of applied saline was varied – from 125 ml to 75 ml during treatment due to increasing of granulation tissue and decreasing of wound area. In the second period of treatment a constant negative pressure of 75 mm Hg (for 2.5

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Fig. 2a. Hemodynamically significant stenosis of the left AFS

>>> this arrow indicates the critical stenosis

Fig. 2b. Status after angioplasty with stenting of left AFS

>>> this arrow indicates the successful revascularization

Fig. 3a. The wound with V.A.C. VeroFloTM dressing

Fig. 3b. The wound after 48 h – the first change of V.A.C. VeroFloTM dressing

Fig. 3c. Status after the second change of the dressing – after 72 h
hours) was applied. Everytime when the dressing was exchanged, the swabs from the wound were taken and after finished NPWTi the results of wound swabs and blood cultures was negative. The wound was closed with a intermediate thickness skin graft and after 21 days of treatment patient in good general condition was discharged to home (fig. 4).

The first control was performed 7 days after discharge, and next after 30 days. The post-amputation wound was fully healed. Currently, after orthopedic treatment patient regained full mobility.

DISCUSSION

NPWTi essentially consists of three main phases: a short installation phase, instantaneous drain phase, and the longest stage – application of the negative pressure. Dressings are changed most often every 2 to 5 days. In our case we decided to change the dressings every 2-3 days, due to frequent monitoring progress of treatment.

The initially literature data about NPWTi concerned and suggested the usefulness of this therapy in the management of infected wounds (8). However, currently there was a prevalence of NPWTi also in the management of patients with non-infected wounds. Leung et al. conducted a study to compare the process of tissue granulation in the wound between constant mode NPWT and NPWTi and demonstrated that NPWTi has significantly better results (9). Lessing et al. demonstrated a greater reduction in wound area and other parameters using NPWTi compared to other methods of NPWT (p<0.05). In addition, significantly faster progress in a wound healing has been demonstrated in NPWTi compared to continuous, intermittent, and dynamic mode NPWT (p<0.05) (10). This same author in other publication showed that the use of injections with suspension of zinc insulin in the skin around the wounds has led to better and faster healing (13). Greenway et al. concluded on the basis of their clinical studies that local use of insulin within the wound promotes the process of faster wound healing in patients with or without the diabetic mellitus (14). All of the authors emphasized the minimal severity or lack of side effects after topical application of insulin in the treatment of non-healing wounds.

CONCLUSIONS

NPWTi received effective treatment outcomes compared to other therapy. Mode of action in this therapy helped the formation of granulation tissue and perfusion, and ensured a close, sterile environment. NPWTi reduced severe complication as phlegmon of the foot. Phlegmon of the foot is a very serious clinical problem and reason of high percentage of failures in the treatment of chronic wounds, especially in patients with diabetic foot syndrome.

Many studies have shown the usefulness of topical application of insulin in the treatment of non-healing wounds. Insulin-like growth factor (IGF) in many in vivo studies has shown efficacy in stimulating proliferation, migration and growth of fibrin by keratinocytes, endothelial cells, fibroblasts and the stimulation of tissue granulation (12). Zhang et al., reported that the use of injections with suspension of zinc insulin in the skin around the wounds has led to better and faster healing (13). Greenway et al. concluded on the basis of their clinical studies that local use of insulin within the wound promotes the process of faster wound healing in patients with or without the diabetic mellitus (14). All of the authors emphasized the minimal severity or lack of side effects after topical application of insulin in the treatment of non-healing wounds.
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The size of wound area and edema, and also removed an excess of exudate. The length of hospitalization was shortened as well as we eliminated the possibility of re-admission of the patient because of application of NPWTi. NPWTi also provides possibility of archiving the progress of treatment by photographic images and volumetric statistics. Future, follow-up studies should be performed on larger groups of patients, in order to draw any further conclusions and evaluate the effectiveness of NPWTi therapy in the treatment of DF associated with phlegmon. Our Department is now conducting the study that is aiming to compare treatment of DF associated with phlegmon using NPWTi and NPWT without instalation.

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