

Negative pressure therapy with instillation, dwell time and an open cell foam dressings in complex vascular patients: a case series

KEY WORDS

- » Chronic wounds
- » Instillation
- » Negative pressure wound therapy
- » Slough
- » Vac therapy
- » Wound healing

Background: In our unit, we routinely use negative pressure wound therapy (NPWT) with either gauze or sponge as the interface and have observed that slough can build up over time, in specific wounds, with use of NPWT. Slough and biofilm build-up can slow healing of diabetic foot ulcerations, postoperative femoral bypass infections, leg ulcers and wound dehiscence. **Aim:** Our aim was to determine the impact of NPWTi-d on wounds which failed to respond to standard treatment and those who could not have surgical debridement in theatre because of their comorbidities. **Method:** We assessed the wound bed response, length of hospital stay and pain, in vascular patients with a range of wound types. The NPWTi-d and V.A.C. VeraFlo Cleanse Choice dressing were used to treat wounds for an average of seven days. Wound size and wound beds well as pain were assessed daily by a wound care specialist. Pain was recorded on a validated pain scale 1-10 visual analogue scale (VAS). **Results:** Improved wound bed preparation was shown using the silhouette photography system in all five patients in the evaluation. Theatre and surgical debridement was avoided in all cases. There was a significant pain reduction associated with treatment in 4/5 patients. Dressing were changed on average three times with digital photography taken before and after. **Conclusion:** NPWTi-d improves wound bed preparation, healing and pain in wounds that fail to improve with standard treatment. This case series demonstrates the benefit in adopting this as an option in the treatment of complex vascular wounds. It also highlighted a need for more research for example; type of instillation fluid, plus optimal volume and dwell times.

In the vascular department, surgical site infections (SSI), and subsequent vascular infections near or in graft sites are considered a very serious complication. In patients with groin infections that includes a graft, the mortality rates are reported as high as 52–58% (Lakhiani et al, 2019). Due to multiple comorbidities and older age, these patients are at high risk of requiring further surgical debridement. In order to create a viable wound bed it became apparent that we needed to explore other non-surgical options to achieve healing. This case series is designed to determine if the V.A.C. VERAFLU Cleanse Choice can prepare the wound bed for healing and/or skin grafting in the management of complex vascular wounds. The

negative pressure wound therapy (NPWT) system we currently use is appropriate in less complex wounds, however, the wounds in this case series would normally not respond to standard NPWT due to thick slough, as well as necrotic and non-viable tissue over the wound bed. These wounds would generally require surgical debridement to remove the biofilm and slough (Sibbald et al, 2011).

A review of the literature was conducted for all papers including randomised controlled trials (RCT), case series and case presentations between January 2013 and January 2020 using the search terms "NPWTi-d therapy units and open-cell foam dressing" and "vascular surgical site infections". The articles were then reviewed and

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grouped into evidence strength depending on the number of participants and study design. In 2015 an expert panel prepared recommendations and a best practice document (Kim et al, 2015a). The recommendations from this group were developed to help health professionals worldwide understand the changes that had occurred since NPWT dressing systems were upgraded in 2013 to include instillation therapy. In 2016 a novel open cell reticulated foam V.A.C. VeraFlo Cleanse Choice dressing with 1cm² channels in a wound contact layer was introduced. Studies have shown how the wound bed is accessed by the instillation fluid, as the wider holes allow a better interface with the wound bed. The channels also enable the mechanical disruption of thick slough and the movement of debris to the second contact layer. Use of automated instillation, to instil fluid into the wound and allow it to soak for a pre-set period of time then re-vacuum, is considered advanced therapy, it differs from the traditional NPWT, where continuous vacuum is used. The proposed outcome is a cleaner wound bed, allowing the non-surgical removal of non-viable tissue, which can accelerate healing (ClinicalTrials.gov, 2015). Since its introduction, published case reports have demonstrate the positive impact NPWTi-d can have on wound healing (Lakhiani et al, 2019; Kim et al, 2015a). There are other uses for the NPWTi-d that include antibiotic therapy instilled directly by the system to an infected graft (Lakhiani et al, 2019), which may prevent more invasive treatments such as bypass surgery (Lakhiani et al, 2019).

