Accelerated wound healing with combined NPWT and IPC: a case series

Abstract

Negative pressure wound therapy (NPWT) and intermittent pneumatic compression (IPC) have traditionally been used in patients with chronic complicated non-healing wounds. The aim of this study (retrospective case series) was to describe the use of NPWT in combination with IPC in patients with a relatively short history (2–6 months) of ulcers. All wounds showed improved healing during the treatment period with marked or moderate reduction in ulcer size, and granulation tissue formation was markedly stimulated. Oedema was markedly reduced due to IPC. Treatment was generally well tolerated. The results of this study indicate that combined NPWT and IPC can accelerate wound healing and reduce oedema, thus shortening the treatment period. Therefore, patients may have a shorter healing period and may avoid entering a chronic wound phase. However, controlled studies of longer duration are needed in order to show the long-term effect of a more accelerated treatment course.

■ accelerated wound healing ■ NPWT ■ intermittent pneumatic compression ■ leg ulcers

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Ulcus cruris of venous and arterial origin is commonly seen in patients aged over 65 (Callam et al, 1985). The quality of life in these patients is frequently impaired because of pain, recurrent infections and, for some, physical disability (Hoopman et al, 2016; Persoon et al, 2004; Herber et al, 2016). The duration of the medical intervention is often long before reaching complete wound healing, and resources used to reach that endpoint can be of a considerable amount. The full financial expenditure of ulcus cruris is not known, but this cannot be other than a costly affair for us. A decrease in time to reach wound healing would certainly be an advantage to all aspects of this condition. The principles used in conventional wound therapy are both surgical and non-surgical (Böhler, 2016). The non-surgical approach is mainly a combination of different types of dressings, stockings, and the surgical approach involves the removal of devitalised tissue (debridement) (Harding, 2016). Newer techniques, like intermittent pneumatic compression (IPC) and negative pressure wound therapy (NPWT), have increasingly been used in the treatment of a variety of recalcitrant wounds over the past few years (Morykwas et al, 2006). NPWT can be used in a wide range of clinical situations where stimulation of wound healing is needed following surgical debridement of acute and chronic wounds (e.g., orthopaedic, necrotising infection, pressure ulcers), diabetic foot ulcers, and reconstructive surgery (e.g., burns, skin graft, muscle flap). There are relatively few contraindications and include malignancy in the wound, untreated osteomyelitis, non-enteric and unexplored fistulas, necrotic tissue with eschar present. NPWT is based on distribution of local negative pressure on the wound surface, with the surface covered by a separate wound dressing and an air-tight film. A control unit providing negative pressure is connected to a suction tube and the wound dressing. A container connected to the control unit collects the fluid suctioned from the wound. There are few adverse effects with NPWT, and those described are only mild. The suggested modes of action of NPWT on the wound healing are many: increased blood flow in the microcirculation, reduction of wound oedema and removal of exudate. All these factors enhance wound healing by promoting cell proliferation, angiogenesis and formation of granulation tissue. IPC is a mechanical compression technique used to prevent development of blood clots during long periods of rest, and in the treatment of limb swelling (lymphoedema) and venous leg ulcers. The device consists of either a single or multiple chambers wrapped as a stocking around the limb (Nelson et al, 2014). The chambers are inflated/deflated in adjustable compression cycles and thereby removing the surrounding oedema and promoting wound healing. Having IPC and NPWT as possible treatment options in wound care, we wanted to analyse if a combination of NPWT and IPC could improve and accelerate wound healing. The other important objective of our study was to determine if this dual treatment is tolerable. To our knowledge little is known about this polytherapeutic approach in handling of leg ulcers.

Patients

Patients included in this retrospective study were all treated at the wound care centre of the Department of Dermatology, University Hospital of Aarhus. Eight patients with a relatively short history of ulcers (less than 6 months) and 3 patients with longstanding non-healing venous ulcers were evaluated retrospectively. In total 11 patients, six females (mean age 74) and 5 men (mean age 57.6, range from 39–84 years) diagnosed with venous ulcer (7 patients), combined venous and arterial ulcer (3 patients) and pressure induced leg ulcer (1 patient) were evaluated in this study. The pressure ulcer patient was evaluated in the study as the ulcer was pressure-induced in the ankle region and developed in an oedematous leg and thus regarded as a venous leg ulcer. All patients had various kinds of comorbidities (*Table 1 and 2*). Prior to NPWT/IPC, all patients received moist wound treatment. Nine patients received compression therapy with compression bandages, one patient did not use compression whereas one of the patients had an earlier history of moist wound treatment combined with long stretch bandages and IPC.

