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NEGATIVE PRESSURE THERAPY IN THE TREATMENT OF WOUNDS – REVIEW OF LITERATURE DATA AND MULTICENTER EXPERIENCE

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Large, complicated wounds pose a significant surgical problem. The duration of treatment is usually long-lasting, the number of complications and therapy failures significant, and one should not forget about high-treatment costs. Negative pressure wound therapy is one of several methods enabling to obtain better treatment results in case of complicated wounds (1, 2). Literature data mentions the following nomenclature connected with the above-mentioned problem: TNP – topical negative pressure, VAC – Vacuum-assisted closure, NPWT – negative pressure wound therapy, and LHT – local hypobaric therapy.

The basic principle of the method consists in the creation of a sealed environment surrounding the wound, enabling the evacuation of the contents of the wound by means of a regulated subatmospheric pressure (3). Negative pressure, apart from the mechanical drainage ability is also a factor activating several physiological mechanisms accelerating wound healing. The dilatation of the arteries increases the oxygen saturation of peripheral tissues, which positively influences wound granulation (4). Changes which take place in the capillaries connected with the increase in their diameter and volume, also increase blood flow and facilitate the migration of inflammatory cells (especially macrophages and granulocytes) towards the lumen of the wound, which has been proved by means of experimental studies (5). The activation of factors stimulating angiogenesis has also been demonstrated, both in experimental (6) and clinical studies (3).

Another factor influencing faster healing, especially the reduction of the size of the wound is the experimentally proven increased production of collagen and the filling of the tissue defect (6). Clinical observations of leg wound healing confirmed the above-mentioned, where in case of hypobaric therapy one observed a significantly faster reduction in the size of the wound, as compared to patients subject to traditional therapy (7-9).

In case of extensive wounds bacterial infections pose a significant problem. Apart from the deterioration of local healing conditions, bacterial infections negatively influence the patients' general condition and can lead towards the development of sepsis. The use of negative pressure therapy enables to obtain a reduction in the number of bacteria (10, 11), which significantly reduces the number of purulent complications (12).

Such a positive effect of negative pressure therapy, small number of complications and contraindications (described at the end of the article) is evidence of the wide indications for the

use of the above-mentioned therapy, including the following: leg ulcerations, sternum wound infections after cardiosurgical operations, graft complications, post-trauma and postoperative injuries, open abdominal operations (3), or extensive, infected necrotic tissues (13). Indications and dressing techniques will be presented in the following sections of the study.

Devices and dressings used in negative pressure therapy

Treatment of wounds by means of negative pressure therapy is a recognized method in the management of difficult and complicated wounds. The above-mentioned method was first applied in the nineties of the past century (14), considering the management of patients with leg ulcerations (15). In spite of the technical progress concerning the use of the above-mentioned device and dressing kits, the basic principles of the method remain unchanged. In order to obtain a negative pressure, kits containing a substance filling the wound are used, being tightly connected by means of a drain with the system producing an adjustable, continuous or intermittent negative pressure. The intermittent character of negative pressure therapy enables to avoid passive hyperemia, due to excessive and prolonged capillary and venous filling. The interruption renders possible residual blood outflow and fresh oxygenated blood inflow. Investigations aimed at optimizing negative pressure values, the time of the above-mentioned, and the duration of the interruption with the negative pressure of -125 mm Hg were recommended. The negative pressure therapy lasted 5 minutes, while interruption intervals 2 minutes (16). Negative pressure values, as well as the time of activity and interruption depend on many factors, and are usually modifiable, depending on the indications and experience of the managing team.

Nowadays, two types of negative pressure therapy systems are most popular.

The stationary VAC ATS Unit device, manufactured by KCI Inc. enables to obtain negative pressures in the wound, ranging between 50-200 mm Hg with a regulation caliber of 25 mm Hg, and the possibility to apply continuous or intermittent therapy of any duration. The device requires the use of disposable canisters and dressings with sealed system connections. The dressings are composed of polyurethane mesh, which enables fluid drainage of different volume, Trac Pads enabling a tight connection between the drain and dressings, as well as the adhesive, elastic film. VAC Abdominal Dressing systems are additionally composed of a non-adhesive, perforated film, which can be placed on the surface of the bowels.