Although NPWTi-d systems were available, they were not routinely used until the updated system was released in 2010 in the US, and 2013 in New Zealand. A retrospective study that compared instillation of normal saline with polyhexanide (polyhexamethylene biguanide, PHMB) solutions, in 142 hospital patients with chronically infected lower leg ulcers. They found no difference in the primary outcome which was healing rates, however, those on NPWTi-d had a shorter treatment time compared with standard NPWT therapy (Kim et al, 2014). Limitations to this study include the different sponges used that may have affected treatment time and healing.

There is growing interest in NPWTi-d and the

management of complex wounds especially within specialities and for wounds such as venous leg ulcers (VLU) and diabetic foot ulcers (DFU; McElroy, 2019; Obst et al, 2019). A case report of an infected infrainguinal arterial bypass prosthetic graft in a 78-year-old following complex vascular surgery, described the use of rifampin as the instill fluid, which aided wound healing (Lakhiani et al, 2019).

In another report, a patient with critical limb ischaemia, who had undergone a femoral popliteal bypass surgery, developed an infected prosthetic graft. The patient had a complex vascular and cardiac history preventing further surgery. Treatment was using NPWTi-d with the Cleanse Choice dressing. The authors found that the NPWTi-d can be an alternative when further surgery increases the risk of mortality, especially in this high-risk group. Of interest, the fluid amount needed for the instillation was calculated based on wound depth and wound circumference (Kim et al, 2018)

There is a need for further research to inform clinical guidelines for NPWTi-d V.A.C. Ultra instillation. The system contains a new grey foam, Cleanse Choice, a polyurethane ester foam dressing that is less hydrophobic than standard NPWT foams. The grey foam has bigger holes on the contact layer to allow more contact between the solution and the wound bed including the slough and necrotic tissue.

The benefits of NPWTi-d with the grey foam dressing are the facilitated removal of debris and microorganisms from the wound bed, dilution of inflammatory and cytotoxic organisms that prevent wound healing by constricting blood flow and inhibiting cell migration, wound hydration, removal of excess fluid and increase production of granulation tissue. Instillation is thought to lower fluid viscosity, making it easier to clean and wash the wound bed. Frequent debridement inhibits matrix metalloproteinases and breaks up glycocalyx that causes biofilm to form (Driver et al, 2016; Gilbert et al, 2016).

Aims

The following vascular case studies present postoperative wounds that were either covered in thick slough or necrotic tissue, and would normally require sharp debridement to promote healing.



Figures 1. NPWTi-d with grey foam dressing for right groin wound. a) Day one before starting b) NPWTi-d in progress and c) 48 hours of NPWTi-d slough removed

METHODS AND MATERIALS

Informed consent to use the NPWT system and for photography was obtained from the patients, information was given about the system, the consent form also included permission to use any images for education, research and publication. Photos were taken before, during and after treatment.

The V.A.C. Ultra instillation system (NPWTi-d) with Cleanse Choice dressing was used in all the presented cases. Before application the surrounding skin was dried and prepared with cavilon skin wipes. The open reticulated cell foam dressing was cut to the size of the wound and placed onto the wound bed.

