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Vivano[®] Spectrum

Convincing case examples of negative-pressure wound therapy.



Abdominal · Traumatic · Chronic · Special Indication

Editorial details

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Editorial



Dear Colleagues,

I am very pleased to introduce the sixth edition of the "Vivano Spectrum" series.

We would like to thank you, our readers, for your trust and for sharing your experiences. Vivano is celebrating its 5th anniversary, and I can say that these past five years have been five successful and exciting years. Medical expertise and exchange has always been an integral part of the Vivano concept.

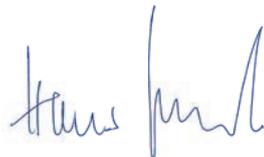
Together with you, we are looking forward to an exciting future. In 2017, the HARTMANN Learn Inform Network Knowledge platforms (L.I.N.K.) will be introduced. These events serve the purpose to further encourage exchange of information and to share information on a local level in addition to the Vivano congress. Authors of the Spectrum, who are also part of the Vivano competence network, will be invited to some L.I.N.K. events as experts. This shows you that exchange among experts at all levels really is the focus of Vivano. The aim is to link experts in order to achieve the common goal of better therapy outcomes.

In our anniversary edition, you will find reports on NPWT in a wide variety of clinical indications. Really interesting and rare cases, such as the successful treatment of a patient with calciphylaxis, are described in this edition. Again, sharing best practices and knowledge is key. If you have any comments or practical tips of your own to share, please get in contact and let us know, so that we in turn can let our "Vivano Spectrum" readers know.

I am really looking forward to further collaboration and exchange with you.

Please share your experiences and your knowledge!

Yours sincerely,



Prof. Dr. med. Hans Smola

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Current status of best clinical practice and specific aspects of the treatment of open abdomen with NPWT

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Open abdomen (OA) is a surgical approach that has emerged in last 15 years, its management being complicated, demanding in terms of time and finances, and fraught with high morbidity and mortality. In recent years, several publications proved the superiority of the application of negative pressure wound therapy (NPWT) over application of conventional temporary abdominal closure techniques in the treatment of open abdomen. Various aspects of the treatment of OA with NPWT remain to be assessed and expounded.

Aim of the study

Prospective assessment of the patients with open abdomen treated with NPWT was performed, identifying and describing various aspects of the treatment in the context of morbidity and mortality.

Patients

The group of prospectively assessed patients comprised 48 patients (25 male, 23 female, average age 57 years), all managed by one and the same surgeon between 2006 and 2014.

Treatment algorithm

After creation of open abdomen, either no traction mechanism, or compression sutures, or their modification were applied, depending on the local status. Re-dressings with NPWT were performed every 48-72 hours, in exceptional cases at intervals of up to 5 days. Where it was possible to close the open abdomen, this was attempted, either in the form of STAR (staged abdominal repair), or in the form of VAFC (vacuum assisted fascial closure) or VAWC (vacuum assisted wound closure). Continuous mode with -125 mmHg was applied in all patients; in patients with EAF (enteroatmospheric fistula), the vacuum was reduced to -75 mmHg. In cases where an

enteroatmospheric fistula (EAF) was present, either the creation of a proximal stoma, or primary closure, or diversion according to Goverman or Al Khoury was attempted.

Results

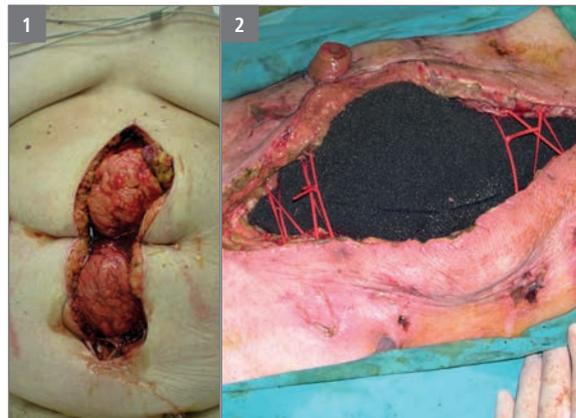
While in 40% of the patients, no fascial fixation was applied, dynamic compression sutures were applied in 12.5%, static compression sutures in 37.5%, and sandwich mesh compression sutures in 10%. No significant difference between the groups with regard to mortality (overall mortality 35.41%, $p = 0.18$) or wound closure rate (overall wound closure rate 83.33%, $p = 0.027$) was observed. The differences between the groups with regard to the rate of fascial closure were statistically significant (5 % with no fixation vs. 100% with sandwich mesh abdominal closure (SMAC), 67% with static compression sutures (SCS), and 67% with dynamic compression sutures (DCS); overall rate of fascial closure 44%, $p < 0.0001$). 37.5% of the patients developed EAF. In 28%, closure of the fistula was successfully accomplished; in 39%, diversion was successfully accomplished, and in 33%, diversion attempts were unsuccessful. The differences in mortality between these groups were statistically significant (closure of EAF, 20%, diversion of EAF, 29%, vs. unsuccessful diversion attempts, 83%, $p = 0.0356$).

No significant difference in mortality was observed between the groups in relation to maximum level of procalcitonin, C-reactive protein, or body mass index (BMI) on admission.

Conclusion

The application of NPWT in patients with OA has proven to be a gold standard in the management of patients with OA. The application of NPWT significantly reduces morbidity and mortality in patients

with OA. The application of sequential abdominal wall closure techniques significantly increases the rate of fascial closure, has an impact on esthetic and functional properties of the abdominal wall, and should be accepted as a gold standard in the management of patients with OA using NPWT. The management of enteroatmospheric fistulas with NPWT remains one of the few effective possibilities for achieving diversion of enteral content, which, when not diverted, has been proven to be a predictor of mortality. Temporary abdominal closure should be performed as soon as possible to avoid complications of OA (fistula, fascial retraction).



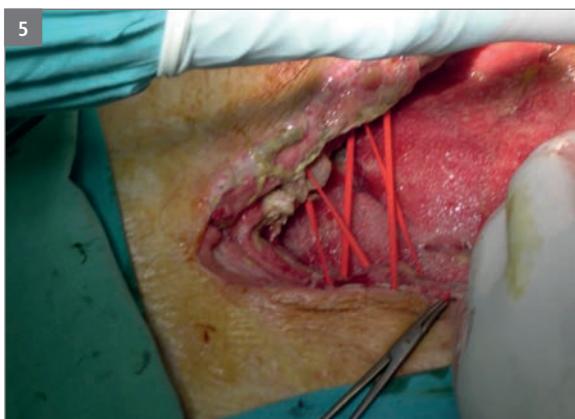
Picture 1: Static compression sutures
Picture 2: Dynamic compression sutures



Picture 3: SMAC – Sandwich Mesh Abdominal Closure



Picture 4: Conservative treatment of small fistula 1



Picture 5: Conservative treatment of small fistula 2



Picture 6: Fistula diversion acc. to Al Khoury 1
Picture 7: Fistula diversion acc. to Al Khoury 2

Open abdomen – NPWT in laparotomy to treat compartment syndrome

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A 40-year-old male with acute necrotic haemorrhagic pancreatitis who developed compartment syndrome.

Patient anamnesis

A 40-year-old male was diagnosed with acute necrotic haemorrhagic pancreatitis with a Balthazar score of 10 and an APACHE II score of 6.

Wound anamnesis

The patient developed abdominal compartment syndrome (defined as a sustained intra-abdominal pressure >20 mmHg with/without an abdominal perfusion pressure <60 mmHg) related to a persistent increase in intra-abdominal pressure due to acute necrotic haemorrhagic pancreatitis.

Aim of the treatment

Performance of laparotomy supported by negative pressure wound therapy (NPWT) to treat abdominal compartment syndrome.

Wound treatment

NPWT was applied using the Vivano system. The abdominal dressing was repeatedly changed, leading to the immediate disappearance of the compartment syndrome while preserving asepsis throughout the peritoneal cavity with normal functioning of the intestinal tract. There was no intra-abdominal adhesion syndrome. Therefore, the abdominal dressing was able to be easily changed.

Conclusion

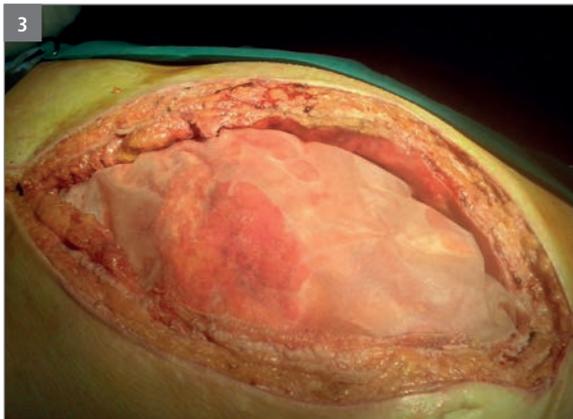
NPWT can be applied safely for a long period in critical patients with compartment syndrome (normally 3–5 weeks) without the development of complications that would normally be associated with laparotomy, particularly sepsis. While this technique relieves compartment syndrome and the peritoneal drainage, it nevertheless did not play a decisive role in our patient's clinical course, which was determined by the seriousness of the initial pathological process.



Patient with abdominal compartment syndrome: The compartment syndrome is related to increased intra-abdominal pressure due to acute necrotic haemorrhagic pancreatitis.



Acute necrotic haemorrhagic pancreatitis: Laparotomy supported by NPWT is indicated.



Wound-bed preparation: Covering of the organs.



NPWT: Black sponge inserted and covered, and NPWT applied.

NPWT of enterocutaneous and biliary cutaneous fistulas within an extensive postoperative abdominal wound

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A 23-year-old male following blunt abdominal trauma in a traffic accident with a deteriorating condition was haemodynamically unstable and had increased bile drainage.

Patient anamnesis

A 23-year-old male was admitted to a tertiary reference centre because of biliary fistula and enterocutaneous fistulas (ECFs) associated with an extensive abdominal wound following blunt abdominal trauma. The patient underwent four laparotomies. Initial surgery involved perihepatic packing and peritoneal-cavity drainage. This was followed by suturing of a transverse colon perforation, Roux-en-Y hepaticojejunostomy and peritoneal-cavity drainage. At the third intervention, insufficiency of the anastomotic (hepaticojejunostomy) site was found. Intraabdominal abscess drainage and suturing of a small bowel perforation were performed. At the final re-surgery, laparotomy was performed to address the insufficiency of the hepaticojejunostomy and the bowel perforation.

Wound anamnesis

Due to a deteriorating general condition accompanied by increased bile drainage, the patient was transferred to referral hospital. The patient was in poor condition. Wound dehiscence, sepsis, bile discharge, skin maceration, five drains and no intestines contents in the stoma bag were observed. On admission, explorative laparotomy revealed insufficiency of the hepaticojejunostomy, a small bowel perforation and a large bowel perforation and contamination of the peritoneal cavity.

Aim of the treatment

Application of negative pressure wound therapy (NPWT) following initial unsuccessful conventional therapy of ECFs and biliary cutaneous fistula.

Wound treatment

The patient was operated on within 24 hours of admission. Hepaticojejunostomy Roux-en-Y procedure and segmental resection of the small bowel were

performed. Moreover, large bowel perforations were sutured and a loop ileostomy was created. However, after 4 days, persistent abdominal wound dehiscence was present complicated with bile discharge (biliary fistula) and intestine discharge (two ECFs). The impairment of wound healing was observed with an intraabdominal inflammation due to enteric fistulas (grade 3 according to the Bjorck classification). Previous Roux-en-Y hepaticojejunostomy procedure excluded any endoscopic management. Therefore, NPWT was initiated, applying an intermittent negative pressure of 125 mmHg, using a polyurethane sponge. Dressings were changed every 2 days or if needed. Abdominal drains were removed. Wound cleansing was preferably performed using Lavasept solution, and the skin was protected with paraffin/silver gauze. Stoma paste and stoma bag were used to secure the fistulas. The wound progressively improved, decreasing in size and starting to granulate. Moreover, the irritation and maceration of the surrounding skin decreased and gradual patient recovery was observed. At the end of the first week of NPWT, the ileostomy started providing intestine contents. At the second week, reduction in volume of one of the ECF output was observed. Epithelialization of the right site of the wound allowed for securing of the biliary cutaneous fistula with a stoma bag. A progressive daily reduction of ECF output was observed, and one ECF closed spontaneously at the third week of the therapy. Closure of the biliary cutaneous fistula was achieved at 4 weeks of NPWT. After 5 weeks, the abdominal wound was almost completely healed, with one remaining ECF, with further qualification for gastrointestinal tract reconstitution. NPWT was accomplished within 6 weeks.