Setup

Patients were generally treated for a period of 2 weeks as inpatients with combined NPWT and IPC followed by 2 weeks as outpatients. The first 2 weeks of the treatment period started in the inpatient setting at the Department of Dermatology followed by 2 weeks in the outpatient wound care clinic. At both locations NPWT was applied and changed twice a week and IPC was used twice daily (1–2 hours, 40–60mmHg). Prior to NPWT/IPC all the patients received conventional wound care with debridement, wound care dressings and compression therapy and, if necessary, systemic antibiotics. Antibiotics were continued if needed during and/or after the treatment period of NPWT/IPC.

Endpoint measurement

The wound area was routinely clinically assessed once a week during the treatment period by measuring the ulcer size and determining the formation of granulation tissue. Also, the degree of oedema reduction was clinically evaluated together with patient compliance once a week. Application of the NPWT/IPC devices and measurements were all done by trained wound specialist nurses.

Results

Table 1 and *2* summarise the results of the study. All wounds showed improved healing during the treatment period. The ulcer size was either markedly or moderately reduced in size. The granulation tissue formation was markedly stimulated during the treatment period. There was a marked reduction of oedema due to IPC. All wounds showed improved healing during and immediately after treatment. On follow-up, 4 patients were healed, 4 patients showed marked improvement whereas 3 patients did not improve or showed worsening with increase in ulcer size. The 3 patients with very longstanding chronic wounds all showed improvement during treatment. On cessation of treatment one of these patients still showed marked improvement with only a small residual wound after 3 months, whereas the two other patients showed no improvement on follow-up. On cessation, one patient with short wound duration showed severe deterioration with an increase in wound size. This can be explained by worsening of her disseminated cancer disease. The combined treatment with both applications of NPWT and IPC was generally well tolerated and there was no negative impact of one treatment modality over the other.

Discussion

The use of negative pressure in wound healing has been practised since the 1940s (Fay, 1987; Fox and Golden, 1976). NPWT was developed in the 1990s and the use of this intervention has increased dramatically in developing countries over the past few years. We used Pubmed to do a search of the literature and the search terms were (alone or in combination): venous ulcer, management of venous ulcer, management of mixed ulcer, mixed ulcer, IPC, intermittent pneumatic compression, NPWT, negative pressure wound therapy, wound management and quality of life.

The literature describes the use of NPWT in wounds of various of origin, both in acute and chronic stages with duration of use from days to months depending of the wound (Vikatmaa et al, 2008; Franzo, 2016). There are a lot of advantages with NPWT: the devices are small, user-friendly and quite portable. A small canister-free version of NPWT equipment has recently been developed (Hudson et al, 2015). Biochemically, one of the favourable effects of NPWT is the removal of wound exudate and possible infectious material, both decreasing the frequency of changing the dressings. This keeps the wound clean, odour-free and minimalises wound exposure to the environment. Another suggested beneficial effect is that by applying suction to the wound, the edges are drawn together and combined with increased local perfusion, this promotes the process of healing (Huang et al, 2014). The negative effects reported after NPWT treatment are wound maceration and skin breakdown due to exposure to wound exudate (US Food and Drug Administration, 2011).

Several studies have been conducted on different types of leg ulcers to prove the efficacy of this treatment, but the evidence of its effectiveness is limited. In a recent Cochrane review of NPWT treatment in leg ulcers, the conclusion was low quality evidence of a difference in time to healing by use of NPWT compared to standard wound therapy (Dumville et al, 2015). Oedema is known to be unfavourable in healing of ulcers. The standard and most used technique to treat oedema is with hosiery and bandages (Harding, 2016). For many patients the often long treatment period with hosiery/bandages may reduce their quality of life because of pain during the compression treatment. Reduction of pain and faster healing of ulcers due of more effective compression are some of the proven benefits of IPC (Alvarez et al, 2012; Coleridge Smith, 1988; Schuler et al, 1996). Looking at the literature, the results of IPC treatment are diverging. Several studies, mostly small, have been performed to demonstrate the efficacy of IPC. As a conclusion, IPC is proven to be more effective than no compression at all (Nikolovska et al, 2002). Investigating treatment with IPC alone versus IPC and standard compression, there is proof that the dual