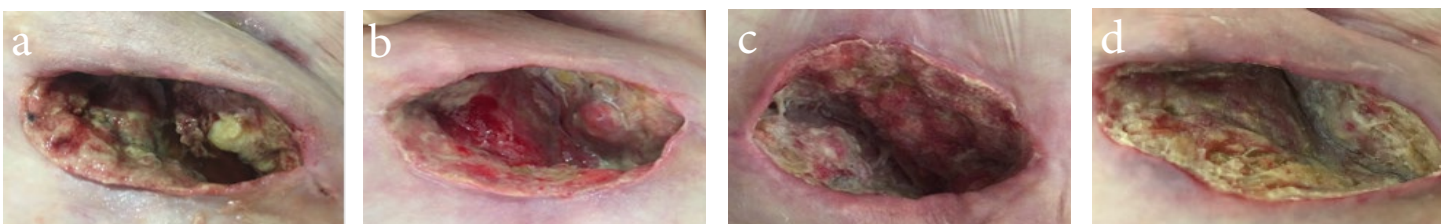
Prontosan instillation fluid was used, the amount determined using a depth x width x 10 of the wound bed calculation. Cycles were set on 3 ½ hourly vacuum at -125mmHg with non-vacuum dwell time of 20 minutes. To measure perceived pain level the visual analogue scale (VAS) of 1–10 was used; 1 being no pain and 10 being the most pain experienced (Price et al, 1983; Melzacket al, 1993).