The V1STA (and Renasys EZ) device manufactured by Smith&Nephew is also a stationary device. It has a wide range of negative pressure (1-200 mm Hg) with the possibility of a 1 mm Hg regulation, and a pre-set working time of 16 seconds with 8 second interruptions (possible regulation). The disposable canisters have a capacity of 250 ml or 800 ml. The basic difference concerns the dressing kit, which is of universal character. It enables the connection by means of standard drains and the use of a sterile, bacteriostatic gauze. Sponge dressings (polyurethane foam) are a novelty. In order to obtain a sealed connection an adhesive membrane and stomal paste are required.

Both the VAV and V1STA device systems possess the alarm function enabling to detect leaks or drain occlusions. Both devices also have the possibility of becoming portable, thus, enabling management of out-patients.

One should also mention that constant negative pressure is possible using the standard suction drainage. We used the pleural drainage kits ensuring sterility, pressure regulation, and possibility to evaluate the volume and character of the secretion. We applied gauze dressings, standard drains, and an adhesive membrane. The above-mentioned system was used in the management of local wound complications, such as hematomas, purulence and limited eventration. The system was considered as useful, safe, simple and cheap, as adjunctive therapy in the management of local postoperative wound complications.

There exist publications concerning the use of a „simplified vacuum therapy" in the management of an open abdomen. The so-called „VAC pack" consists of a non-adhesive, perforated polyethylene membrane, gauze dressings, and drainage system without pressure control and alarm functions (17).

Vacuum therapy in the management of extensive post-traumatic wounds

One of the most important indications of negative pressure therapy is the adjunctive

management of post-traumatic tissue defects and III degree open fractures of the lower leg (Gustilo-Anderson's scale) (18). The provision of extensive skin and soft tissue defects can be undertaken simultaneously by means of appropriate reconstructive techniques during emergency operations, although the abovementioned is often difficult. Several hours of reconstructive surgery can be contraindicated, especially when the patient is hemodynamically unstable. In such cases surgery is limited to „damage control" activities. After the stabilization of the patients' condition further reconstructive procedures can be undertaken. Additionally, the contamination of the wound is often extensive, and thus, early wound debridement is often incomplete and flap closure impossible. On the other hand, delay in definitive reconstructive therapy is non-beneficial, especially when the bones and joints are exposed. Such a condition can lead towards deterioration of the sustained injuries with the possibility of amputation. The time elapsed between the injury and definitive wound debridement is under discussion. It seems that 72 hours is the time required for closure of the tissue defect (19). Steiert et al. demonstrated that distant treatment results considering patients following open fractures with significant tissue defects, and reconstruction operations performed more than 72 hours after the injury (average 19 days), were similar to those obtained after therapy during the initial hours after the injury. These patients were subject to VAC therapy (20). VAC therapy favors the reduction of post-injury edema, which in turn reduces the size of the wound, stimulating granulation, preparing it for flap coverage. Additionally, favorable healing conditions are observed, preventing the spread of inflammation. VAC therapy prepares the wound for final flap coverage. Extensive tissue defects are the result of high-energy injuries leading towards damage of other organs. Usually, abdominal or thoracic injuries require immediate intervention. Thus, compensation of the patients' general condition requires more than 72 hours. Reconstructive treatment should be delayed until full compensation using negative pressure therapy (21, 22). Each sponge exchange of the VAC system enables to accurately inspect the wound and remove residual necrotic tissues until the wound will be clean and prepared for final closure.

