Optimising the use of traditional NPWT in plastic and reconstructive surgery

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Negative pressure wound therapy (NPWT) has been widely adopted for a broad range of wound indications in both the inpatient and outpatient setting since its introduction in clinical practice in the 1990s (Bobkiewicz et al, 2014). An expert international panel of specialist surgeons with a high level of experience of NPWT in plastic and reconstructive surgery (PRS) convened to discuss the appropriate use of NPWT in this specialty. Throughout the course of the panel meeting, they were encouraged to identify the limitations, cautions, contraindications and advantages of NPWT usage in PRS.

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Negative pressure wound therapy (NPWT) is a concept that has been around for more than 20 years and is used for the treatment of various wounds, including traumatic, hard-to-heal and chronic wounds, as well as wounds (which will secondary cover) with flaps and/or skin grafts (World Union of Wound Healing Societies [WUWHS], 2016).

In terms of the evidence base surrounding NPWT use in PRS, Krug et al (2011) explained that while there was "an enormous number of Level 3 studies describing the safety and efficacy of [NPWT], there is a relative paucity of comparative studies including randomised clinical trials" (to our knowledge there is only one). For this reason, expert consensus becomes a vital part of producing effective recommendations, with PRS no different in this regard.

Krug et al's (2011) evidence-based recommendations for NPWT use in traumatic wounds and reconstructive surgery were developed during a number of meetings between the members of the NPWT-EP over a period of 6 months, with a total of 12 recommendations developed; four relating to soft tissue trauma and open fracture injuries, four for skin grafts, three for flap and one for burn injuries. Eleven of the 12 recommendations were accepted after reaching the 80% agreement threshold *[Box 1]*.

Aims of the expert panel

An expert panel of surgeons specialising in PRS from across Europe gathered in Budapest, Hungary, on September 10, 2019, for the LINK Wound Healing Congress 2019. The group drew on their own experiences and current literature to discuss and debate the contraindications and limitations of NPWT, as well as indications and advantages of NPWT in PRS.

Contraindications, cautions and limitations of NPWT plastic and reconstructive surgery (PRS)

A key area of focus was the potential contraindications of NPWT in PRS. The literature cites contact, infection, bleeding, malignancy, allergy and other (ischaemic wounds, fragile skin, non-enteric and unexplored fistula) as contraindications (Novak et al, 2014). Depending on the specialist's level of experience, the use of NPWT can be adapted even in the instance of contraindication, which was deemed to be a 'caution'. In critical cases, a multidisciplinary approach to treatment is recommended.

Contraindications may include: osteomyelitis, allergies, untreated coagulopathy, the presence of cancer/metastasis (if direct contact with the NPWT), critical ischaemia, untreated infection, necrosis and direct contact to cerebrospinal fluid (CSF).

In terms of malignancy, anecdotal evidence suggests that NPWT could be used in palliative care (e.g. for a breast cancer patient) with positive results. It was agreed that malignancy should not be considered a strict 100% contraindication. Numerous other potential

Box 1. Tips for NPWT use in wound management (adapted from Krug et al, 2011).	
NPWT may be used when primary closure is not possible after or in between debridement's as a bridge to definitive closure (Grade C)	Agreement in consultative phase — 98%
NPWT may be used as a method to downscale the complexity of reconstruction (descend the reconstructive ladder) (Grade C)	Agreement in consultative phase >80%
NWPT may be stopped when delayed surgical closure is possible (Grade C)	Agreement in consultative phase >80%
NPWT may be used to improve the healing of fasciotomy incisions (Grade C)	Agreement in consultative phase >80%
NPWT should be considered when primary closure is not possible after or in between debridement's as a bridge to definitive closure (Grade B)	Agreement in consultative phase — 99%
NPWT may be used to downscale the complexity of closure procedures (Grade C)	Agreement in consultative phase 94%
NWPT should be stopped when delayed surgical closure is possible (Grade B)	Agreement in consultative phase >80%
NPWT may be beneficial at preventing burn wound progression (Grade C)	Agreement during consultative phase 66%; *Recommendation rejected*
It is possible to use NPWT as a treatment for flaps, which have suffered partial necrosis after debridement of necrotic tissue (Grade D)	Agreement in consultative phase — 88%
Expert opinion recommends significant caution in applying NPWT to newly planted or compromised flaps (Grade D)	Agreement in consultative phase >80%
It is possible in flap surgery to use NPWT to manage secondary (donor site) defects which cannot be closed primarily (Grade D)	Agreement in consultative phase >80%
NPWT must be considered to improve the rate of graft success (Grade A)	Agreement in consultative phase >80%