Conclusion

ECFs and a biliary cutaneous fistula associated with

an extensive postoperative abdominal wound were successfully treated by application of NPWT. In complicated cases, with large defect of the abdominal wall,

accompanied by ECF and biliary cutaneous fistula, NPWT should be considered as the method of choice.



Referral: Abdominal wound on admission. Dehiscence of the wound with skin maceration due to intestinal contents. Five abdominal drains and no intestine content within the stoma bag.



Conventional treatment: was unsuccessful, with bile discharge from a biliary fistula and intestine output from the abdominal wound due to two ECFs .



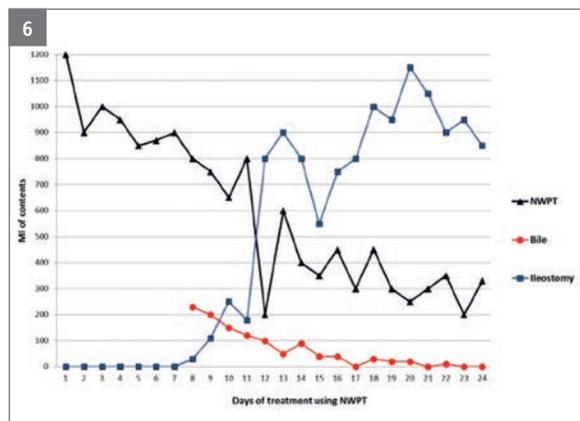
NPWT, week 3: Two active ECF: high output (black arrow) and low output (white arrow). Biliary-cutaneous fistula located outside the wound (yellow arrow).



NPWT, week 5: Biliary-cutaneous fistula healed. ECF regarded as a "stoma". Progressive granulation of the wound.



NPWT, week 6: Enterocutaneous and biliary cutaneous fistulas treated successfully.



Bile, bowel (ileostomy) and NPWT contents: Reduction in the bile exudate and NPWT content indicate healing of fistulas, supported by the increased content of the ileostomy stoma bag.

NPWT of extensive retroperitoneal haematoma in a polytraumatised patient

Jiří Voves

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A 35-year-old female with polytrauma after jumping from the fourth floor of a building.

Patient anamnesis

A 35-year-old female, after jumping from the fourth floor of a building, was conscious but spoke incoherently, was stable in terms of cardiopulmonary function and exhibited reduced breathing on the right side and shortening and rotation of the right leg. The patient was transported by helicopter to the Emergency Admission Unit, where diagnostics and right hemithorax drainage were performed.

Wound anamnesis

Computed tomography (CT) revealed liver fissure, bladder rupture, fractured ribs, retroperitoneal haematoma, abruption of the traverse processes of L1–5, pelvic fractures and proximal femur fracture. On transfer to the operating theatre for abdominal exploration, significant haemoperitoneum and retroperitoneal haematoma were found.

Aim of the treatment

Application of negative pressure wound therapy (NPWT) for the management of retroperitoneal haematoma.

Wound treatment

During primary surgery, the bladder rupture was sutured and the rectouterine pouch was drained. The central liver fissure was treated conservatively and the abdomen was left open due to the retroperitoneal haematoma. The right femur fracture was reduced and subsequently internally fixed using a nail, while the pelvic fracture with minimal dislocation was treated conservatively. Due to bleeding under the open-abdomen cover, as well as massive haematuria and circulatory instability, CT angiography was performed. Intrahepatic haematoma without significant progression, subcapsular haematoma of the right kidney and possible minor

leak from the bladder suturing were found. Slight progression of the retroperitoneal haematoma was observed. Surgical revision was performed approximately 10 hours after primary surgery. Although there was no significant intra-abdominal source of bleeding, the retroperitoneal haematoma increased. Tamponade of the lower left retroperitoneum was performed during this procedure and the abdomen was kept open. A second surgical revision was performed due to continuing leakage of blood from the retroperitoneum. The tampon was extracted, a drain was applied and NPWT was initiated. After 3 days, partial suture of the laparotomy was possible and the NPWT was changed. NPWT was stopped after a further 2 days and a complete suture was made. After 3 days, the patient had stabilised and weaning was started following extubation. The wound healed without complications and the peroral intake was fully restored. Follow-up CT revealed complete regression of the retroperitoneal haematoma.

Conclusion

Retroperitoneal haematoma may constitute an obstacle to the early closure of a laparotomy due to the risk of compartment syndrome. This leads to prolongation of the therapy, and additional surgery may be required. It also constitutes a risk factor for paralytic ileus. This case report highlights the successful application of NPWT for the management of retroperitoneal haematoma.



CT scan on arrival at the Emergency Admission Unit:
This sectional slice shows retroperitoneal haematoma.



Postoperative complications: Bleeding under the open-abdomen cover. Massive haematuria and circulatory instability are further complications.



Initiation of NPWT: Despite surgical revision approximately 10 hours after primary surgery, continuing leakage from the retroperitoneum is observed. A second surgical revision is performed, the tampon is extracted, a drain is applied and NPWT is initiated.



NPWT, day 3: Wound has improved.



NPWT changed, day 3: After partial suturing, NPWT is restarted for a further 2 days, after which it is terminated and the wound is sutured completely.



CT after 1 year: Complete regression of the retroperitoneal haematoma.

NPWT in resolving mesh-related complications in abdominal-wall reconstruction

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Three female patients with complications arising from rejection of the mesh used in abdominal-wall reconstruction.

Patient anamnesis

All three female patients had a high body mass index. Patient 1 had undergone an operation for primary umbilical hernia 6 years previously. Recurrence was observed, which was treated by hernioplasty with onlay polypropylene mesh implantation. Patient 2 had undergone laparotomy for myoma, followed by reoperation for adhesional ileus, and had subsequently developed incisional abdominal wall hernia. Laparoscopic herniotomy was performed twice. The recurrent abdominal wall hernia was confined by reconstruction with onlay implantation using mesh. Patient 3 had a large postoperative abdominal-wall hernia, with recurrence and three re-operations. Abdominal-wall reconstruction was performed with onlay implantation of polypropylene mesh.

Wound anamnesis

Chronic fistulation with partial mesh rejection occurred in Patient 1. Suppuration and mesh rejection was found in Patient 2. Patient 3 exhibited acute suppuration and skin necrosis, with partial mesh rejection.

Aim of the treatment

Application of negative pressure wound therapy (NPWT) as an option to treat suppuration related to rejected mesh implants in abdominal-wall reconstruction.

Wound treatment

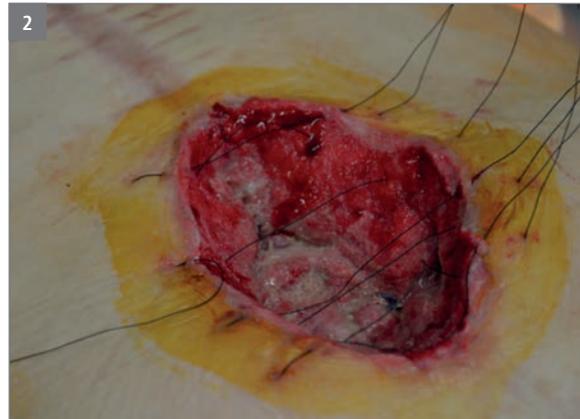
Re-incisions and fistulectomies were performed in Patient 1, and the mesh was extirpated. NPWT using the Vivano system was applied for 10 days. Primary wound closure was performed, and the postoperative period was uneventful. In Patient 2, mesh extirpation was performed, and NPWT was applied for 10 days on an outpatient basis. Following primary closure, an uneventful postoperative period was observed. In Patient 3, partial mesh extirpation was performed. NPWT was applied for 30 days, with coverage of the skin defect using skin mesh graft. The patient was subsequently treated for 2 weeks on an outpatient basis with further dressing changes, producing a good aesthetic result.

Conclusion

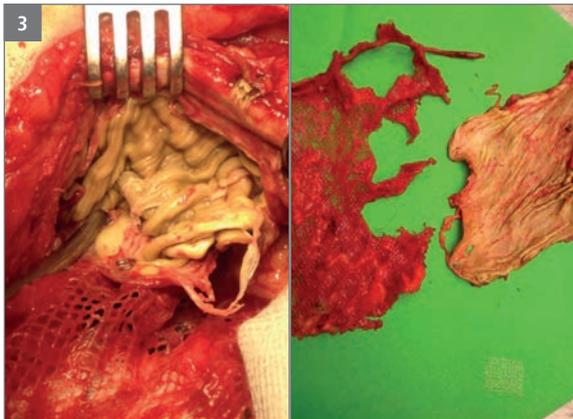
NPWT was effective in treating chronic suppuration and surgical-mesh rejection following abdominal-wall reconstruction, suggesting that its application be considered in such cases.



Patient 1: Chronic fistulation with partial mesh rejection. Re-incisions and fistulectomies are performed and the mesh is extirpated. NPWT is initiated using the Vivano system.



Patient 1, NPWT applied for 10 days: On completion of NPWT, primary wound closure is performed, with an uneventful postoperative period.



Patient 2: The ejected previously laparoscopically inserted two meshes, during the acute operation because of incarceration.



Patient 2, NPWT applied for 10 days: The mesh has been extirpated and NPWT is applied. A healthy wound is observed on completion of outpatient NPWT (left), and primary wound closure is able to be performed (right), the postoperative period being uneventful.



Patient 3: Failed abdominal-wall reconstruction of recurrent hernia by onlay implantation of polypropylene mesh. The wound exhibits acute suppuration and skin necrosis, with partial mesh rejection.



Patient 3, NPWT applied for 30 days: Partial mesh extirpation is performed and good healing is observed with application of NPWT for 30 days, during which time the skin defect is covered with skin mesh graft. The patient is subsequently treated for 2 weeks on an outpatient basis with further dressing changes, producing a good aesthetic result.

NPWT in liver transplantation

Astrid Schielke

Department of Digestive and Hepatobiliary Surgery, Pitié-Salpêtrière University Hospital, Paris, France

Two females aged 61 years and 24 years respectively who underwent liver transplantation with subsequent open abdomen due to the large liver graft size.

Temporary abdominal wall closure following liver graft implantation

In the case of a large liver graft, the risks of abdominal compartment syndrome, liver-graft compression and compromised graft vascularisation as well of postoperative ascites and intestinal oedema, must be taken into account. Abdominal wall closure is important to avoid infection due to increased susceptibility due to immunosuppressive treatment. Therefore, it may in some cases be necessary to leave the abdomen open and to use a temporary abdominal wall closure device like Vivano, which can even be used in the absence of sepsis or peritonitis.

Patient anamnesis

Patient 1, a 61-year-old female, and Patient 2, a 24-year-old female, both received a liver graft from taller and heavier donors due to a high-urgency situation.

Wound anamnesis

Following transplantation in Patient 1, primary abdominal wall closure was impossible after transplantation due to a large graft size. In Patient 2, after initial abdominal wall closure, on postoperative day (POD) 1, unusual high cytotoxicity was observed (aspartate aminotransferase (AST) 8145, alanine transaminase (ALT) 3016). An immediate secondary look operation was performed, and there were visible rib marks on the graft, while patency of all vascular structures was confirmed.

Aim of the treatment

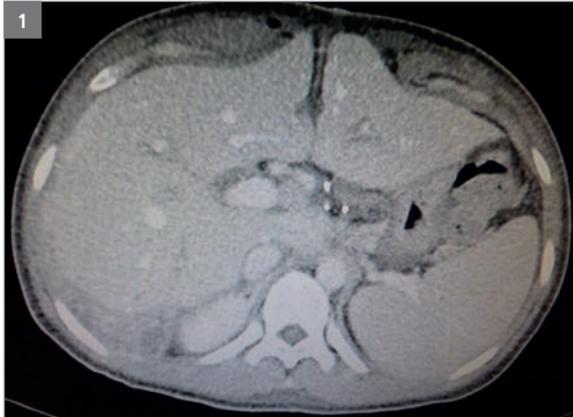
Application of negative pressure wound therapy (NPWT) to an "open abdomen" due to a large liver transplant preventing abdominal-wall closure.