It seems that management of III degree open fractures with significant soft tissue defects requires multi-stage treatment. Initially, the wound should be thoroughly inspected with removal of necrotic tissues, especially the skin and fat tissue. Complete tissue excision should be performed until bleeding is observed, followed by irrigation with an antiseptic agent and drainage. External stabilization of the fracture should be performed covered by the VAC system sponge. Temporary wound closure will seal the doors of potential inflammation, and limit local infection, draining the exudate, blood, wound secretion, favoring the development of granulation tissue. Each time the VAC system is exchanged the wound can be explored, residual necrotic tissues removed, and prepared for final debridement. It seems that the best method of covering the granulation tissue is by means of a skin graft. However, when the bones, joints, ligaments, and tendons are exposed one of many flap closure techniques should be applied (23).

As an example: A 62-year old patient who sustained a spiral fracture of the shaft of the tibial bone with extensive soft tissue necrosis of the antero-medial surface of the lower right leg. Blood supply and innervation were normal. The initial stage of the operation consisted in the external stabilization of the fracture by means of a one-plane stabilizer localized on the lateral surface of the leg. Subsequently, the necrotic skin and deep tissues were excised, followed by antiseptic agent lavage and implantation of the VAC system. After three days the VAC sponge was removed, wound granulation was observed and remaining necrotic tissue excised. Similar procedures were performed several times every 3-4 days. Granulation was observed in the upper part of the wound, without features of active inflammation. However, during the entire period of negative pressure therapy an 8 cm segment of a bare tibia was observed in the inferior part of the wound. The granulation tissue was covered by a perforated skin graft collected from the thigh. VAC therapy was continued for another week in hope of covering the tibia with granulation tissue. After three weeks of VAC therapy the tibial bone remained exposed. Due to the extensive soft tissue damage in the vicinity of the fracture there were no technical possibilities to cover the bone by means of a local flap. The use of a free muscle flap by

Fig. 1. Negative pressure therapy in the management of a complicated lower leg open fracture. A – fracture after stabilization by means of an external stabilizer before excision of necrotic tissues; B – after removal of necrotic tissues and implantation of the VAC system; C – after removal of the VAC system – Granulation tissue at the bottom of the wound; D – subsequent removal of the VAC system and coverage by means of a perforated skin flap-upper part of the wound; E – sacral flap: the soft tissue defect covered by a cutaneous-fascial flap collected from the left lower leg. Femoral plaster on both legs protecting from movement and flap rupture; F – sacral flap after excision and modeling, covering the exposed tibial bone; G – healed sacral flap after excision

means of microsurgical techniques was out of the question, due to significant risk of failure connected with the patients' age, general atherosclerosis, many years of smoking, and concomitant cardiac diseases. Thus, after obtaining patient consent we decided to cover the defect by means of a sacral cutaneous-fascial flap. A fragment of the skin and fascia collected from the opposite leg was used to cover the exposed tibia. Both legs were joined by a femoral plaster for a period of two weeks. After healing of the flap it was excised from the left leg and modeled above the defect. After two more weeks the wound was completely healed.

Thus, it seems that VAC therapy is beneficial when preparing the wound for reconstructive surgery. One must underline that the above-mentioned is considered as temporary action, and does not solve the problem of extensive post-traumatic defects. It is an excellent adjunctive method, accelerating wound healing, prior to reconstructive surgical techniques.

Negative pressure therapy in the management of lower leg wounds- venous etiology

Lower leg wounds of venous etiology, being considered as the most advanced form of chronic venous insufficiency (CVI) constitute a significant percentage of poorly healing chronic wounds. Epidemiological investigations showed (Western Europe countries) that the above-mentioned concern 0.2 to 2% of the

population, while treatment costs constitute 10% of the health care budget (24). In spite of the improvement in the efficacy of venous ulceration therapy, due to the deep knowledge of the pathophysiology of the disease, the rate of permanent cure cases and costs remain unsatisfactory. The search for novel therapeutic concepts resulted in the application of local negative pressure therapy, as an adjunctive method to surgical management of venous ulcerations (25). The basic condition for the above-mentioned concept was the analysis of the failure of the current therapies. Surgery is the most effective method consisting in the suppression of the superficial venous reflux, ulceration debridement, and mesh skin grafting (26, 27, 28). Therapeutic failure is observed in case of a non-healing ulceration, due to graft rejection. The most common reasons for autogenous skin graft rejection include poor substrate preparation and adhesion, as well as immobilization of the grafted tissue (28). The legitimacy of VAC therapy concerns improvement of the efficacy of the graft localization and better security (29-32).