Table 1. Clinical data of patients 1–5

Patient no Age (years)/ gender	Associated diseases/ conditions	Wound diagnosis and localisation	Wound history before treatment with IPC/ NPWT	Previous treatments	Treatment (IPC and NPWT)	Effect of IPC and NPWT	Follow-up treatment	Outcomes	Comments
1 57/female	Hypertension (compensated), wound pain, minimal oedema ABPI: 0.8	Healed longstanding ulcer situated of left lateral malleolus, present ulcer: recurrent	Ulcer (recurrent) duration unknown	Moist wound treatment and long stretch bandage	2 weeks as an inpatient, followed by 2 weeks as an outpatient	Reduction of wound size and wound depth. Stimulation of granulation tissue formation and initiation of ulcer healing No reduction of oedema	Moist wound treatment and long stretch bandage	Wound healing continued after cessation of IPC/ NPWT. Complete wound closure 2 months later	Reduction of wound pain shortly after initiation of IPC/NPWT Complete healing
2 76/female	Obesity, Immobilisation, venous insufficiency ABPI: 1.0	Pressure ulcer, right ankle	Ulcer (recurrent) for 4 weeks	Moist wound treatment and long stretch bandage	2 weeks as an inpatient, followed by 2 weeks as an outpatient	Reduction of wound size and wound depth. Stimulation of granulation tissue formation and stimulatation of wound healing. Slight reduction of oedema	Moist wound treatment and long stretch bandage	Wound healing continued after cessation of IPC/ NPWT. Complete wound closure 2 months later	Patient had concomittant pressure ulcer of her right buttock also treated with NPWT resulting in markedly healing Complete healing
3 52/male	Hypertension, venous hypertension, localised oedema of right lateral malleolus Duplex scan shows slight reflux of the distal part of the right lower leg. ABPI: 1.4	Healed longstanding ulceration of the right lateral malleolus, present ulcer recurrent	Trauma-induced ulceration 8 years back, presently recurrent ulcer	Moist wound treatment and long stretch bandage	2 weeks as an inpatient, followed by 2 weeks as an outpatient	Reduction of wound size and wound depth. Stimulatation of wound healing. Moderate reduction of oedema	Moist wound treatment and multilayer bandage	Wound healing continued after cessation of IPC/ NPWT. Complete wound closure 2 months later	Patient now used compression stockings controlling oedema, patient is still working Complete healing
4 84/female	Localised oedema, stasis eczema, recurring cellulites, compliance problems ABPI: 1.0	Venous leg ulcers, infections, almost circular ulceration around distal portion of the lower right leg	Eczema for 4 years, development of venous ulceration, no healing for 3 months	Moist wound treatment and long stretch bandage	3 weeks as an inpatient	Reduction of wound size by 50% and wound depth markedly reduced and stimulation of wound healing. Moderate reduction of oedema	Moist wound treatment and short- stretch bandage as multilayer bandage is not tolerated by patient Lost for follow-up	Wound healing continued after cessation of IPC/ NPWT followed by deterioration and increase in wound size	Patient needed, due to compliance problems, admittance for two periods for intensified wound and oedema treatment
5 73/female	Metastatic lung cancer, palliative treatment, chronic obstructive lung disease, smoker Toe pressure: 25mmHg	20cm long ischaemic ulcer of the left crus with exposed tendon Localised oedema	Ulcer started after a trauma 3 months prior to treatment, Tibialis anterior tendon removed surgically prior to TPC/NPWT	Moist wound treatment	3 weeks as an inpatient	Reduction of wound size by a third, markedly stimulation of wound healing Moderate reduction of oedema	Moist wound treatment and short stretch bandage	Improvement during treatment, but lost for follow-up	Patient died due to severe deterioration of her metastatic lung cancer Improved healing