Wound treatment

NPWT was initiated in Patient 1 on POD 1 using the Vivano system with a continuous negative pressure of 100 mmHg for 24 hours. Initially, maximum cytotoxicity was observed on POD1 (AST 13489 and ALT 3813) along with major ascites of 8–10L/24 hours, which was successfully diminished after lowering the continuous negative pressure to 45 mmHg. Skin closure was possible on POD 6, with normal liver-graft function during follow-up. NPWT was applied to Patient 2 with a continuous negative pressure of 45 mmHg. Skin closure was achieved on POD 4, with normal liver-graft function during follow-up.

Conclusion

Vivano management of liver transplantation with open abdomen was safe in the presence of recent biliary and vascular anastomoses. Ascites production was able to be limited by a low continuous negative pressure of 45 mmHg, with skin closure achieved within 4–6 days. The liver grafts exhibited normal function during follow-up.



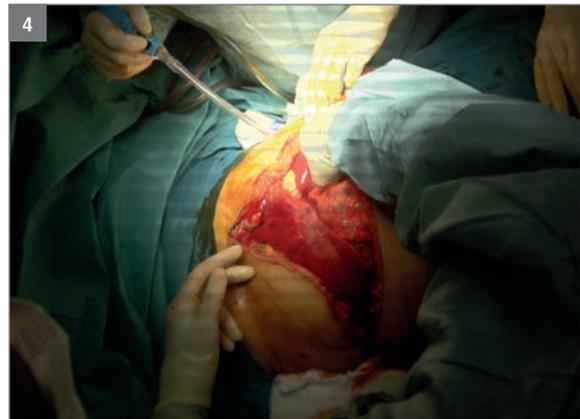
Patient 1, postoperative computed tomography (CT) scan: Liver graft compression and hypovascularisation.



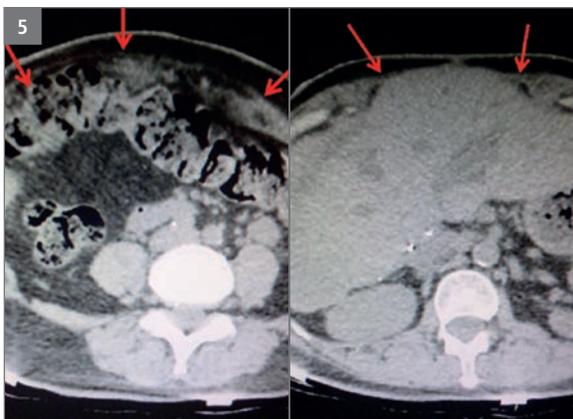
Patient 1, 3-month CT scan: Graft compression, but all vascular structures are patent.



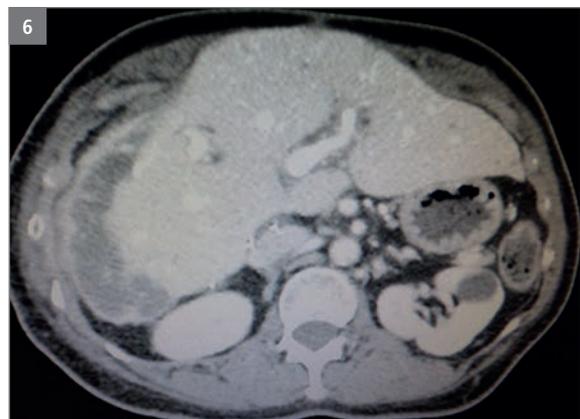
Patient 2: Graft hypoperfusion with ribs compressing the liver graft.



Patient 2, immediate secondary examination: Visible rib marks on the liver graft. Patency of all vascular structures confirmed.



Patient 2, follow-up CT scan: Persistent abdominal wall defect and graft deformation.



Patient 2: CT scan after 3 months.

NPWT in traumatology

Wim Fleischmann
Germany

Problems and solutions for negative pressure wound therapy (NPWT) in trauma patients.

Debridement

This is the first step. The method applied is not critical, be it mechanical, with enzymes or even organisms that nibble away dead tissue. However, it is critical that the wound is clean and the tissue vital before the application of NPWT, otherwise pathogens can grow within the deep vital tissue, leading, for example, to gas gangrene.

Assessment of tissue damage

Before the application of NPWT, a thorough assessment of the extent of tissue damage is not only important in deciding the treatment strategy but also for avoiding complications. Once NPWT is initiated, the foam prevents observation of the wound bed, apart from during changes. Complications can develop during this period if the original assessment was insufficient, leading, for example, to progressive soft-tissue damage.

Hazards during NPWT (short- and long-term)

The foam must never be forced into a cavity if it is too bulky because the force used can collapse the pores, preventing the subsequent establishment of a vacuum when initiating NPWT. Consequently, if oversized the foam should be removed and cut to a size to fit the wound cavity loosely, whereby the foam collapses on applying NPWT, creating a vacuum at the foam-wound interface. Clogging of the foam due to blood clotting is a major problem after surgical intervention, preventing vacuum formation at the foam-wound interface by occluding the pores. The foam can be removed again and cleaned manually or using jet lavage. The foam pad is applied rapidly and the vacuum is started immediately, sucking out the water and creating a vacuum at the interface using sufficient pressure to prevent further bleeding from the vessels. For PVA foam, which is more soft and pliable, a

drainage tube can be inserted and connected to a surgical aspirator, which is set to generate a negative pressure of ≥ 600 mmHg. The wound is washed to prevent clotting and the drainage tube removes the diluted blood. The foam is rapidly stapled to the wound edge. Washing is stopped as draping is placed over the wound to seal it, and the foam collapses under the high vacuum pressure of the aspirator, preventing further bleeding.

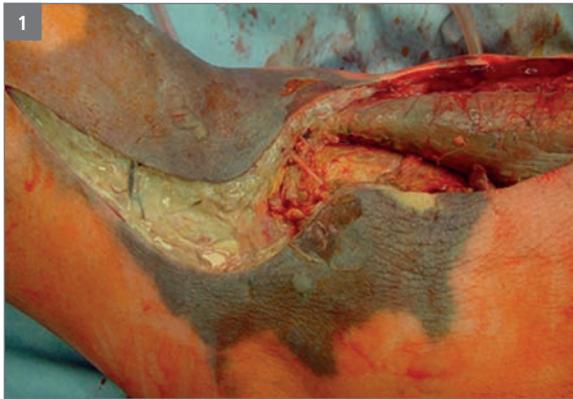
Ingrowth occurs in PU foam because of its microporous structure. Therefore, the foam must be regularly changed. The higher the vacuum the less the ingrowth.

NPWT can lead to the wound edge becoming sclerotic, such that the degree of rigidity prevents closure of the wound, thus requiring skin grafting. To avoid this, in gaping edematous wounds the NPWT system is changed and acute high-force skin stretching is applied to squeeze out edema.

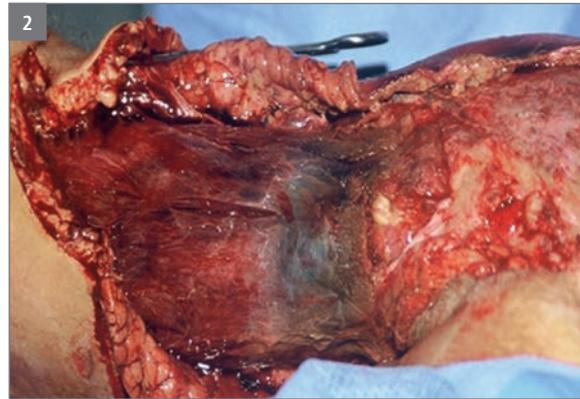
Scar tissue formation due to collagen deposition in secondary wound healing is a major problem in traumatology, which can be exacerbated when NPWT is applied for too long. Therefore, NPWT should be ceased as soon as is practical.

Conclusion

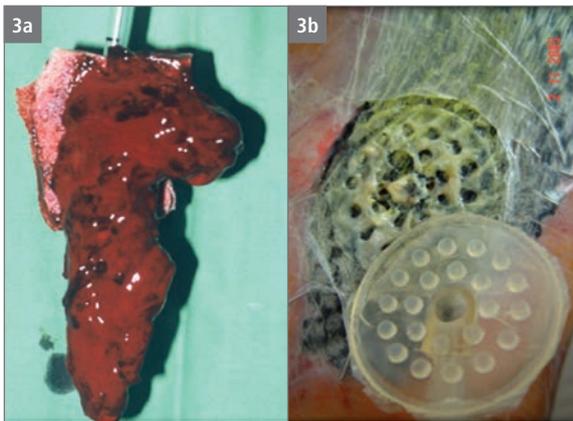
The role of NPWT in traumatology is to safeguard healing and to prevent wound infection. For the optimal effectiveness, NPWT should be applied as soon as possible but also ceased as soon as possible. Its application for trauma patients can be very challenging, with a loss of the vacuum and clogging of the foam promoting infection and it is a demanding application technique, particularly for fresh bleeders. Therefore, a specialist team is needed in the operating theatre for speed and efficiency and the doctors and nurses on the ward need to have sufficient knowledge for troubleshooting on a 24-hour basis.



Efficient debridement: Dead and necrotic tissue, as well as any oedema must be completely removed, ensuring the wound is clean and vital before applying NPWT, otherwise pathogens may grow in the deep vital tissue. Here, an example of gas gangrene.



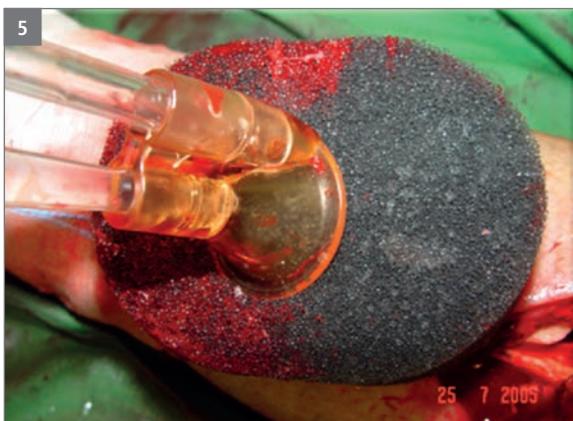
Assessment of tissue damage: Correct assessment of tissue damage prior to NPWT application is essential because the foam prevents direct wound observation during NPWT. If the original assessment was inadequate, complications may develop, leading here, for example, to progressive soft-tissue damage.



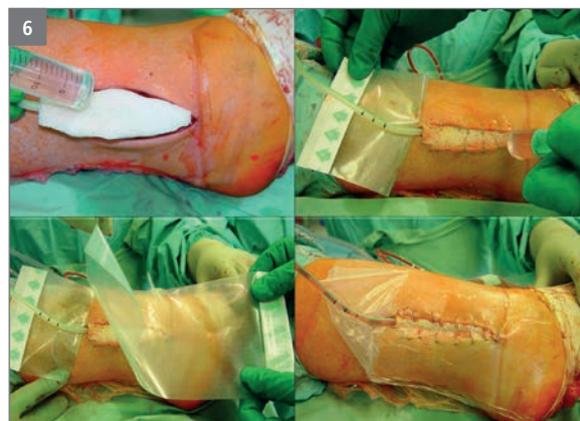
Clogging: Blocking of the foam either by clotting (left) or viscous fluid (right), thus preventing vacuum formation at the foam-wound interface.



Ingrowth: As a routine the PU-foam is changed. The foam is changed every 3 days to avoid ingrowth into the porous structure of the PU foam.



Jet lavage: To remove blood clots and clean the foam. To prevent clot formation during the application of the vacuum dressing fill the wound cavity with water and soak the foam in water. The diluted blood will not clot and bleeders at the wound surface are stopped abruptly the moment the vacuum is established in the finished dressing.



Washing and high-pressure suction: For the soft PVA foam, a drainage tube can be inserted and attached to a surgical aspirator providing a negative pressure ≥ 600 mmHg. The wound is washed with water to prevent clotting by diluting the blood and the diluted blood is removed by suction. Staples are applied, the wound is then covered and sealed under pressure.

NPWT in paediatric and adult trauma patients

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Application of negative pressure wound therapy (NPWT) in paediatric and adult trauma patients.

Wounds in trauma

Problematic wound healing can become the limiting therapeutic factor of a trauma. There is considerable variability in trauma-associated wounds. Primary wounds depend on the injury mechanism, including open fractures, laceration of the skin and subcutaneous tissue, decollement, polytrauma and devastating injuries. Secondary wounds can arise as complications of primary wounds, including compartment syndrome and suture disruption.