RESULTS

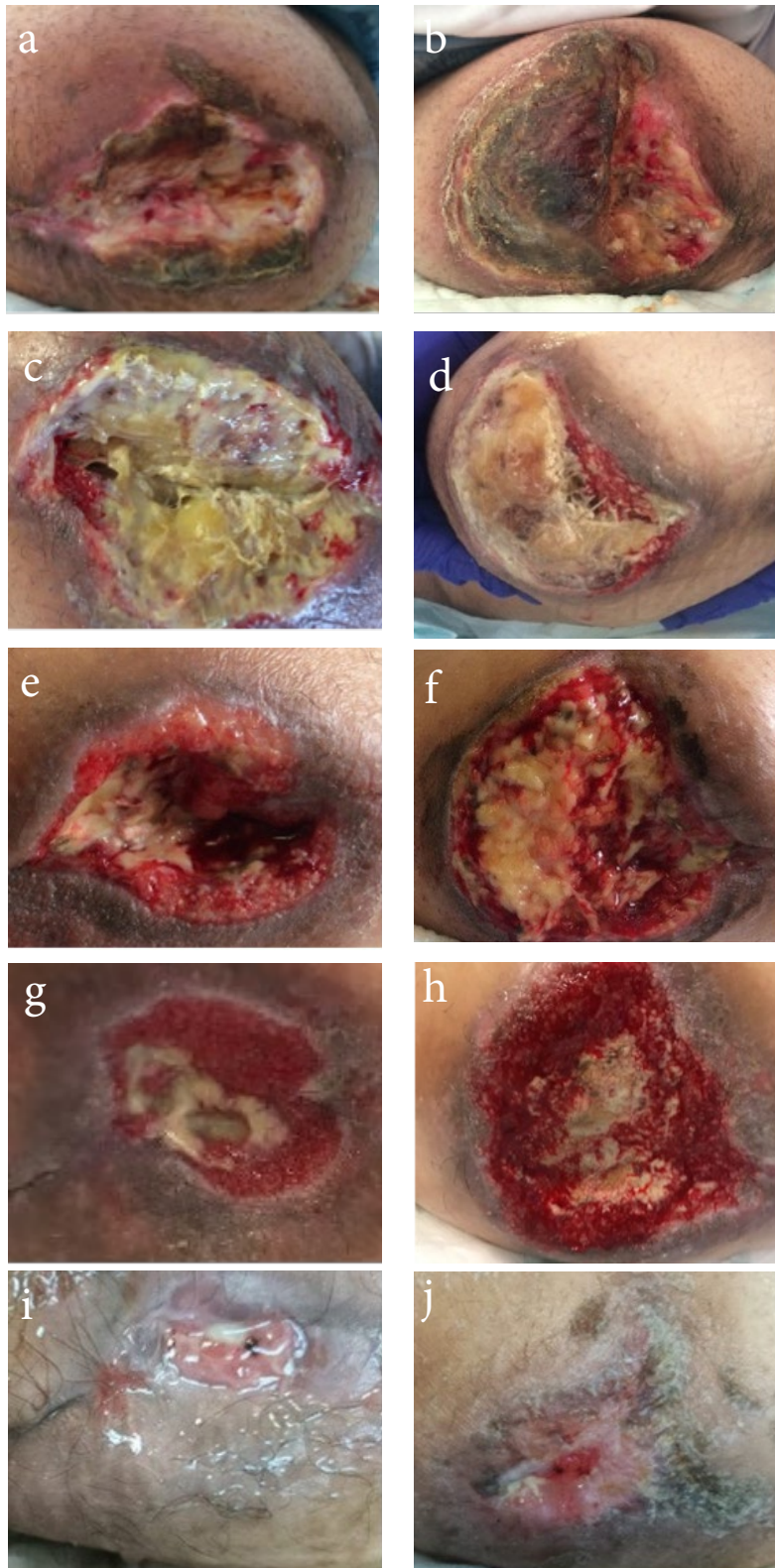
Case 1

A 79-year-old male presented as an acute admission for femoral endarterectomy patch haemorrhage. He had a past medical history of a right femoral endarterectomy for critical limb ischaemia, with patch repair and angioplasty of distal external iliac to proximal superficial femoral artery and stent.

The patient was sent to surgery for right femoral artery exploration, repair and patch of graft. While in surgery, skin necrosis was noted and ischaemic tissue was excised down to healing tissue. The track extended to the bovine patch. Initial postoperative wound management included daily wound washouts with betadine. Instillation was started with the NPWTi-d with the grey foam dressing and Prontosan solution (Figure 1). The instil amount was 20mls with cycle 3 ½ hours with dwell time of 20 minutes. Pain was reduced significantly from VAS 10/10 with daily washes to 0/10 after 48 hours. Wound healing progressed quickly, however there was fresh bleeding from the wound site on postoperative day six. Therapy was stopped and the patient proceeded to angiogram and stenting.



Figures 2. NPWTi-d with grey foam dressing for right groin wound. a) Before NPWTi-d, b) at the first dressing change after 48 hours NPWTi-d. c) Dressing change 2 after another 48 hours and d) after 3 days without NPWTi-d



Figures 3. Right and left stump wounds case 3. Before treatment above knee stump a) right b) left. Dressing change after two days c) right), d) left. Able to perform sharp debridement e) right, f)left. Switched to standard NPWT g) right h) left. Standard dressings i) right j) left

NPWTi-d was discontinued and standard NPWT commenced as the wound bed had been sufficiently prepared and achieved 80% granulation tissue.

Graft infection was resolved with antibiotics and accelerated granulation occurred over the graft site. Standard NPWT meant the patient could be discharged home one week earlier than expected and followed up by the district nursing service.

Case 2

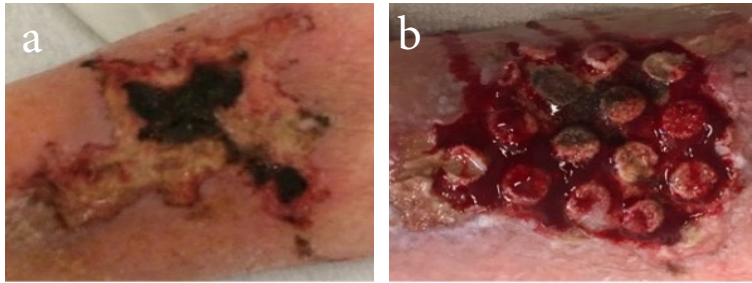
A 85-year-old female admitted for right groin wound dehiscence. The patient had undergone a femoral popliteal bypass 2019, ischaemic heart disease, hypertension, hyperlipidaemia, asthma, gastroesophageal reflux disease, left renal cyst, eye cataracts.