contraindications could in fact be classed as a caution, rather than a contraindication:

- Presence of malignancy (tumors). The recommendation is to ensure the absence of any cancerogenic tissue to avoid neoplasm expansion
- NPWT may have a palliative use in case of post-tumoral wounds to stabilise the closure
- Exposed vascular tissue
- Exposed peripheric nerves (with the use of an interface)
- Use in neonatals/paediatrics (with a diminution of the depression level)
- Systemic infections with or without sepsis: depending on specialist experience, NPWT can be applied, including patients with peritonitis.

On the issue of contraindications and cautions, in particular following reconstructive surgery, positive results had been experienced when using NPWT in this patient group, although some perfusion issues were noted. During the discussion, the panel decided that studies involving NPWT use on brain tissue are needed. It was agreed that NPWT use on neurological tissue, such as directly to the brain or spinal cord, should be avoided. In terms of critical ischaemia, the panel decided to label this a contraindication, as NPWT cannot replace surgical vascularisation, which should be the first treatment whenever possible.

When the subject of infection was discussed by the panel, it was agreed that NPWT should be thought of as a 'dressing', not as a replacement for any other treatments. While debridement's role in wound management when infection is present is key, it could be argued that NPWT can be effective when used after debridement. There was agreement across the panel that untreated systemic infection should be a contraindication.

The issue of limitations when using NPWT is also debatable. Ischaemia should be a key consideration, and as a rule higher negative pressures should be avoided as it may worsen ischaemia. In addition, when tissue is exposed, NPWT should be avoided if other more suitable methods are available, as it should be when fractures are exposed where periosteum is missing. Patients with third degree burns represents another limitation, with NPWT indicated once any necrotic tissue is removed.

Case 1

Figure 1a: NPWT initiated.

Figure 1b: +5 days NPWT and +4 days Grassolind dressings.

Figure 1c: Final assessment.

Case 2

Figure 2a: Initial assessment.

Figure 2b: NPWT initiated.

Figure 2c: +23 days after autodermoplasty.

Case study presentations

Indications and advantages of NPWT in PRS are demonstrated by case studies involving the use of Vivano® (PAUL HARTMANN AG).

Case 1 (Sidonia Susanu)

The first case focused on the role of NPWT in the treatment of severe trauma in a 7-year-old girl who had been involved in a traffic accident *[Figure 1]*. The patient had suffered both a left and right tibial shaft fracture, a degloving injury to the right leg, a left knee joint opening, internal femoral condyle fracture, left ankle and foot degloving injuries, opening of the left foot joints, posterior tibial artery rupture at the ankle level and a left forearm fracture.

The wound was necrotic, with an excess of oedema. The patient was transferred from another hospital so early intervention was not possible. The NPWT pressure applied was -85mmHg (this would be lowered to -25mmHg rising to -60mmHg for a baby).

The use of NPWT in this case resulted in a smaller amount of bandage changes, easier wound management, more precise appreciation of fluid loss, enhanced immobilisation of skin grafts with higher graft intake and expedited hospital discharge. She praised NPWT for being an excellent tool in managing paediatrics with severe trauma. In this case, it enabled a much better functional and aesthetic result for the patient.

Case 2 (Alena Kolke, case courtesy of Dr. Vyacheslav Zavatskiy)

This was a 77-year-old female with peripheral arterial disease (PAD) and critical limb ischaemia.

Box 2. Tips for NPWT use in wound management.