Effects of the application of negative pressure in trauma

We have applied NPWT as part of the treatment of trauma wounds since 2009 using the system by HARTMANN Rico. We have found that NPWT reduces the hospital stay, stimulates granulation and epithelialisation and reduces oedema in soft tissue. It provides a closed system and controlled moist wound environment, and allows rehabilitation without leakage, thus reducing bacterial colonisation and the possibility of secondary infection. NPWT helps in the treatment of infected wounds with and without osteosynthetic material.

NPWT in paediatric trauma patients

In paediatric patients, wound necrectomy is performed under general anaesthesia, particularly in very young patients. To avoid painful daily dressing changes, we make dressing changes after 5 – 7 days, which are initially conducted under general anaesthesia and subsequently with premedication and sedation in older paediatric patients whereas all dressing changes in younger paediatric patients are made under general anaesthesia. The negative pressure applied is adjusted according to age. We can achieve a clean wound free of leakage with the possibility of manipulation and rehabilitation without contact with

wound secretions, particularly for hepatitis B surface antigen (HBsAg)-positive patients. The paediatric patients with trauma, including fractures, whom we have treated, healed without complications. Paediatric patients generally display more rapid healing and thus a shorter hospital stay than adults.

NPWT in adult trauma patients

Adults present with polytrauma, soft-tissue lacerations and open fractures. We also see many defects after primary suture with and without metal parts and osteosynthetic material. Adult patients also present with compartment syndrome. Additionally, defects from expansive haematoma following blunt trauma are presented, the situation exacerbated by "warfarin"-induced haemorrhage, with haematoma common in the extremities. NPWT is particularly helpful in patients with osteomyelitis. Premedication and sedation are applied for dressing changes. Patients with a wide range of traumata with and without infection have been successfully treated.

Conclusion

NPWT has become an important element in trauma and surgical disciplines. Vivano is an integral part of the equipment at our trauma centre; its main benefits are accelerated therapy, good handling for re-dressing and its ease of operation.



An 8-year-old female with femoral fracture and severe skin injury: The patient had been hit on the leg by a falling heavy metal object, resulting in a comminuted diaphyseal femoral fracture. The fracture was reduced and intramedullary osteosynthesis and elastic nail were applied. There was severe skin and subcutaneous tissue damage in the femoral region (top left; defect 20 × 15 cm). Necrectomy was performed under general anaesthesia and NPWT initiated using GranuFoam and a negative pressure of 125 mmHg (top right). After 15 days of NPWT, the wound was ready for skin autograft (bottom left). The patient recovered without complications (bottom right), and with the bone healed.



A 5-year-old male with major foot injuries: The patient had been hit by a car on a crossing, resulting in open luxation of the metatarsal phalangeal joint of the big toe and extensive laceration of the skin of the foot (top left). The patient also suffered concussion and a diaphyseal clavicle fracture. Necrectomy was performed under general anaesthesia. A special silicone cover was placed over the wound (top right) before application of NPWT because of the patient's age. NPWT was initiated (bottom left) using a negative pressure of 80/90 mmHg and all dressing changes were performed under general anaesthesia, both because the patient was very young. The wound healed well (bottom right).



An 80-year-old female with complications following surgical treatment for a fracture: The patient had undergone surgery for a fracture of the proximal tibia. Complications developed, whereby there was sutural disintegration and vasculature trauma over the medial region of the proximal tibia (top left). Necrectomy was performed, GranuFoam was placed inside the defect and elastic sutures were applied (top right). NPWT was initiated using Vivano, with the osteosynthesis in place for bone healing. After a few weeks, the osteosynthesis could be removed and NPWT continued. Shortly afterwards, an autograft was performed in the wound, with GranuFoam placed over the skin graft and NPWT continued. The graft took well (bottom left). Although a small area of necrosis developed, the wound subsequently healed completely (bottom right).



A 62-year-old male who developed sutural disruption and infection: The primary trauma was deep lacerations to the soft tissues of the leg from the blades of a grass cutter. These were treated using primary sutures, drainage and all the standard steps. However, complete disruption of the primary sutures occurred and the wound became infected with *Staphylococcus aureus* (top left). The wound was debrided and NPWT was initiated (top right). Once the wound was clean, secondary suturing of the top half of the wound was performed and a skin autograft covered the lower half of the wound (bottom left). NPWT was reapplied and the wound healed successfully (bottom right).



An 82-year-old female on warfarin with expanding haematoma: The patient received a slight hit on the leg from a car in a car park. Although the initial injury was minor, a large haematoma subsequently developed in the tibial region accompanied by necrosis (top left). Necrectomy was performed and NPWT initiated (top right) and applied continuously until the wound was ready for skin autograft (bottom left). The wound healed successfully (bottom right).



Patient with implantation infection and multi-fistulation: The patient had a subcapital femoral fracture and received a cervicocapital endoprosthesis. After several days, infection of the implant developed in the joint area, which was extremely painful. Multiple fistulation, including around the primary sutures, with skin defects developed (left). The endoprosthesis was removed, antibiotic therapy was initiated and NPWT using Vivano was applied to all the fistulation using a bridge-like method (right). The treatment required 3 – 4 weeks.

NPWT in paediatric patients with severe trauma

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Negative pressure wound therapy (NPWT) in paediatric patients with severe trauma.

Severe trauma is normally accompanied by further injuries, which, in addition to the extremities, may include the brain and thoraco-abdominal region. Trauma implies major haemorrhage and soft-tissue defects, bone-support discontinuities and vascular- and nerve-axis rupture, and is accompanied by traumatic and/or haemorrhagic shock.

Important particularities related to paediatric patients with severe trauma

In comparison to adults, a lesser kinetic force is capable of creating greater lesions. Due to physiological particularities, paediatric patients are more prone to shock, display less haemodynamic stability and have greater susceptibility to hypoxia in certain tissues. Extremely small peripheral vessels make reconstruction, particularly in the free flap, very difficult. In contrast, the capacity for tissue regeneration and recovery is greater.

Trauma treatment

Particularly in paediatric patients prior to tissue defect covering, the patient should undergo algorithmic diagnostic and treatment management and clinical and paraclinical evaluation. Vital functions must be re-established, together with hydroelectrical and acidobasic resuscitation and restoration of the blood volume. Optimal cerebral / somatic oxygen perfusion requires maintaining. Therefore, treatment involves the collaboration of several specialists, including, for paediatric patients, specialists in anaesthesia, intensive care, paediatric orthopaedics, paediatric surgery, plastic and reconstructive surgery, neurosurgery and ENT.

Role of NPWT in paediatric trauma patients

Performing these essential tasks in stabilising the patient could delay the surgical reconstruction for an unpredictable length of time, particularly when a patient is in a coma. For the plastic surgeon, treatment involves the re-establishment of tissue from the func-

tional rather than the morphological point of view. Therefore, during the delay, NPWT plays an important role in preventing infection, reducing tissue defects and in preparing the wound for reconstruction.

Paediatric trauma patients with treatment including NPWT

Twelve cases, including with large soft-tissue defects, severely infected wounds, vascular anastomosis within the wound, bone fracture, nerve damage and burns, were evaluated. On admission, in most cases, treatment involved surgical wound debridement, stabilising bone support and the recovery of the main vascular and nerve axes. This was followed by NPWT until the general status of the patient and the local wound conditions permitted surgical reconstruction using free flaps, pedicled flaps, prefabricated flaps and skin grafts.

Results of treatment

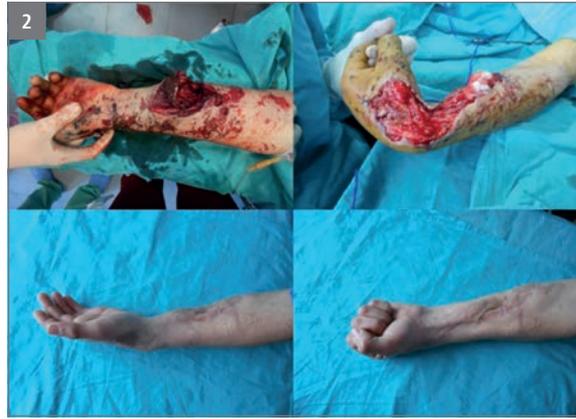
Granulation tissue formation in paediatric patients was relatively more rapid compared to adults. In all patients, defects were eliminated, oedema reduced, wound infection prevented / treated, producing completely clean wounds and stimulating angiogenesis.

Conclusion

NPWT is an excellent tool in the management of severe trauma in paediatric patients when used in combination with surgical procedures to close large soft-tissue and bone defects. NPWT allows a clean wound to be obtained and to be maintained until the patient has been stabilised, allowing reconstructive surgery. It aids in the wound preparation for surgical reconstruction and results in rapid granulation and good flap and skin-graft uptake. The classical indications for NPWT can be extended to wounds including injury to bones, tendons, vessels and nerves. NPWT appears to improve the permeability of vascular anastomosis and stimulates the reperfusion of free transfer tissue.



1
A 12-year-old male with bone and soft-tissue defects in the right foot: The patient had been in a bicycle accident. No extensive surgery was possible due to severe cranio-cerebral trauma and coma. There was a high risk of infection. The patient received NPWT for 4 days, after which there was granulation tissue over the bone surfaces, allowing skin grafting to cover the tissue defect. Stable wound closure was present after 1 year.



2
A 17-year-old male with shell explosion trauma to the left forearm and hand: The wound was highly contaminated (top left) and shell shrapnel was present, which was difficult to remove. Additionally, the patient had also suffered disembowelment and a knee injury, and the right arm required amputation. After wound debridement, NPWT was applied for 5 days, obtaining a clean and highly vascular wound (top right), allowing simple grafting. An excellent functional result was obtained after 1 year (bottom), which was critical for the patient because of the loss of the right arm.



3
A 16-year-old male who developed compartment syndrome: The patient had been in a motorcycle accident, resulting in a left tibial plateau fracture and left leg compartment syndrome (top). Other injuries were cranio-cerebral trauma and a nasal bone fracture, with the patient in a coma. NPWT was applied to the tibial proximal extremity for 7 days. This resolved the oedema and minimised the

post-fasciotomy defect. There was some muscle necrosis, which was cleaned at each bandage change. On completion of NPWT, there was no necrosis and the defect was sufficiently reduced to allow closure by direct suture because the skin could be readily stretched. There was a good functional result after 1 year (bottom).



4
A 16-year-old male with crushed left arm: The patient had trapped his arm in a sunflower pressing machine, with all the bones from the phalanges to the elbow smashed and with many levels of fracture (top). There were proximal fracturing of the radius and ulna, multiple metacarpal fractures and several phalangeal fractures.

The ulnar and radial arteries required reconstruction due to crushing. Latissimus grafts from both legs were applied to reconstruct the whole axis. NPWT was applied for a few days until the defect could be covered with a flap.

NPWT in chronic wounds

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A 60-year-old male and a 48-year-old female with chronic ulcers and a 50-year-old female with a major wound following removal of sacral tumour.

Patient anamnesis

Patient 1 was a 60-year-old male with type II diabetes, microangiopathy and resistant *Escherichia coli* indicated by extended-spectrum beta-lactamase (ESBL). The patient was given acetyl salicylic acid, statin and imipenem. Patient 2 was a 48-year-old female who had undergone endovenous laser surgery for a chronic but superficial venous ulcer. Patient 3 was a 50-year-old female who had undergone major surgery for a sacral tumour.

Wound anamnesis

Following a minor trauma, Patient 1 developed a non-healing 7 × 3 cm ulcer of the right foot at the calcaneus, with necrosis in the periwound area. Following laser varicectomy, patient 2 developed a second, much deeper necrotic ulcer proximally, at the puncture site of the endovenous laser. The whole tumour of Patient 3 was removed, including L4, L5 and the sacrum, being replaced with the patient's own bone, and the spine supported using metallic devices.

Aim of the treatment

The application of negative pressure wound therapy (NPWT) to stimulate healing in chronic wounds.

Wound treatment

Systemic treatment of Patient 1 consisted of antibiotics, non-steroidal antirheumatics, anticoagulants and analgesics. Boric acid, Dermazin and Sorbalgon were applied topically. Necrectomy and debridement were performed and NPWT was applied with two changes. After 2 weeks of NPWT, the wound bed was surgically prepared, and a reverse sural artery flap was created over the defect, a mesh graft applied to the area from which the flap was taken and the wound was sutured. Almost 9 months after the flap operation, the wound had healed and the patient

could walk on this foot again when using specialised diabetic footwear.

Wound necrectomy was performed for Patient 2.