Initially there was erythema and tenderness over the groin area and medial leg wounds secondary to wound infection with *Staphylococcus aureus*. Tissue in the wound bed was necrotic and non-viable requiring sharp debridement during dressing changes (Figure 2). When dressing with standard wound care products the VAS pain rating was 10/10. The wound was 100 % slough, and it was decided to apply NPWTi-d with the grey foam dressing and prontosan solution in order to help remove non-viable tissue and, also avoid further use of acute operating time. For the initial application of NPWTi-d, short acting oral morphine was administered 45 minutes before dressing change and nitrous gas was used during the procedure with good effect a VAS 3–4 was reported.

Using NPWTi-d with prontosan solution produced significant benefits in healing and pain management for this patient. It was decided on week three to switch to standard NPWT, however, the wound bed became more sloughy. See the comparison between Figures b and d for case study 2, NPWTi-d with prontosan solution was resumed to clean up the wound bed for a further week (3 dressing changes in total), after which standard dressing treatment was started.

Case 3

A 46-year-old female who developed bilateral stump infections post-amputation. The patient had poorly controlled type two diabetes with retinopathy, neuropathy and nephropathy. This patient had prolonged admission to hospital, more



Figures 4. NPWTi-d with grey foam dressing for right groin wound. a) before NPWTi-d and b) after the first dressing change, 48 hours post application of NPWTi-d

than three months with an infected DFUs. These had required multiple surgical debridement's with trans-metatarsal amputation. Multiple attempts at improving distal flow with balloon angioplasty and localised catheter-directed thrombolysis were made. When all failed, bilateral above knee amputations for critical limb ischaemia were performed. Past medical history included

hypertension, ischaemic heart disease with diffuse chronic arterial disease noted on angiography in 2015 and chronic kidney disease, chronic anaemia, morbid obesity. She was an ex-smoker (30 pack years). Further surgical time for this patient was not an option due to her anaesthetic risk.

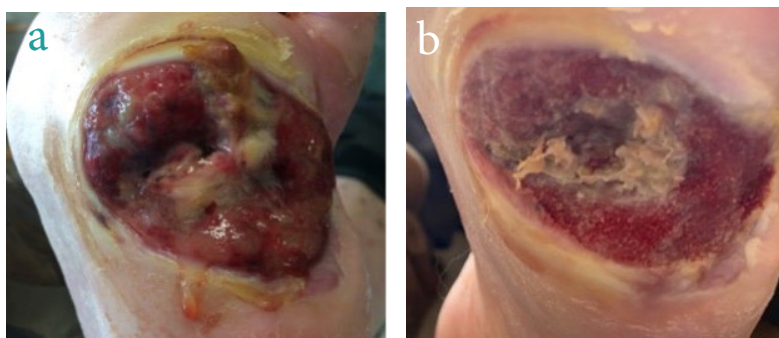
The patient was in a lot of pain during dressing changes with no improvement in wound healing. This delayed discharge to rehabilitation, causing the patient and her family great distress. We used NPWTi-d with with prontosan solution to help loosen the necrotic tissue and enable a viable wound bed.

The use of The NPWTi-d with grey foam dressing and prontosan solution in this case was a valuable adjunct to standard therapy, as surgical debridement either under general anaesthetic or local was not an option. The treatment was able to debride effectively non-viable tissue to help accelerate healing. The patient was able to enter a rehabilitation facility.

Table 1. Breakdown of dressing costs										
Case	Age	Wound type	Length of time wound before treatment	Instill fluid amount/ type	Cycle for treatment	Number of Dressing changes	Theatre time	% non-viable tissue after TX	Healing achieved	Silhouette photos show improvement
1	79	Right Femoral incision site infection	One week	30ml PHMB/ betadine	3 ½ hourly vacuum; 20min dwell time	1	X1 prior to NPWTi-d	10%	Yes	Yes
2	85	Right Femoral incision site infection	Two weeks	40ml PHMB/ betadine	3 ½ hourly vacuum; 20min dwell time	6	Nil	20%	Yes	Yes
3	46	Bilateral AKA secondary to diabetic foot ulcerations and sepsis	4 months	40ml right 50ml left PHMB/ betadine	3 ½ hourly vacuum; 20min dwell time	3	Nil	20% Left 10% Right	Yes	Yes
4	66	Ischemic shin ulceration	3 weeks	30ml PHMB/ betadine	5 hourly vacuum; 20min dwell time	1	Nil	100%	Yes	Yes
5	46	Venous leg ulcer	2 years	50ml PHMB/ betadine	3 ½ hourly vacuum; 20min dwell time	2	Post NPWTi-d 3 hours for skin grafting	100%	No	Yes