- Use a pressure to not exceed -60 -65 mmHg
- Adapt always the pressure level
- Use white sponge
- Use interfaces (silicones, paraffin, polyester, etc serve as a non-adherent barrier dressing).

Case 3

Figure 3a: Initial assessment.

Figure 3b: NPWT initiated.

Figure 3c: +5 months after plastic reconstruction.

Case 4

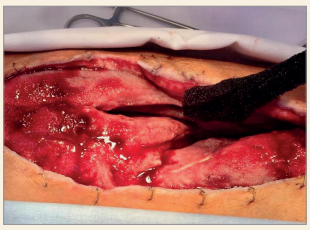

Figure 4a: Initial assessment.

Figure 4b: NPWT initiated.

Figure 4c: +50 days of treatment.

NPWT was applied in continuous mode at -80mmHg and free autodermoplasty with perforated NPWT stabilised the graft. At first, angioplasty was carried out on the arteries of the right lower extremity with the installation of one stent, followed by hydrotherapy and surgical debridement. After 46 days, tangential excision of granulation tissue and free autodermoplasty with perforated NPWT was performed to stabilise the graft *[Figure 2]*. The graft was protected by Atrauman® Silicone.

Case 3 (Alena Kolke, case courtesy of Dr. Vyacheslav Zavatskiy)

This 64-year-old female presented with PAD and diabetic foot syndrome. She had diabetes mellitus type 2 and past medical history included amputation of the 1st and 2nd fingers of the right foot. At first, the hybrid reconstruction of the right lower extremity arteries was carried out. On the third day, after revascularization, sanitation of the right foot was carried out for transmetatarsal amputation and the mobilisation and transposition of the created plantar flap and shelter of the metatarsal bonesaw-line. In this case, NPWT was used both at the preparation of the wound stage and at a stage of combined plastic reconstruction used. A transmetatarsal amputation of the right foot took place on January 26, 2019 and NPWT was applied in continuous mode with level of negative pressure -110 mm Hg with changed in intermittent mode -120/80 mm Hg. After 28 days, the wound was prepared for plastic closure. It was made plastic by local tissues and free autodermoplasty with NPWT stabilization. The graft was protected by Atrauman® Silicone. NPWT was applied in continuous mode 80 mm Hg for 4 days *[Figure 3]*.

Case 4 (Alena Kolke, case courtesy of Dr. Vyacheslav Zavatskiy)

This case centred on a 34-year-old male with a trauma wound and dislocation of the knee joint with a complete separation of the popliteal artery and a vein, which formed an intense hematoma of the left femoris and surae. His left lower extremity was experiencing ischemia for more than a day. He received prosthetics for the left popliteal artery. In an early post operate period, multiple mosaic necrosis of the muscles formed in all parts of the affected surae, with subsequent multiple sanitation and the formation of an extensive wound defect of the back surface of the surae. Considering the rigidity of tissue of the postoperative wound and the need for a full-layer restoration of the integrity of the given area, for the purpose of a maximally protect for the prosthesis popliteal artery, a gradual dosed tension of tissue was carried out in combination with NPWT in the intermittent -120/80 mm Hg *[Figure 4]*.

NPWT in these three cases prevented the development of sub-flap haematomas, stabilised numerous tissues and was effective in reducing exudate.

Case 5

Figure 5a: NPWT initiated.

Figure 5b: Healing by secondary intention.

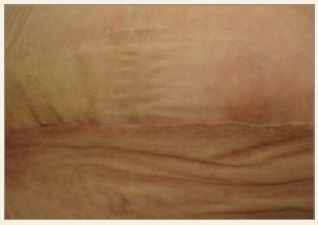

Figure 5c: Wound closure.

Case 6

Figure 6a: Initial assessment.

Figure 6b: NPWT initiated.

Figure 6c: Healing by secondary intention.

Figure 6d: Wound closure.