NPWT was simultaneously applied to both wounds with a negative pressure of 125 mmHg using a single device with the aid of a Y-shaped connector. On the first change after 5 days, skin grafts were applied to both wound beds and NPWT was reapplied for 5 days. NPWT was ceased and the wounds healed 3 months after surgery.

Wound treatment for Patient 3 included necrectomy, debridement and antibiotics. NPWT was applied and changed several times. Although the wound was difficult to heal, after 55 days, it had progressed sufficiently to allow plastic surgery with wound closure. Despite the patient subsequently being wheelchair-bound and incontinent, he was alive and his overall quality of life was still generally good.

Conclusion

The application of NPWT stimulated healing in chronic wounds, allowing further surgical intervention where required, leading to complete healing. This clearly improved the quality of life of the patients, including after major surgery and in regaining mobility after foot ulceration.



Patient 1, NPWT: Non-healing ulcer (7 × 3 cm) at the calcaneus of the right foot, with necrosis in the periwound area. NPWT applied after necrectomy and debridement.



Patient 1, further surgery: Wound after 2 weeks of NPWT (top left). The wound bed is prepared for grafting (top right). A reverse sural artery flap is created over the defect and the wound is sutured (bottom left). Almost 9 months after the flap operation, the wound has healed (bottom right).



Patient 2, chronic ulcer: Following laser varicectomy of a chronic venous leg ulcer, a much deeper, necrotic ulcer developed proximally, at the puncture site of the endovenous laser (on the bottom in the images). The wound was debrided.



Patient 2, NPWT: First application of NPWT using a single device via a Y-shaped connector, and showing the wounds after foam removal on day 5.



Patient 2, grafting and NPWT: Skin grafts are applied to both wound beds and NPWT reapplied for 5 days. Three months after surgery, the wounds have healed.



Patient 3: The patient underwent major surgery for the complete removal of a sacral tumour (top left). NPWT is applied and changed several times. Although a difficult to heal wound, after 55 days it had progressed sufficiently (top right) to allow plastic surgery (bottom left), with wound closure (bottom right).

Treatment of the septic complication in the chest cavity

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A 19-year-old, HCV-positive young man, who has used intravenous drugs for three years, suffered a fracture of the right 9th rib and had bleeding in the thoracic cavity. Due to the patient's non-compliance and owing to his poor immunology status, superinfection of the free fluid and a septic status had developed.

Patient anamnesis

Due to the psychological status of the patient, the thoracic tubing and the antiseptic lavages commenced were unsuccessful. Thoracic CT examination showed cellular transformation of the process, thus surgical intervention became necessary. We performed a partial removal of the 8th and 9th rib at the deepest point of the chest and the abscess cavity, we sutured the pleura and the skin together, and we created a window on the wall of the chest. We removed the abscess and the abscess wall through the working channel. We closed up the thoracic cavity following antiseptic lavage, with the help of negative pressure wound therapy with Vivano, placing the sponge via the working channel.

Wound anamnesis

The pyogenesis of the thoracic cavity was localised; a thick walled pus-sack had developed. With this clinical status, a result cannot be achieved using minor surgery methods.

Aim of the treatment

With the open-chest management, and with the application of negative pressure wound therapy (NPWT), the lungs are able to achieve full capacity dilation, residual fluid reservoirs and air inclusions are not formed, thus the septic focus can be directed towards the window in the wall of the chest. By eliminating the free cavity and with targeted antibiotic therapy, the septic process can be completely healed.

Wound treatment

The negative pressure therapy performed in the thoracic cavity is a treatment that can be used safely. The sponge placed in the thoracic cavity needs to be changed regularly. Using the window in the chest wall, we changed the sponge every 3rd day. In the case of this patient, the size of the sponge was initially an 'L'. Following the primary surgical intervention, we performed a revision and changed the sponge, decreasing in size, 5 times; the free chest cavity has disappeared. We closed the window in the chest wall with a muscle lobe and the skin, after a sterile status had been achieved. The total duration of the treatment was 25 days.

Conclusion

Negative pressure wound therapy can be successfully used for pyogenic processes of the thoracic cavity, even in cases that were initially therapy-resistant. The well-developed therapeutic protocol and the targeted antibiotic therapy may shorten the duration of the treatment, which has economic advantages.



Fig. 1: Insufficiency chest tube in the right chest cavity

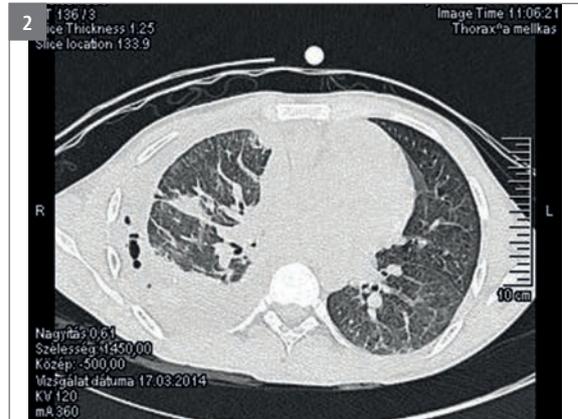


Fig. 2: Thoracic Computer Tomography: air bubbles and fluid on the right side, empyema thoracis



Fig. 3: Open chest treatment after rib resection – pleura and skin sutured



Fig. 4: Open chest treatment after rib resection – pleura and skin sutured



Fig. 5: Surgical procedure, change of the VIVANO system



Fig. 6: Chest X-ray, free space closed, septic complication healed

NPWT in diabetic foot

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A 66-year-old male with infected diabetic foot requiring surgical intervention, including digit amputation.

Patient anamnesis

A 66-year-old male with unstable type II diabetes who had been taking insulin for 25 years and had therapeutically neglected arterial hypertension. The patient was hospitalised with pain and loss of function of the right leg and presented with wet gangrene of the foot.

Wound anamnesis

The wet gangrene involved the region of the second and third toes. Surgical amputation of the second toe had been performed. There was wound infection of the amputated stump, cyanotic dorsalis pedis, a foetid discharge from the residual limb and a dirty appearance. A necrotic ulcer of approximately 6 × 3 cm was present in the middle portion of the plantar surface of the foot.

Aim of the treatment

Application of negative pressure wound therapy (NPWT) in the treatment of an infected diabetic foot and associated necrotic ulcer.

Wound treatment

A more conservative surgical approach was followed. The third toe was amputated and a metatarsal head resection was performed on the second and third toes. The infection was found to be spreading in all the interdigital spaces. Excisional debridement of the metatarsal head revealed a communication between the supportive area of the toes and the planar ulcer, which required wide debridement and excision, preserving a healthy skin flap at the points of the metatarsal support. NPWT was initiated at a continuous negative pressure of 100 mmHg. Necrosis of the first toe was observed on the first dressing change. This digit and the fourth toe were subsequently amputated, and NPWT reapplied. Treatment continued for

2 weeks in our department. The wound size decreased, the oedema resolved, granulation occurred in the wound bed and bacteriological examinations became negative. Systemically, the blood count normalised, the blood sugar corrected to within normal limits and blood cultures were negative. The patient was transferred to the Department of Plastic Surgery for skin grafting to the defect; the graft was obtained from the same leg. The patient was subsequently moved to Surgery Clinic II for 2 weeks of further treatment. Wound healing had occurred after 3 months.

Conclusion

Application of NPWT stimulated healing of surgical wounds and an ulcer in a diabetic foot, including elimination of infection, oedema resolution and supporting granulation formation for subsequent skin grafting.



Diabetic foot: The second toe is surgically absent and there was infection of the amputated stump, foetid discharge from the residual limb and cyanotic dorsalis pedis. A necrotic ulcer of approximately 6 × 3 cm was present in the middle portion of the plantar surface of the right foot.



NPWT, first application: NPWT was applied at a continuous negative pressure of 100 mmHg.



First dressing change: The first toe was now necrotic (left). This digit and the fourth toe were amputated (right), and NPWT was reapplied.



Progression of wound healing: Over 2 weeks, the wound size decreased, the oedema resolved, granulation occurred in the wound bed and the bacteriological examinations were negative.



Skin grafting: A skin graft taken from the same leg was applied to the defect.



Final wound healing: The wound had healed after 3 months.

NPWT in the treatment of a refractory venous ulcer

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A 46-year-old male with a long-term non-healing ulcer.

Patient anamnesis

The 46-year-old patient presented in October 2013. Recurrent episodes of deep venous thrombosis started at 22 years of age, with warfarin prescribed for 6 months. The patient developed the first varicose ulcer related to post-thrombotic syndrome at the age of 25, with episodes of closing and relapse. Antiphospholipid syndrome had been diagnosed in 2005, with subsequent permanent warfarin treatment for an international normalised ratio (INR) of 2 – 3. Suprarenal arterial thrombosis with suprarenal bleeding and consequent irreversible suprarenal failure occurred in 2008, requiring permanent corticotherapy. The leg ulcer deteriorated whenever the INR was below therapeutic ranges, requiring leg compression. The ulcer had now remained open for 3 years. Venous doppler and phlebography evaluation in 2012 indicated persistent obstruction of the right femoropopliteal axis, with venous drainage ensured by the right saphena magna vein.

Wound anamnesis

Two ulcers were present in the medial malleolar area of the right leg (proximal 2 × 2 cm; distal 2 × 1.5 cm). Tissue damaged was related to venous hypertension disease, with many varicose dilatations, lipodermatosclerosis and hemosiderin pigmentation and an ankle-brachial index (ABI) of 0.9.

Aim of the treatment

Application of negative pressure wound therapy (NPWT) to a refractory venous ulcer to assist in wound evolution, in outpatient care.

Wound treatment

Systemic treatment included leg compression, phlebotonics, continuous corticotherapy and anticoagulation with warfarin (INR 2–3). Locally, standard wound

treatment and venous contention were applied. The ulcer initially improved, but never closed, with subsequent deterioration from May 2014. Treatment was ceased in February 2015. Punch biopsy indicated an ischaemic cutaneous chronic ulcer without malignancy. The right saphena magna vein had severe insufficiency and major dilatation, and there was virtually no femoral vein recanalisation, very limited popliteal vein permeabilisation and extensive venous collateralisation. The ABI was 0.9. It was decided to perform a whole ulcer excision, with NPWT to stimulate wound-bed granulation, venous contention and skin grafting, all under local anaesthesia. Warfarin was ceased and 1.5 mg/kg enoxaparin applied daily. Treatment was as an out-patient due to the patient needing to be free to work. The entire ulcer was removed up to, but not into, the fascia, to leave good bleeding tissue. NPWT was commenced on day 4. Split-thickness skin grafting (STSG) was performed on day 17 and NPWT was recommenced on day 22, continuous at –80 mmHg. By day 45, the graft had been lost and granulation was poor, with friability and intense pain. *Pseudomonas aeruginosa* was present, which was treated systemically with oral ciprofloxacin and locally with daily changes of dressing with acetic acid. The infection was controlled by day 65. However, granulation was insufficient and NPWT was recommenced on day 86. Good granulation developed. On day 105, a sharp debridement was made due to some fibrin in the wound bed and NPWT was continued. By day 138, granulation was well developed for STSG and NPWT was applied from the same day, initially at –90 mmHg but later increased to –120 mmHg, due to significant moisture. Although there was superficial skin graft loss by day 150, epithelialisation was very good. Topical oxygen therapy was initiated, producing excellent results by day 160, with re-epithelialisation expected within a week.

Conclusion

In refractory and difficult ulcer cases, wide local excision and skin grafting combined with NPWT

to stimulate granulation and epithelialisation may provide a treatment option. NPWT should be applied immediately after skin grafting to help the graft take.



Day 0: Ischaemic cutaneous chronic ulcer undergoes whole ulcer excision down to, but not into, the fascia, producing an 8 x 6 cm wound.



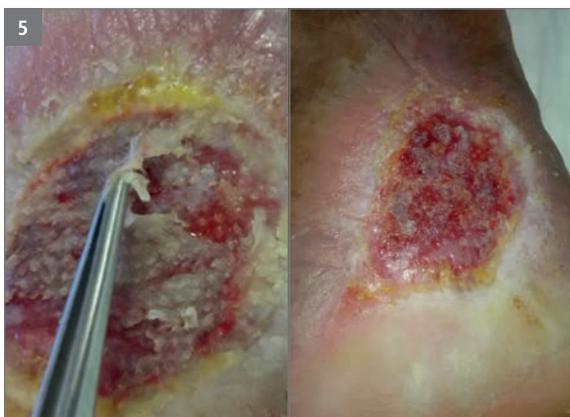
Day 17: Following 14 days of NPWT, split-thickness skin grafting is performed. NPWT is re-applied on day 22.