More than forty patients were subject to treatment at the Department of General and Vascular Surgery, Medical University of Poznań during the period between 2006 and 2010, due to venous ulcerations resistant to conservative therapy. All patients' underwent surgery in addition to local negative pressure therapy. After ulceration debridement a VAC dressing was introduced for a period of 3-6 days using continuous therapy with a vacuum pressure of -125 mm Hg.

After obtaining granulation tissue the patient was subject to mesh skin grafting, which was secured by means of the VAC system. The sponge device was separated from the graft by means of a gauze soaked in paraffin. The graft was secured for a period of 2-3 days, with the subatmospheric pressure amounting to -75 mm Hg. A significantly shorter substrate preparation time was observed, as well as graft healing and hospitalization period, as compared to the control group (without VAC therapy).

Thanks to the LHT (local hypobaric therapy) system we obtained faster substrate debridement, granulation tissue growth, and edema elimination with the inflammation. The covering of the graft during the initial days after the procedure by means of the VAC system enabled to obtain better graft adhesion, and elimination of the excess of the exudate and bloody deposit. Thus, the patient did not require immobilization. Additionally, the separation of the graft by means of a paraffin-soaked gauze prevented the contraction of the transplanted tissue during the induction of vacuum. Graft healing and leg ulcerations were observed in all patients. Additionally, the use of the VAC system eliminated the necessity of frequent change of dressings during substrate preparation, and immediately after graft surgery. The above-mentioned and shorter hospitalization period positively influenced the economical therapeutic balance, and the patients' mental condition, in case LHT caused no pain.

Negative pressure therapy in the treatment of an open abdomen

Treatment by means of the open abdomen method is connected with many potential problems. These problems result from the patients' general condition and local wound conditions. Most patients subject to treatment by means of the method are in severe general condition, with metabolic and organ function disturbances, requiring mechanical ventilation. They are often diagnosed with bacterial or fungal infections, including sepsis. The large, open wound is the gateway to inflammation. One can observe the secretion of a large amount of fluid posing a significant hygienic problem, increasing the risk of secondary skin infections and bedsores. Another problem is the shrinking of the integuments leading towards gradual increase in the size of the wound with common closure problems. A retrospective study analyzed the use of VAC therapy considering management by means of the open abdomen technique, demonstrating a high efficacy of the method and recovery rate: 15 of 18 patients' survived, being subject to negative pressure therapy (33). In most cases the authors' applied a non-adhesive membrane onto the intestinal surface, and under the dressing. However, in four cases only a sponge was placed on the surface of the wound. In spite of the fact that they observed no intestinal fistula development the method seems risky. Based on our own experience and the opinion of other authors we definitely recommend the use of a non-adhesive, perforated membrane in all cases at risk of intestinal loop

or internal organ contact with the dressing. Considering our material we often applied the simplified version of negative pressure therapy using the pleural drainage set. Significant exudative fluid secretion and difficulties in wound care were the main indications. In such cases the non-adhesive barrier was used between the dressing and peritoneal cavity organs. Other authors using the simplified version of negative pressure therapy, the so-called „VAC-pack", which was described in the subsection concerning devices and dressings, also applied the non-adhesive membrane (17).

The efficacy of negative pressure therapy in case of drainage of large quantities of peritoneal cavity fluid were confirmed by investigations undertaken in patients with liver cirrhosis and ascites, subject to surgical intervention, due to various indications. Better control of fluid secretion, less frequent necessity to change dressings, faster fluid volume reduction, and good wound healing were observed, in spite of cirrhosis as a potential factor of healing complications (34).