Figures 4. NPWTi-d with grey foam dressing for right groin wound. a, b) before NPWTi-d. c, d) at dressing change 2.5 days later and e, f) 5 days post split-thickness skin graft



Figures 4. NPWTi-d with grey foam dressing for right groin wound. a) before and b) after one treatment NPWTi-d

Case 4

A 66-year-old male who was admitted acutely from a tertiary institution with a three-week history of multiple punched out painful ulcerations on the right distal lower limb, and black toes.

Computed tomography angiography of his lower limbs showed high-grade narrowing of the right popliteal artery with occlusion of the right anterior tibial artery distally and of the dorsalis pedis artery.

The patient had necrotising fasciitis of the left leg in 2016 involving extensive debridement and skin grafts, as well as chronic venous insufficiency, recurrent deep vein thrombosis requiring treatment with warfarin, hypertension, hypercholesterolemia, and bilateral hernia repairs.

Angioplasty was performed to open the occlusion. Following successful angioplasty, we were able to put NPWTi-d with the grey foam dressing and Prontosan solution to help lift the necrotic skin removing a thick layer of non-viable tissue.

Pain at dressing change was 4 using the VAS. NPWTi-d helped removed the necrotic tissue, which accelerated the healing so after 48 hours there was a viable wound bed. The wound was then able to heal, within two weeks there was 40% reduction in the wound size.

Case 5

A 46-year-old male venous leg ulcers 20 to venous insufficiency CEAP (Clinical-Etiology-Anatomy-Pathophysiology classification; Lurie et al, 2020) C6. The patient was obese, with venous insufficiency and pain especially at dressing changes and on mobilising. His pain score was between 4–5 as an average and at dressing changes up to 8.

The patient received a skin graft as an inpatient and two weeks post-graft we were able to use a standard NPWT device. Pain at time of dressing change in this case study was significant (VAS: 8/10), managed with oral short- and long-acting analgesics. This led to improved comfort, after two years of constant and debilitating pain. This was a complicated case that represented with further breakdown now bilaterally five months later and chronic infection heavily colonised with *Pseudomonas aeruginosa* resistant to ciprofloxacin. NPWTi-d with the grey foam dressing and Prontosan solution was restarted and due to pain, we trialed saline on the right leg and Prontosan

solution on the left. Re-swabbing showed on the leg that had Prontosan, scanty growth of *Pseudomonas aeruginosa* and on the saline side light growth, although this was not quantifiable. Due to pain we had to abandon the NPWTi-d.

A problem we identified with heel wounds was that when the patient was walking there was added pressure over a plantar wound and instill treatment meant the seal could more easily be broken.

Other experiences

We have also trialled the same NPWTi-d treatment on two complex DFUs. We achieved cleaner wound bed, using the NPWTi-d with the grey foam dressing in complex DFUs that had chronic osteomyelitis. This patient refused to have further surgery to remove devitalised bone and tissue. We were able to then put standard NPWT and with six weeks of oral antibiotics healing was achieved.

DISCUSSION

The NPWTi-d with the grey foam dressing and Prontosan solution was demonstrated by our cases as an option to help prepare the wound bed by removing non-viable tissue. NPWTi-d can effectively prepare and cleanse complex wounds for standard wound therapy options, which may help to reduce inpatient days and improve healing.

The ability to remove slough from the wound bed helped reduce acute theatre time, for all the cases, however we did find we had some issues with managing the pain at time of removal as in case 5. We used inhaled pentrox (Methoxyflurane) for pain relief. This is an analgesic that is fast acting and is ideal in management of dressing changes where pain is an issue.