Day 45: The graft was lost and granulation was poor, with friability and intense pain. Cyto-bacteriological examination indicated the presence of *Pseudomonas aeruginosa*.



Day 138: The infection was controlled (by day 65) and granulation was sufficiently developed for split-thickness skin grafting. NPWT is commenced directly after grafting.



Day 150: Although there is superficial skin-graft loss (left), epithelialisation is very good (right). Topical oxygen therapy is commenced.



Day 160: Excellent progress in epithelialisation, with re-epithelialisation expected within the following week.

Day 175: Practically epithelized.

Indications and limitations of endoluminal NPWT

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Where and when negative pressure wound therapy (NPWT) is indicated in the upper gastrointestinal (GI) tract.

Patients with a perforation of the upper GI tract resulting from a surgical complication or occurring spontaneously require surgical intervention, with its associated high morbidity and mortality rates. The aims of endoscopic management are to prevent (repeat) surgery, to be safe, to provide a high success rate and to reduce morbidity and mortality, as well as to reduce the hospital stay and costs. Among the options available is endoluminal NPWT.

Hypopharynx

Perforation of the hypopharynx is rare (< 2% of upper GI perforation), occurring due to sharp or blunt trauma, a foreign body, vomiting and iatrogenically (intubation, endoscopy). Balster et al. (2015) reported that four out of six patients who received endoluminal NPWT for ≥ 7 days required follow-up surgery. The problem was the anatomy and constant movements of the oral cavity, such that it was not possible to create a vacuum above the upper sphincter of the oesophagus. We were similarly unsuccessful. Therefore, NPWT is not indicated here.

Oesophagus

In contrast, oesophageal perforation is a good indicator for NPWT, with iatrogenic rupture the main cause (80%; during or after interventional diagnostic procedures and therapies). Other causes are a foreign body (8%), trauma (5%), and spontaneous rupture. Regarding the standard therapy for a non-septic patient, in Germany, the S2k-guideline for endoscopy of 2015 recommends that, for endoscopic treatment of postoperative leaks in the upper GI, fully covered stenting or endoscopic NPWT is indicated. Three retrospective studies found endoluminal NPWT to be more successful. Schniewind et al. (Surg Endosc 2013; 27:3883-90) reported mortality rates for NPWT and stenting of 12% and 83% respectively. The clinical success rates for

NPWT and stenting reported by Brangewitz et al. (Endoscopy 2013; 45:433 – 4338) were 84% and 54% respectively, while in our study (Mennigen et al. J Gastrointest Surg 2015; 19: 1229 – 1235), these were 93% and 63% respectively. While the first results are very promising, the general clinical condition of the patient must be considered and the chosen therapeutic route questioned, for which we suggest a modified algorithm (see Fig.: Suspicion of oesophageal perforation).

Stomach

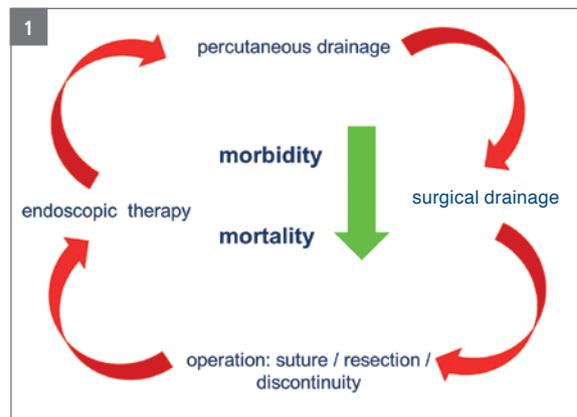
Gastric perforation arises from ulcer perforation, postoperative leak (e.g. bariatric surgery) and iatrogenically (endoscopy, NOTES). Although the evidence for NPWT is limited, the tendency is to apply an over-the-scope clip (OTSC) for a new perforation after endoscopic procedures, while NPWT is favoured for postoperative and chronic leaks. Fluid not drained by either technique should be removed by an interventional / surgical technique.

Duodenum

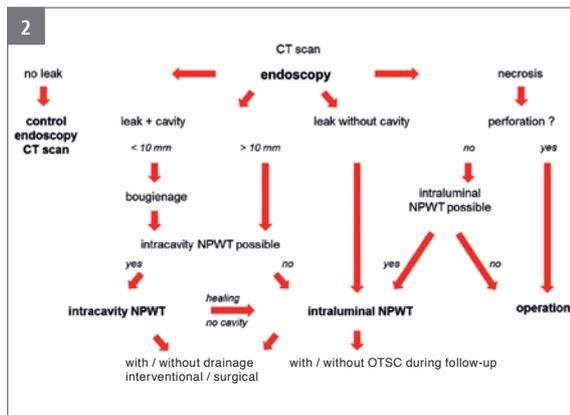
The duodenum is difficult to access, with perforation diagnosis using computed tomography (CT), and a mortality rate of up to 25%. There is no clear agreement on treatment and no standard treatment. However, a common classification of the perforation location (see Fig.: Localisation of perforation) indicates a decreased likelihood of surgery with an increasing distance from the duodenum. A range of approaches are applied, including stents, loops and clips. We have successfully treated a few patients with NPWT (unpublished). Despite the lack of published data, NPWT appears promising, and we suggest a modified algorithm for duodenal and peri-ampullar / ductal perforations (see Fig.: Duodenal perforation).

Conclusion

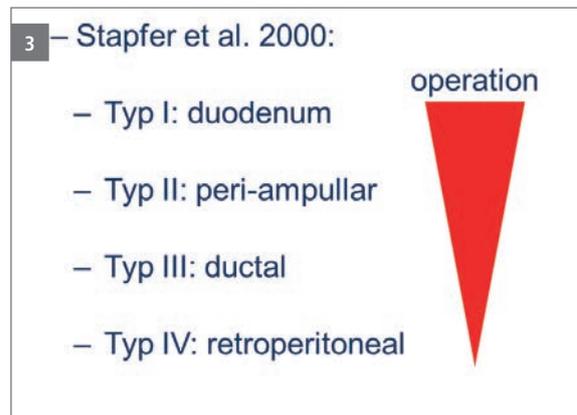
NPWT is not indicated in the hypopharynx, while more research is required for the duodenum, although initial results are promising. In the stomach, NPWT appears to be effective, while it is most actively applied to oesophageal complications and perforations. For correct diagnosis, a CT scan and endoscopy are effective tools. Once diagnosed, adequate treatment is required, with NPWT ± antibiotics ± drainage (surgical, interventional).



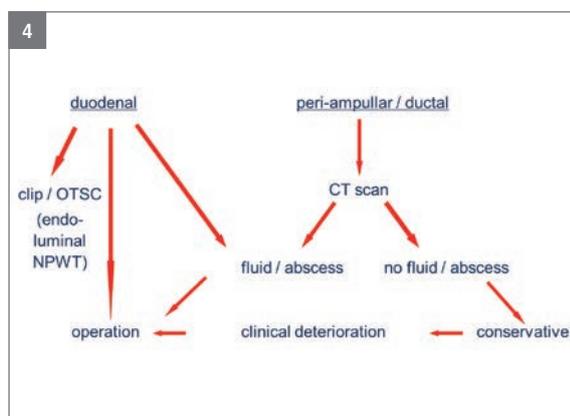
Complications in the upper GI: Therapeutic options.



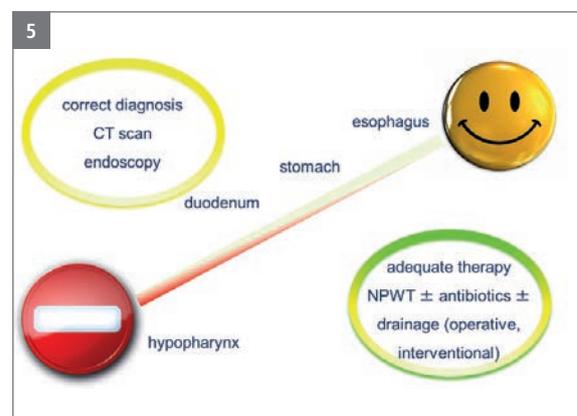
Suspicion of oesophageal perforation: Algorithm for diagnosis and treatment; modified according to Schorsch et al. (Der Chirurg 2014; 85:1081-93). CT: computed tomography; OTSC: over-the-scope clip.



Localisation of perforation: Classification of the perforation location (Stapfer et al. Ann Surg 2000; 232:191 – 8). Arrowhead indicates relative frequency of an operation in relation to distance from the duodenum.



Duodenal perforation: Algorithm for diagnosis and treatment; modified according to Avgerinos et al. (J Gastrointest Surg 2008; 12:1783 – 1789), Kim et al. (J Korean Surg Soc 2011; 81:195 – 204), Kwon et al. (J Korean Surg Soc 2012; 83:218 – 226), Stapfer et al. (Ann Surg 2000; 232:191 – 198). CT: computed tomography; OTSC: over-the-scope clip.



Indication for NPWT in the upper GI tract: Diagnosis and treatment of perforation in the upper GI tract.

Application of NPWT in penile skin graft reconstruction

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A 59-year-old male with Fournier's gangrene and sepsis in the genital area.

Patient anamnesis

The 59-year-old male had diabetes mellitus type II, which was insufficiently controlled by an oral anti-glycaemic.

Wound anamnesis

Diagnosis was Fournier's gangrene. The patient was transferred to intensive care, and underwent debridement of dead tissue and excision of necrotic tissue. The patient's general condition and laboratory findings indicated sepsis.

Aim of the treatment

The application of negative wound pressure (NPWT) using the more rigid VivanoMed white foam to assist in penile skin graft reconstruction.

Wound treatment

Systemic treatment and supportive therapy was initiated (day 0), including antibiotics (crystacillin garamycin, efloran) for 7 days. Due to microbiological indications, the antibiotic set was then changed (ceftriaxone, clindamycin) for 7 days, with *Proteus mirabilis* and *Escherichia coli* present. Repeated excision of necrotic tissue and debridement improved the general wound conditions, as confirmed in laboratory findings. On day 9, the patient was referred to the plastic surgeon with a large wound in the genital area extending up to the umbilical level on both sides and from the abdominal fascia to the abdominal skin. After the excision of necrotic tissue and a right orchidectomy, it was decided to apply the Vivano system. On day 12, white foam was placed circumferentially around the penis, leaving the glans uncovered for monitoring. A single piece of alginate was used to cover and protect the urethral orifice around a catheter; the rest of the wound was covered

with black foam, with two abdominal drains placed on both sides to ensure proper sealing of this large wound. Negative pressure was applied at 125 mmHg. After 2 days, there was 800 ml drainage and the oedema was reduced. With the good local findings, it was decided to cover the wound with skin and apply an autograft to the penis. The skin was undermined in the upper and distal portions and directly closed over the scrotal and pubic areas, with the penis placed in the proper position. A split-skin autograft from the left thigh was placed circumferentially on the penis, recreating the medial raphe on the ventral side, stitching the autograft to the skin of the pubic and scrotal areas. White foam was placed circumferentially, directly over the autograft, leaving the glans uncovered for monitoring. Two small pieces of white foam covered the other wounds. One small piece of alginate was placed on the urethral orifice around catheter to protect the mucosa. Negative pressure was set to 75 mmHg and two drains were placed in the abdominal wall. NPWT was ceased after 5 days (day 7 NPWT), with 100% attachment of the autograft around the penis. After 10 days, there was constant leakage at a portion of the penile root, the weakest part of the wound. Inactive drains were removed and an additional drain was placed in the scrotal area and attached to a urinary bag. The patient was discharged on day 32 with a urinary catheter and drain inside the scrotum. On the first outpatient visit (day 47) the scrotal drain had fallen out (day 40) and there was a small fluid discharge in the penile root. There was no sign of infection with a good general wound condition. By day 60, the wound had improved further. On day 77, all wounds, including the autograft site, were healed, laboratory findings were unremarkable and urinary and erectile functions were normal.

Conclusion

This application of the Vivano system using the white foam enables monitoring within the foam, being much stronger than black foam, and allows the immobilisation of the penis in the appropriate upright

position, and is thus a valuable option for the closure of this type of wound. It produces long-lasting and durable skin, with a more natural skin coverage than with flap surgery. There is no need for additional de-bulking procedures.