The use of negative pressure therapy in case of the open abdomen technique provides beneficial distant effects. In such patients one observed a reduction in the number of postoperative abdominal hernias (35).

Negative pressure therapy in the management of wounds complicated by intestinal fistulae

The use of negative pressure therapy in the management of wounds complicated by intestinal fistulae is an important topic under vivid discussion (36). On one hand, there exist negative opinions concerning contraindications towards negative pressure therapy in the presence of intestinal fistulas (37) and increased risk of complications (38), including damage of internal organs (39). Active intestinal fistulas are also mentioned as one of many contraindications for negative pressure therapy.

On the other hand, there exist a series of reports concerning the efficacy of the above-mentioned method in case of wounds and fistula presence (39-44), even in infants (45). Reports concerning complete recovery are rare. Usually one can observe improvement of the patients' general condition, reduced inflammation (46), and amount of secretion (47), as well as the creation of conditions for future surgical intervention (48).

Negative pressure therapy modifications are also applied, being one of many elements of treatment. Closure of the intestinal fistula by means of a muscle flap (the serratus and latissimus back muscles) was described, where VAC was applied before and after grafting. The dressing was introduced between the muscles by means of the „Sandwich" technique, in order to obtain faster fistula closure and wound healing (49). Another modification consists in the separation of the fistula from the wound, as to avoid intestinal content secretion to the wound. The fistula was supplied by means of a stomy; negative pressure therapy was used on the surface of the wound (44). Many authors considered the effect as good. However, our experience showed significant problems in combining negative pressure therapy adhesive membranes with the stomal device. One can observe leakage or the „steal syndrome effect" and active aspiration of the intestinal content by the negative pressure therapy system.

Three patients with extensive, infected postoperative wounds complicated by fistulas were treated at the Chair and Department of General, Gastroenterological, and Endocrinological Surgery. All patients were qualified towards negative pressure therapy, due to lack of surgical treatment possibilities and efficacy, as well as poor prognosis, considering further conservative therapy. The condition of all patients was severe. They presented with symptoms of sepsis and respiratory insufficiency requiring mechanical ventilation.

Negative pressure therapy began by wound debridement, necrectomy, and revival of the margins of the wound. The intestinal loops were separated from the sponge by means of a non-adhesive membrane, which was part of the abdominal dressing kit. Initially, the sponge was cut as to fit the wound. Afterwards, the sponge was smaller than the wound, fixed by means of cutaneous sutures (size 0-2), as to obtain the traction effect, which rapidly reduced the size of the wound. A small hole was incised in the sponge at the site of the most intensive secretion, in order to obtain best conditions for intestinal content outflow, and not collect the above-mentioned under the sponge. Nevertheless, the significant secretion of biliary and duodenal contents (1500-3000 ml), both by the wound and drainage ports lead towards sponge "congestion" and content leakage under the adhesive mem-

brane, followed by unsealing of the negative pressure system. Thus, during the initial three days after the operation dressings were changed 1-2 times daily, with increased negative pressure amounting to 200 mm Hg, as to improve the conditions of intestinal content drainage. In order to reduce secretion, interrupted sutures were introduced into the ostium of the fistula. Additionally, the ostia of the fistulae were initially supplied by stomal bags, and afterwards sealed by means of gastrostomy drains with a balloon at the end. Stomal paste with sealing and healing properties was used, in order to improve the tightness of the dressing and diminish the intestinal content leakage under the membrane. After 2-4 weeks the patients' general condition improved. We observed a reduction in the number of fistulas and improved wound healing. After 5-7 weeks advanced wound healing was observed, patients' presented with only one fistula, which was supplied typically for a stoma. After complete recovery (2-6 months) patients' underwent surgery, in order to reconstruct the continuity of the digestive tract. Postoperative complications were not observed.