Case 5 (Csaba Halmy)

This case focused on temporary wound closure in the surgical treatment of panniculus morbidus. The patient was at the end stage of abdominal obesity, had difficulty moving, problems with personal hygiene, oedema and lymphoedema, cellulitis, exanthema, abdominal wall elephantiasis, ulceration and infection. Evidence from Friedrich et al (2008) supports the use of NPWT in such cases. In the presented case, the decision was taken to resect the panniculus morbidus and closure was provided by a three-layer running suture in the middle and by NPWT at the lateral ends of the incision. Wound depth gradually decreased at the NPWT treated areas and eventually they were left to heal by secondary intention *[Figure 5]*.

Case 6 (Bartosz Cybulka)

This case centred on Fournier necrotising fasciitis, which is a rare infectious disease that affects the perineum, scrotum, buttocks, rectum, anus and genitals. The incidence rate is 1.6 per 100,000 people with an associated mortality rate of 20%–30% (Stone and Martin, 1972). The patient in Bartosz's case was a 48-year-old male with a history of diabetes, a fever and severe local symptoms, in tandem with Fournier necrotising fasciitis. A decision was taken to apply NPWT on the patient after an extensive, aggressive surgical debridement with necrosectomy, as well as evacuation and gravitational drainage of the abscess cavities. In addition, empirical broad-spectrum antibiotic therapy was initiated, as well as a left-sided orchiectomy due to inflammatory and necrotic changes affecting the testicle.

After 12 days of dressing treatment, NPWT was initiated at -125mmHg and after 29 days of NPWT treatment, there was a visible reduction of the wound surface. Normal, metabolically active granulation was visible at the base of the wound. The patient was discharged with full wound healing and the total treatment time for gangrene was 52 days, including 29 days of NPWT usage *[Figure 6]*. In this case, use of NPWT resulted in a shorter hospital stay, with this therapy effective in managing a complex wound.

Case 7 (Franck Duteille)

This was a 6-year-old female who had experienced trauma due to a traffic accident, suffering a defect to the dorsal part of the foot. The decision was taken to delay flap and continue with NPWT after this therapy had enhanced the formulation of granulation tissue *[Figure 7]*. The decision tree was amended as a result of this case, due to the success of NPWT meaning that other techniques were not needed.

Advantages of NPWT in PRS

Advantages of NPWT in PRS were agreed to include:

Case 7

Figure 7a: Initial assessment.

Figure 7b: NPWT continued.

Figure 7c: 1-year follow up.

- Expedited healing times
- Reduced hospitalisation
- Reduced costs in wound management
- Preparation of the wound bed for further medical procedures
- Reduced pain
- Early recovery, resulting in delay of other surgical decisions (e.g. flap procedure cancelled due to good evolution under NPWT)
- Reduced number of products required
- Effective wound management
- Reduced inflammatory response
- Enhanced granulation tissue formation
- Reduced wound depth
- Easy to manage versus dressings in difficult anatomic locations
- Removal of necrotic tissue and of exudate in excess
- Reduced risk of bacterial colonisation/ contamination
- Allows calculation and adaptation of necessary negative pressure to be applied
- Reduction in number of dressing changes (NPWT may be changed every 48–72 hours).

Conclusions

NPWT in PRS was agreed to enhance the quality of tissue, as well as facilitating stabilisation of the tissue. NPWT facilitates further surgical procedures, such as HydroTherapy with HydroClean® and HydroTac® (both HARTMANN AG), as well as securing grafts and reducing oedema. NPWT has been shown to prevent sub-flap haematoma, reduce wound size and depth, and prevent amputations. It helps in bringing edges together and preventing high surgical risk, including in patients with obesity, diabetes and smokers). NPWT can also be used in wounds with critical locations, such as cranio-facial applications.

Multiple wound types can benefit from NPWT and it was agreed that it should be made available to all reconstructive surgeons. The general conclusion of the expert panel was that in PRS Departments and Clinics, NPWT availability is absolutely necessary and its use should be regarded as first intention. The quality of life (QoL) of the patient should never be forgotten during the process of initiating NPWT treatment, with a reduction in pain a key factor in improving QoL for patients. WINT

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