Day 9: Patient was referred to the plastic surgeon. A large wound in the genital area, as far as the umbilical level is present bilaterally.



Day 12, NPWT day 0: Initiation of NPWT at -125 mmHg, with white foam around the penis, apart from the glans, for monitoring, and black foam within the wound.



Day 14, NPWT day 2: The wound area is sufficiently improved to allow wound closure and skin grafting. The skin in the upper and distal portions is undermined and then closed directly over the scrotal and pubic areas. A split-skin autograft is placed around the penis, with skin taken from the left thigh.



Day 14, NPWT day 2: Again, white foam is placed around the penis, together with two further small pieces over the wounds. NPWT is re-commenced at -75 mmHg.



Day 19, NPWT day 7: NPWT is ceased, with 100% attachment of the autograft around the penis



Day 77: Complete healing of all wounds, including the donor sight.

NPWT in plastic surgery

Martin Bohac

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Application of negative pressure wound therapy (NPWT) in the management of extensive soft-tissue defects of the head, torso and limbs.

Patient anamnesis

Patient 1 was an 83-year-old male who was being dialysed, was polymorbid and had exulcerative baso-cellular carcinoma of the calvarial skin (4.5 × 4.5 cm and 2.5 × 2 cm). Patient 2 was a healthy 21-year-old male who had suffered an upper extremity injury on a conveyer. Patient 3 was a healthy 47-year-old female with upper extremity injury caused by a press. Patient 4 was a 24-year-old male receiving systemic treatment. Patient 5 was a 60-year-old obese female who had undergone abdominoplasty for supraumbilical hernia. Patient 6 was a 56-year-old obese female who had undergone bilateral reduction mammoplasty.

Wound anamnesis

The full-thickness skin graft on Patient 1 had been unsuccessful, with necrosis and calvarial exposure. Releasing fasciotomies were performed on the left hand as primary care for Patient 2 at the district hospital before transfer to our department after 3 days. The left hand of Patient 3 had been severely crushed. Patient 4 developed hidradenitis suppurativa after systemic treatment. The wound of Patient 5 was infected and developed dehiscence after 5 days. Nine days after the reduction operation, Patient 6 developed necrosis of the AMC and wound dehiscence.

Aim of the treatment

Application of NPWT to extensive soft-tissue defects to allow subsequent wound closure using skin flap, skin graft or re-suture.

Wound treatment

The NPWT protocol involves the use of polyurethane sponge, a non-adherent or active layer and negative pressure of 85 – 125 mmHg applied continuously or

intermittently, and the dressing changed on average every 3 – 5 days.

Follow-up surgery was performed on Patient 1 after 40 days and 5 cycles of NPWT were applied. After 27 days, a split-thickness skin graft (STSG) was performed and combined with NPWT, resulting in complete healing. The wound of Patient 2 was debrided using 3 changes of maggots. After 1 month, 4 NPWT cycles were applied and wound coverage was performed after 38 days, using a pedicled inguinal flap and STSG. Complete healing was achieved. Primary treatment was performed on Patient 3 and NPWT was initiated after 1 month, with the application of 5 cycles. After 36 days, a meshed STSG was applied and healthy full-wound coverage was obtained. The axillary infection of Patient 4 was excised and 4 NPWT cycles were applied. After 26 days, dorsal transposition flap coverage was performed and the wound healed completely. Patient 5 underwent pus evacuation and wound lavage, followed 1 week later by the initiation of 4 NPWT cycles. After 22 days, the wound was re-sutured and subsequently healed. Patient 6 underwent pus evacuation, wound lavage and debridement. After 25 days, 2 NPWT cycles were initiated and the wound was re-sutured after 4 days, leading to complete healing.

Conclusion

NPWT enhanced the healing process, reducing the healing and hospitalisation times. It created a uniform wound surface, improved flap and skin graft healing, reduced antibiotic and analgesic use, protected the wound against infection, reduced the time for the dressing change and improved the quality of life of the patients and their families.



Patient 1: Unsuccessful coverage of the calvarial exulcerative basocellular carcinoma using full-thickness skin graft, with necrosis and calvarial exposure (top left). The wound is debrided (top right) and NPWT initiated. After 27 days, there is sufficient granulation and a split-thickness skin graft is applied (bottom left) combined with NPWT, resulting in complete healing (bottom right).



Patient 2: Releasing fasciotomies were performed on the left hand as primary care at the district hospital following injury on a conveyor, and the patient was transferred to our department after 3 days (top left). The wound is debrided with 3 changes of maggots (top right) followed by 4 cycles of NPWT (bottom left). After 38 days, wound coverage is performed using a pedicled inguinal flap and split-thickness skin graft, and complete healing is achieved (bottom right).



Patient 3: The left hand was crushed in a press (top left). The skin is pulled back and sutured (top right) and 5 cycles of NPWT applied (bottom left). Meshed split-thickness graft is applied, with full wound healing obtained (bottom right).



Patient 4: Developed hidradenitis suppurativa after systemic treatment (top left). The axillary infection is excised (top right) and 4 cycles of NPWT are applied (bottom left). Dorsal transposition flap coverage is performed, the wound healing completely (bottom right).



Patient 5: Following abdominoplasty for a supraumbilical hernia, the wound had become infected, developing dehiscence. Pus is evacuated and wound lavage applied, followed after 1 week by 4 cycles of NPWT. After 22 days, the wound is re-sutured and subsequently heals.



Patient 6: Had undergone bilateral reduction mammoplasty and developed necrosis of the AMC and wound dehiscence after 9 days. The patient undergoes pus evacuation, wound lavage and debridement. After 25 days, 2 cycles of NPWT are initiated and the wound is re-sutured after 4 days, leading to complete healing.

NPWT in crush injury of the lower limb

Tomasz Tuzikiewicz
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A 26-year-old female with a circumferential wound of the left leg involving the knee and two-thirds of the lower leg, with dislocated knee and fracture of the tibia and fibula.

Patient anamnesis

A 26-year-old female was a passenger in a car accident and was found outside the car. The 72 kg patient had no medical history. On admission to the accident and emergency department, the patient had a blood pressure of 90/60 mmHg and heart rate of 100 beats/min.

Wound anamnesis

The isolated left leg injury consisted of a circumferential wound involving the knee and two-thirds of the lower leg. The peroneal nerve was completely disrupted. Diagnostic imaging indicated open knee dislocation and open shaft fracture of the tibia and fibula (Gustilo-Anderson type IIIB).

Aim of the treatment

Application of negative pressure wound therapy (NPWT) to treat a major crush injury.

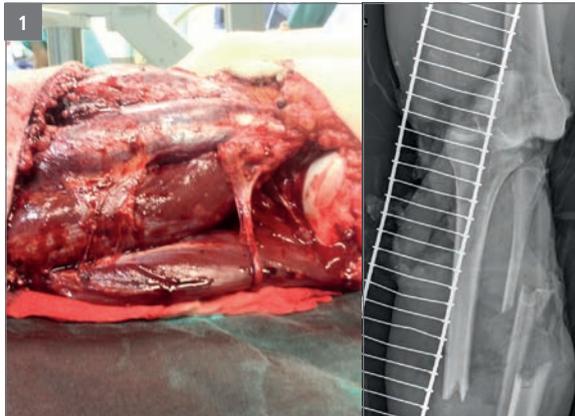
Wound treatment

Treatment was initiated in the accident and emergency department (A&E), with administration of analgesics, antibiotics, fluids, blood transfusion and tetanus prophylaxis. In open fractures, the wound is both irrigated and debrided twice, on admission to A&E and again on arrival in the operating theatre following diagnostic examination, which usually occurs within 1 hour. The dislocation and fractures were reduced and external fixation was applied. The duty doctor decided on wound closure. After 3 days, the de-gloving injury led to skin and soft tissue necrosis, with a C-reactive protein (CRP) level of 206 mg/mL. Necrectomy of the whole circumference was performed, removing all tissue from the lower leg. The wound was fully covered with foam and NPWT was initiated. The potential complication of circumferential

dressing affecting the blood supply to the foot did not occur. Indeed, this is a problem we have not yet encountered. We changed the dressing every 3 days. Within 3 days, the CRP level was reduced to 35 mg/mL. At this time, it was observed that the fracture and the tibial shaft were exposed. After 2 weeks, we decided to close the wound. A soleus muscle rotation flap was created and the wound was closed using a split-thickness skin graft, which was stabilized by NPWT because the graft was elevated in several places. The whole skin graft was in place after 5 days. After 6 months, the wound had healed. However, the external fixator was still in place due to fracture non-union, with the next step of intramedullary nailing.

Conclusion

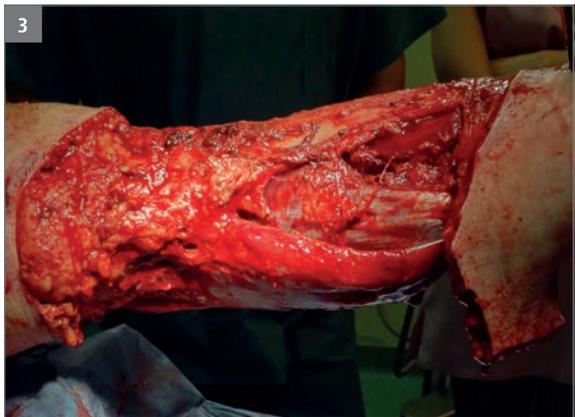
Aggressive and precise debridement should be performed on admission together with low-pressure lavage using saline (> 5L) because high pressure is considered less effective at removing bacterial colonies. Fractures are stabilised and staged debridement and irrigation should be performed every 48 hours as required, depending on the wound condition. In very dirty wounds, antibiotic beads with bone cement can be applied to prevent osteomyelitis.



Day 0: Circumferential wound of the left leg involving the knee and two-thirds of the lower leg, together with open knee dislocation and open shaft fracture of the tibia and fibula.



Day 3: De-gloving injury led to skin and soft tissue necrosis.



Day 3: Circumferential necrectomy.



Day 3, NPWT day 0: Initiation of NPWT with circumferential dressing.



Day 17, NPWT day 14: Wound ready for closure. A soleus muscle rotation flap is created and a split-thickness skin graft applied, which is initially stabilized by NPWT until the whole graft is in place due to being initially elevated in several places.



Six months: Good healing of the wound.

NPWT application in calciphylaxis

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A 62-year-old female with calciphylaxis, displaying a large area of necrosis of the left trunk.

Patient anamnesis

A 62-year-old obese female with insulin-independent diabetes mellitus, chronic renal failure and cardiovascular atherosclerosis after a coronary artery bypass graft for a previous myocardial infarction was referred to our hospital in February 2015 because of a lack of dialysis facilities at the original hospital. The patient was first seen in December 2014 with painful nodules, indicating livedo reticularis. Calciphylaxis was diagnosed from biopsies and medical history.

Wound anamnesis

The patient had a large necrotic defect (20–25x15 cm) on the left side of her trunk, with gangrene down to the adipose tissue, but not into the fascia. Laboratory tests indicated a high white blood cell count and C-reactive protein, and slight anaemia. The nutritional indicator albumin was 24.4 g/l and transferrin 0.65 g/l. The complex therapy was maintained. After a further 5 days, the necrosis was spreading to the central parts of the abdominal wall.

Aim of the treatment

Negative pressure wound therapy (NPWT) to treat a large necrotic wound in calciphylaxis.