As there are few guidelines on the optimal fluid used to instill into wounds, our unit opted to use Prontosan fluid, a wound irrigation solution that has polyhexamethylene biguanide (PHMB). A recent review of use of Prontosan found that it minimised antimicrobial resistance and was an effective way of managing infected wounds. While the mechanism of action is poorly understood, it is believed that Prontosan confers antimicrobial resistance by altering the pH of the wound bed (Fjeld and Lingaas, 2016). In this case series we found that use of PHMB/betadine has helped with pain reduction. We also found if pain was an issue we could change the dwell cycle to extend beyond 3 ½ hours. We

Box 1. Groin wounds tips for application that we found helpful during the trial:

- ▶▶ Ensure adequate pain management
- ▶▶ Prepare the surrounding skin so that it is clean, and dry.
- ▶▶ Use skin preparation to >5cm surrounding the wound bed
- ▶▶ Always have a second pair of hands to aid access the groin and apply dressing
- ▶▶ Use good lighting
- ▶▶ When packing a deep cavity, cut the open foam layer if needed to obtain good contact
- ▶▶ While the self-test is running (leak test), ensure patient is prepared for this — it can be painful
- ▶▶ This treatment is limited to therapy being delivered as an inpatient treatment only
- ▶▶ Application in to deep cavities can be challenging. In these cases we found it helpful to cut the open cell foam to fit the cavity

could then increase after 24 hours when the pain had settled.

Key practice points

Pain can be an issue at dressing changes and with re-suction after dwell time. Use of methoxyflurane at the bedside has helped with pain management. Methoxyflurane has been used frequently in preoperative and outpatient settings with good effect. Patients can self-administer, it's portable, has a rapid onset, and has been used in acute preoperative care settings for more than 60 years (Porter et al, 2018; Jephcott et al, 2019).

Determining instill amounts, we recommend calculating the circumference by depth x 10 to obtain the instill volume, administering this manually (Gilbert et al, 2016). There is limited evidence in the literature to aid in determination of the instill amount, and clinical experience has been so far trial and error.


The use of NPWTi-d with Cleanse Choice dressing and Prontosan solution offers health professionals options for what are very difficult wounds to heal in complex vascular patients. In the vascular department we see many complicated wounds, and NPWTi-d adds to our options in wound management. We have, however, found it is not as effective as standard care in cases such

DFUs, especially for patients who are mobilising. The other important factor is how long to offer therapy to patients with chronically infected wounds and confirmed *Pseudomonas*. All of the wounds were challenging and complex, for example the VLU that had been chronic and painful for more than two years (Case 5) in this patient, the goal of managing infection was initially achieved to have a skin graft. The fact that he has represented five months later is due to many factors.

The Cleanse Choice eliminates necrotic wound material and increases healthy wound bed granulation. Bacterial loading is decreased by using a cleanse/surfactant on the wound bed. A recent RCT compared hypochlorous acid with saline, finding improved wound healing rates and decreased bacterial loading the results were statistically significant in favour of hypochlorous acid (Fernandez et al, 2018). Our observations from the presented case studies are consistent with these findings. Limitations are the number of case presented and the complexity of the wounds we trialled the product on.

CONCLUSION

Further research is needed to understand the impact of the NPWTi-d with Cleanse Choice dressing with Prontosan solution on wound healing, surgical outcomes and pain management. This system provides another option in the treatment of chronic and acute wound care. The cases in this series had good results when slough was removed, and this led to improved healing. This therapy should be considered for difficult to heal wounds in patients with significant comorbidities.

With good patient selection, NPWTi-d can provide adjunct therapy for complex wounds. As there is no one dressing-fits-all in wound care, having sufficient clinical evidence is critical to management of complex and expensive wounds. Our case series adds to the understanding of how this therapy can fit into the suite of treatment options for patients requiring wound care. 

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