Based on our observations the introduction of VAC therapy favorably affects the general condition of patients' with extensive wounds complicated by numerous fistulas, which is in accordance with data obtained by other authors (50). The use of the method can increase survivability and shorten the duration of treatment. Considering the above-mentioned indications one should strive towards improvement of the patients' general condition, better wound healing, fistula development in the form of a stoma, and final surgical intervention.

In our opinion, negative pressure therapy in case of extensive postoperative wound dehiscence complicated by numerous fistulas reduces inflammation and abdominal cavity adhesions, which is important in view of future surgery.

Negative pressure therapy in the management of fistulas – "endo sponge"

One of many technical modifications used in the treatment of intestinal fistulas is the application of ready-to-go kits, the so-called Endo-Sponges (Redyrob® TRANS PLUS or Endo-SPONGE B. Braun Medical B.V.), especially in case of fistulas with a good endoscopic approach (the diameter of the canal>5mm). Amongst advantages of the method one should mention the possibility of continuous drainage, rapid debridement and granulation of the fistula canal, mechanical reduction of the size of the wound, better infection control, patient acceptation, greater comfort and improved hygiene conditions, reduced odor, as well as easy replacement, even on an outpatient basis in selected cases (51). Most of the mentioned advantages concern negative pressure therapy as such. Amongst practical and useful features one should mention the reduction of the inflammatory condition, and skin protection from content staining by means of complete „sealing" of the fistula canal.

Good results were described in case of treatment of anastomotic fistulas following anterior low rectal resections (52) or reconstructive proctocolectomy (53). One should expect further progress of the above-mentioned method with its wider application.

Negative pressure therapy – other indications and applications

The extent of potential indications for VAC therapy is extremely wide. In general, each poorly healing wound can be an indication for negative pressure therapy. Sometimes, the above-mentioned is the method of choice. Such is the case with poorly healing sternal wound infections, where randomized, prospective investigations demonstrated a significantly higher efficacy, safety, and lower costs, as compared to conventional therapy (54). Thus, negative pressure therapy is recommended as the standard therapeutic method in case of patients with deep sternal wound infections (54). One should not forget about the proper technique of changing the dressing, and best wound debridement. Negative pressure therapy in the management of complicated sternal wounds enables to obtain significant therapeutic efficacy only in case of a wide opening, debridement, and abscess drainage (55).

A separate group of indications constitute wounds that, due to there localization and anatomical conditions significantly impede the use of standard dressings. They do not adhere to the wound, absorb the secreted content and thus, hinder normal hygiene. Complicated perineum wounds after extensive perianal operations and abdomino-perineal anal resec-

Fig. 2. Skin graft procedure LHT: A – substrate preparation, B – granulation tissue, removal of VAC, C – skin graft covered by a gauze soaked in paraffin, D – graft healing using the LHT system, E – initially healed graft after VAC removal VAC, F – distant result

tions are such an example. Standard dressings are unstable and require frequent change. Diapers favor the development of infections, hindering the secretion of the wound content. Negative pressure therapy used in the management of deep perianal wounds showed accelerated healing and simplified wound care (56). The key role to the success of the method was attributed to the tight and careful adhesion of the membrane assuring tightness and efficacy of the drainage system.

Based on our experience the negative pressure therapy system is worth recommendation, considering management of hypogastric wounds localized in the skin folds of obese patients. These wounds, localized at the site of incision or drain introduction are easily susceptible to infection, especially in obese patients burdened with concomitant diseases. The amount of secretion is often significant, standard dressings and stomal equipment being ineffective, due to the localization of the wound at the bottom of the fold. Negative pressure therapy was applied several times in such cases using original devices or pleural drainage kits. A significant role was attributed to the tightness of the system. Thus, stomal paste proved effective. The subjective opinion of physicians showed wound healing progress, better secretion control, and maintenance of hygienic conditions.

The number of potential applications of negative pressure therapy is almost limitless. In each problematic case of wound healing negative pressure therapy should be considered. The use of the above-mentioned does not require specialistic procedures or facilities. It can be used in all surgical departments and intensive care units, regardless the degree of reference.