Wound treatment

The patient underwent dialysis 5-times per week and was given intravenous sodium thiosulphate as an antioxidant and vasodilator, although mainly to bind calcium as calcium sulphate for dialytic removal. Oral sevelamer carbonate was given daily as a phosphate binder. Following the standard recommendation, surgical treatment was restricted to gentle necrectomy. Wet-to-dry, hydrocolloid and hydrogel dressings were applied. Sterile-maggot therapy was ineffective, possibly because the maggots were restricted to small nets within a large wound. Systemic antibiotic therapy was commenced, based on the biopsy

cultivation results, with *Klebsiella* and *Pseudomonas aeruginosa* present. Hyperbaric oxygen (HBO) therapy was applied and nutritional consultation was sought regarding restricting calcium and phosphate. However, the necrosis continued to expand, including to the right side of the trunk, although, on debridement, the necrotic tissue the wound base was clean. The necrosis had stabilised after a month of hospitalisation with HBO therapy, dialysis and drug administration. Wet-to-dry dressings with peracetic acid solution were applied. At the start of the second month of hospitalisation, there was some necrosis biofilm. NPWT was commenced using the Vivano system, with the wound presenting granulation with some marginal necrosis. After 5 days, the wound improved, became retractive with less biofilm and necrosis. Unfortunately, the patient elected to discharge herself; thus, NPWT was discontinued. The renal reflux functions were stable, the inflammatory tests had improved and the anaemia was more restricted. During hospitalisation, gastroscopy indicated no bleeding. Despite recurrent chest pain and a history of ischaemic cardiac disease, the cardiology results were normal. Ultrasonography and computed tomography together with a high oncological marker indicated a possible ovarian tumour, for which gynaecological testing was performed. The patient's wound was dressed at home using microdacyn solution and gel, with out-patient check-ups, and the wound continued to improve. The patient was re-hospitalised in the Department of Internal Medicine, 4 months after the original transfer to our hospital, for decompensation of diabetes and with inflammation of unknown origin, with the abdominal wall being clean. Unfortunately, the patient suffered a pertrochanteric femoral fracture following a fall, for which immediate osteosynthesis was considered to be very risky. The patient suffered cardiopulmonary failure. Despite artificial ventilation, resuscitation was unsuccessful.

Conclusion

It would have been preferable to have commenced NPWT earlier; however, this was difficult with concurrent dialysis at our hospital and HBO with the

chamber 20 miles away at a different hospital. Even with the restricted NPWT application as part of the complex therapy in calciphylaxis, it appeared encouraging in stimulating healing of a large wound.



Day 5 after transfer to our hospital: Large necrotic defect (20–25 × 15 cm) of the left side of the trunk with gangrene down to the adipose tissue, but not into the fascia.



Day 15: The extent of the necrosis initially expands, reaching the right side of the trunk. Gentle necrectomy reveals that the wound base is clean.



Day 29: A month after hospitalisation, the necrosis was stabilised



Day 56: On commencement of NPWT using the Vivano system, the wound presents with biofilm, some marginal necrosis and granulation.



Day 61: NPWT is stopped because the patient discharged from the hospital. The wound is improved, being retractive with less biofilm and necrosis.



Day 91: Following discharge, the patient's wound is dressed at home using microdacyn solution and gel, with out-patient check-ups. The wound continues to improve

Which filler to use in NPWT; foam versus gauze?

Marco Fracalvieri

Plastic Surgery Unit, ASO Città della Salute e della Scienza di Torino, University of Turin, Italy

The role of the wound filler in negative pressure wound therapy (NPWT); foam versus gauze.

Currently, two forms of filler are employed in NPWT in our hospital; hydrophobic PU foam (polyether type) and gauze, for example, contour gauze primarily permeated with the antibacterial polyhexamethylene biguanide (PHMB). When deciding which form to use, four selection criteria can be considered, as discussed below.

Wound morphology

Both foam and gauze can be used in a superficial or deep uniform wound, whereas in irregular or undermined wounds, the complex wound shape and the lack of shape memory of gauze favour its use. In a large acute wound, “bridging therapy” can be applied using foam because the high negative pressure (NP) can cause major disruption. With a very deep wound, foam provides more rapid and thicker granulation formation in comparison with gauze. In a mixed wound, for example, a deep wound with undermining, foam and gauze can be combined.

Wound characteristics

To manage a large amount of exudate, a high NP level is required, favouring foam. However, a high NP can exacerbate an existing ischaemia. Therefore, gauze would be preferred for compromised vascularity or a “circumferential” wound in using a lower NP.

Patient pain feedback

In a single-blind interview study, we found that the level of patient-reported pain on dressing removal was statistically significantly higher for foam than for gauze ($p = 0.046$). The ingrowth of granular tissue into the foam micropores leads to greater pain on removal. Additionally, the higher NP normally applied when using foam can lead to major micro-contractions. Therefore, foam can be recommended for neuropathic and paraplegic patients. In contrast, for low-compliance patients, including children and

much older patients, and for those with a very painful wound (e.g. pyoderma gangrenosum), gauze would be better.

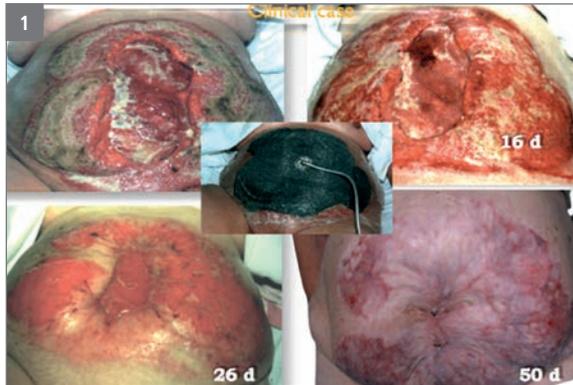
Scar tissue

Granulation tissue from gauze-based NP is smooth while that from PU foam-based NP is patchy because of the micropores. We investigated whether macroscopic differences were reflected at the microscopic level. Haematoxylin eosin staining for inflammatory cells and monoclonal antibodies to detect myofibroblasts and blood vessels showed no difference between the filler types. However, using gauze, the vessels were more rounded, whereas with polyether-type foam they were more flattened, indicating tissue that was more fibrotic. The scar tissue itself was more pliable using gauze. Use of a high-frequency probe and ultrasonography to compare the reconstructed tissue with that of contralateral healthy tissue showed that, with gauze, the scar displayed a similar structure and thickness, while the tissue where polyether-type foam was used was thicker and more fibrotic and disorganised. The addition of a contrast agent showed more vessels in the upper layer with gauze. Staining the biopsies gave the same results for tissue condition and vessel content. Immunostaining indicated higher levels of vascular endothelial growth factor (VEGF) and matrix metalloproteinase 9 (MMP9) with gauze. VEGF is important in angiogenesis, with MMP9 contributing to angiogenesis through degradation of the capillary basement membrane, while also being involved in scar remodelling, reducing scarring and leading to more organised and “normal” tissue. Therefore, when a wound is located where functionality is essential, gauze is recommended. As to whether the filler or the NP level is more important; when using foam with a lower NP of -80 mmHg and gauze with a higher NP of -125 mmHg, the results remained the same.

Conclusion

When deciding which filler is most appropriate, the wound morphology and characteristics and the

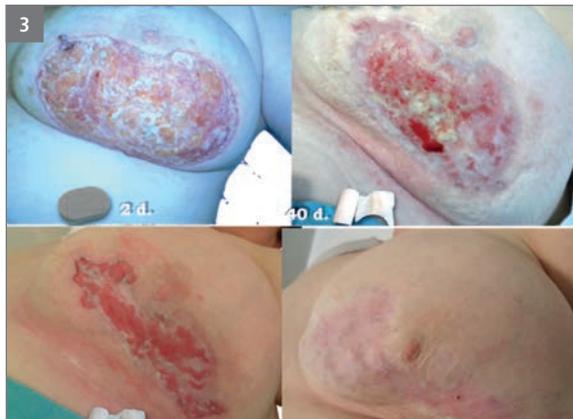
patient's pain feedback have to be considered, as well as, most importantly, the anatomical area involved in the reconstruction.



Large acute wound: A 67-year-old female with necrotizing fasciitis. "Bridging therapy" was applied using foam.



Mixed wound: A 55-year-old female with a complex wound with undermining. Combined application of gauze and foam. Good granulation tissue formation allows grafting.



Painful wound: A 60-year-old female with pyoderma gangrenosum lesion, who, 10 years previously, had been successfully treated for cancer with radiotherapy. Antibiotic treatment failed and after 2 days of foam-based NPWT, the patient requested foam removal because of intense pain. NPWT re-commenced using gauze, leading to successful healing. V.A.S.: visual analogue scale.



Granulation tissue: With gauze-based NPWT, the granulation tissue is smooth while, with foam-based NPWT, it is patchy because of the micropores of the foam.



Scar tissue: The skin graft feels more pliable with gauze-based NPWT than with foam-based NPWT. This is related to the thinner and more ordered scar tissue with gauze.



Anatomical area: A 71-year-old female with a major wound on the inner thigh. Here, a functional result is essential to allow good recovery of movement. Therefore, in order to obtain tissue that is as "normal" as possible, gauze-based NPWT is recommended.

NPWT in a rehabilitative hospital setting

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Is there a need for negative pressure wound therapy (NPWT) in a rehabilitative hospital setting and are there any benefits?

Background

Because geriatric medicine in general has to deal with patients older than 70 years, polymorbidity means, that treatment must take into consideration simultaneously a broad range of acute disabilities, malfunctions as well as various chronic disorders. Three questions should be considered as whether to apply negative pressure wound therapy (NPWT) in the rehabilitative (rehab) hospital setting: 1) Is there a benefit for the rehab patient with a wound-healing problem? 2) What prerequisites are necessary to perform NPWT in a rehab setting on a "state of the art" level? 3) Is there a financial incentive for the rehab-centre? In this context, we highlight three examples of "every-day" patients that we encounter in the rehabilitative hospital setting.

Patient anamnesis

Patient No. 1 was a 72-year-old male who had undergone percutaneous coronary intervention and postinterventionally developed acute obstruction of the arteria femoralis communis. The patient underwent emergency thromboendarterectomy and patch plastic. Patient No. 2 was a 74-year-old female referred to the acute medical department for inpatient treatment of diabetic foot syndrome. Patient No. 3 was a 71-year-old male with peripheral arterial obstructive disease (pAOD), who underwent percutaneous transluminal angioplasty of the arteria poplitea and minor amputation (2nd toe) on the left side. During acute treatment, the patient fell and suffered a femoral neck fracture on his right side.

Wound anamnesis

In the course of multiple surgical revisions, Patient No. 1 developed deep wound infection, which progressed to a deep multi-layer inguinal tissue defect, consecutively he was transferred to geriatric-rehab. Patient No. 2 had a superinfected 4th grade diabetic

ulceration of the left heel. Patient No. 3 with pAOD developed a necrotic pressure ulcer at the right foot sole following hip prosthesis implantation which became superinfected after the patient was transferred to geriatric-rehab.

Aim of the treatment

Application of NPWT to problematic wounds in geriatric patients.

Wound treatment

Open wound treatment of Patient No. 1 failed to improve the healing process within 2 weeks, thus NPWT was initiated. NPWT achieved rapid results by inducing an ongoing secondary woundhealing process and eliminating infection while a full range of rehabilitative therapy could be performed. After 5 weeks, the patient was transferred to ambulant care with ongoing NPWT. NPWT was terminated and open-wound therapy was applied until secondary healing was complete the following month. 2 weeks after acute inpatient treatment, Patient No. 2 was first dismissed to ambulant care with no significant improvement of the heel ulcer and subsequently admitted to geriatric-rehab. Thorough necrosectomy of the ulcer was performed and NPWT applied for 4 weeks. NPWT greatly improved the wound bed, inducing granulation and promoting epitheliasation, thus allowing a switch to ambulant open-wound care. Again, in the course of NPWT, a full range of rehabilitative therapy could be applied. In patient No. 3 fractional necrosectomy of the ulcer was performed and open wound therapy applied. NPWT was then initiated, however within 7 days no significant improvement could be achieved, NPWT was stopped, the vascular condition was reevaluated and the patient was transferred to a vascular surgical department for interventional therapy of the pAOD.

Conclusion

NPWT can be very beneficial for rehab-patients with wound-healing problems, provided that an adequate assessment, a professional management and follow-up and a patient compliance is guaranteed. Further prerequisites in the rehabilitative setting are compassion, significant commitment to the patient, expertise in treating chronic wounds and adequate

technical support in regard of the required equipment and materials, including expert knowledge from outside when needed. Although no immediate financial incentive can be claimed for, long-term savings can be found in reduction of the workforce costs, the frequency of dressing changes and the period of dressing required.



Patient No. 1: Deep multi-layer inguinal tissue defect after PCI



Patient No. 1, NPWT: Day 14 (left) and day 35 (right). NPWT achieves rapid results, inducing an ongoing secondary wound-healing process and eliminating infection.



Patient No. 2: Diabetic foot syndrome with superinfected 4th grade diabetic heel ulceration.



Patient No. 2, NPWT: After necrosectomy NPWT greatly improves the wound bed and induces very good granulation (right: day 24).



Patient No. 3: necrotic pressure ulcer at the right foot sole (left) on which initially necrosectomy and open wound therapy was applied (right).



Patient No. 3, NPWT: NPWT for 7 days achieved no significant improvement due to a 4th grade pAOD.



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