Negative pressure therapy – contraindications and complications

Contraindications of negative pressure therapy are most often relative. Each time it is necessary to determine the individual, clinical condition of the patient, as well as the potential benefits of negative pressure therapy. Principle contraindications include the exposition of vessels and vascular prostheses, the use of negative pressure therapy, and mechanical stimulation by means of the dressing, which can lead towards vascular wall perforation and hemorrhage, and thus, hemostasis disturbances. Deep wounds penetrating parenchymal organs are also a contraindication for negative pressure therapy, which can lead to parenchymal organ disturbances, bleeding, and fistula development (biliary, pancreatic, and urinary). Thus, skin cancer (especially malignant melanoma) is considered as a local contraindication for the use of negative pressure therapy, being a risk factor of the development of metastases.

Dirty wound necrosis significantly reduces the efficacy of therapy, tissue lesions can lead towards mechanical dressing blockage. One can observe anaerobic bacteria multiplication under the necrosis. Thus, before negative pressure therapy the wound should be thoroughly cleaned, removing all visible necrotic tissues. One should not forget about proper hemostasis, since the use of negative pressure therapy can potentiate parenchymal and vascular bleeding.

Complications related to the use of VAC therapy are rare, usually limited to superficial bleeding connected with sponge replacement, allergic reactions, and pain (4). Proper hemostasis in case of wound debridement reduces the risk of bleeding. Allergic reactions are easily managed by means of histamine drugs or small doses of steroids. Pain therapy depends on the extent of the wound, its depth, and localization. During the changing of the dressing in case of extensive wounds, such as abdominal connected with wound revision and nephrectomy, patients' should be subject to surgical intervention under anesthesia. Smaller wounds might require sedation, local anesthesia, or the administration of painkillers, before changing the dressing. However, one should not forget that even in case of small wounds granulation tissue predominates. Thus, the need for painkillers every change of dressing.

Considering potential negative pressure therapy complications one should mention the risk of developing subsequent intestinal fistulas in case of extensive wound treatment (37, 38). The above-mentioned complication was not observed by the authors applying the standard, non-adhesive membrane to cover the surface of the bowels.

Costs of negative pressure therapy

Exact analysis of the costs of negative pressure therapy is difficult, depending on the

Fig. 3. The use of negative pressure therapy in the management of an extensive postoperative wound complicated by fistulas. Consecutive photos show the healing process. After 24 hours nearly complete wound closure was observed with only one small fistula supplied by the stomal pouch. After 7 months the patient was subject to laparotomy with partial resection of the small bowel and fistula. The postoperative period proved uneventful

duration of the above-mentioned, type of devices applied, amount of secretion, size of the wound, frequency of change of dressings, and many other independent factors. The price of the many products used in case of negative pressure therapy, are available on the internet. Our intention was not to compare the prices of different manufacturer's, which are constantly changing. Analysis of study results concerning the economic efficacy of VAC therapy demonstrated that its application can reduce therapeutic costs. The cost analysis of diabetic foot ulcer treatment by means of VAC therapy is less expensive, as compared to traditional methods and new generation wound dressings (57). These investigations also demonstrated much faster wound healing. Investigations concerning the economical efficacy of VAC therapy by means of the open abdomen method also showed reduced costs of the above-mentioned. The main reason for lower costs was attributed to the reduced number of operations and decreased wound dressing costs (35). Faster reduction of inflammation shortens antibiotic ingestion, especially in the presence of coexisting opportunistic species. It is difficult to determine the exact cost and economical efficacy of VAC therapy in the treatment of diabetic foot ulcers. According to the authors, negative pressure therapy failed to show its economical superiority, accelerating wound healing. Benefits of the method were observed in case of acute wounds. However, there were more complications (58). Thus, VAC therapy is a breakthrough in the high-cost treatment of severe wounds complicated by sepsis. Standard treatment was long-lasting and proper healing was often missing. Negative pressure therapy often induced the process of healing with further progress observed.

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