Table 2. Clinical data of patients 6–11

Patient no Age (years)/ gender	Associated diseases/ conditions	Wound diagnosis and localisation	Wound history Before treatment with IPC/ NPWT	Previous treatments	Treatment (IPC and NPWT)	Effect of IPC and NPWT	Follow-up treatment	Outcomes	Comments
6 82/female	Chronic obstructive lung disease, smoker, toe pressure: 35mmHg	Combined arterial and venous insufficiency (right leg) Localised oedema	Trauma induced ulceration 5 months prior to IPC/NPWT	Moist wound treatment and short stretch bandage	3 weeks as an inpatient	Reduction of wound size, stimulation of granulation tissue formation, no reduction in oedema. After 3 weeks of IPC/ NWPT, wound infection and IPC/NWPT was stopped	Moist wound treatment and short stretch bandage with moderate external pressure	Deterioration after cessation of IPC/NPWT	Stagnated wound healing 6 months after IPC/NPWT Patient offered surgery, but refused Improved healing
7 66/male	Hypertension (compensated), wound pain, stasis ezcema	Venous leg ulcer (bilateral), localised oedema	Longstandning recurrent ulcers, current wound present for 3 years, on enrolment: progression	Moist wound treatment and multilayer bandage	2 weeks as an inpatient, followed by 2 weeks as an outpatient	Reduction in wound size, oedema: slight improvement, ezcema cleared, stimulation of wound healing	Moist wound treatment and multilayer bandage	Wound healing continued on cessation of IPC/NPWT, closure on left leg after 3 months, minimal residual wound on right leg	Patient is still working in his own business, no wound pain and no impact on QOL Markedly improved healing
8 72/female	Osteoporosis, heart disease, smoker, atherosclerosis of the legs, vascular bypass surgery several times, toe pressure: 30mmHg	Combined arterial and venous insufficiency (right leg) and localised oedema	Ulcer started in a surgical wound after bypass surgery, duration less than 4 months	Moist wound treatment	4 weeks as an inpatient	Reduction in wound size, marked reduction in wound depth, stimulation of wound healing	Moist wound treatment and losely applied short stretch bandage	Wound healing continued on cessation of IPC/NPWT, complete closure after 4 months	Patient now used compression stockings (compression class 1) controlling oedema Complete healing
9 39/male	Coagulation abnormality (Leiden 5 mutation), DVT of both legs, ABPI: 1.2	Venous leg ulcer and localised oedema	Non-healing wound for 5 years	Moist wound treatment and multilayer bandage	One and a half weeks as an inpatient and as an outpatient for 3 months	Reduction in wound size, marked reduction in wound depth, stimulation of wound healing, no reduction in oedema	Moist wound treatment and multilayer bandage	Ulcer still healing during 18 months after cessation of IPC/NPWT	Patient is still working and is physically active in his spare time Markedly improved healing
10 61/male	Chronic renal insufficience, kidney transplant and is treated for life with immunosuppresants ABPI: right: 1.2, left: 1.4	Venous leg ulcer (bilateral), localised oedema and hyperpigmentation Histology of tissue biopsy specimen has shown calciphylaxis	Wounds of both legs (crura) Duration: 2 months	Moist wound treatment and long stretch bandage	2 weeks as an inpatient followed by 3 weeks as an outpatient	Reduction in wound size, marked reduction in wound depth, stimulation of wound healing, slight reduction in oedema	Moist wound treatment and long stretch bandage	Almost full wound closure 3 months after cessation of IPC/NPWT	Fluctuation in wound healing activity related to fluctuations in renal and general status of the patient Markedly improved healing
11 70/male	Polycytaemia vera, DVT and lung embolism, stasis eczema ABPI: 1.3	Chronic venous leg ulcers (bilateral), localised oedema	Since 1980 ulceration of both legs (crura), localised oedema	Moist wound treatment and long stretch bandage combined with IPC	4 weeks as an inpatient	Slight reduction in wound area, minimal effect on oedema	Moist wound treatment and long stretch bandage in combination with IPC	Wound infection 3 weeks after IPC/NWPT resulted in deterioration with cessation of the healing process	Unchanged

CPD reflective questions

- Could you use intermittent pneumatic compression in your own clinical practice?
- Can wound healing be stimulated by using a device producing mechanical compression together with a device producing negative pressure on wound surfaces?
- How do patients tolerate a combination of negative pressure wound therapy and mechanical compression?

treatment is more beneficial. When comparing the possible IPC treatment cycle alternatives (slow or fast), more ulcers healed in shorter time using fast cycles (Nikolovska et al, 2005). Reduction of pain was shown in groups of patients treated with IPC and standard compression than either of these alone (Schuler et al, 1996). Comparing our data and experience with the literature already published we found that the treatment markedly reduced oedema. Reduction of ulcer pain was described by most of our patients after initiating the dual treatment. The ulcers showed improvement with results varying from complete healing to reduced ulcer size and increased granulation tissue.

The results of this study are based on clinical data extracted from patient records. Data are entered by clinicians performing the treatment and the patient records contained no specific information on ulcer size (i.e. area measurements) but changes in ulcer size was based on clinical terms and changes in oedema was also described in clinical terms. The treatment was well tolerated. However, as the patients were elderly, they were offered the accelerated treatment programme aiming for a period of 2 weeks as inpatients followed by a 2-week period as outpatients. The reason for this approach was based on an assumption that the treatment might have impact on the patients' daily activity as they had to carry the pump and canister 24 hours a day together with a tube attached to the bandage. The two-week period as inpatients was used to make the patients getting used to the burden of carrying the treatment equipment and to evaluate the treatment course. Generally, patients tolerated the treatment programme well. Two patients, however, had a hard time tolerating the pump and canister and as a consequence, they could not enter the outpatient phase and needed to stay in the hospital. Three other patients were similar, but could be discharged after 3 weeks as inpatients. During the inpatient phase none of the patients were bedridden and they all moved around freely.

To our knowledge there is no literature describing the combination of NPWT and IPC in the treatment of leg ulcers. Our purpose with this study was to combine two treatment modalities by facilitating the stimulation of the healing process together with reduction of oedema. Although there is no strong evidence of efficacy of these treatment options, with this study we clearly imply that the combined IPC/NPWT treatment precipitates wound healing and decreases oedema, and together with the good tolerance, this clinical approach can be used to accelerate healing of leg ulcers of different origins.

Conclusions

The results of this study indicate that a combination of NPWT and IPC can accelerate wound healing and markedly reduce oedema. As a consequence of these findings, patients may have a shorter healing period and may be protected from entering a chronic wound phase. However, controlled studies of longer duration are needed in order to show the long-term effect of a more accelerated treatment course. **CWC**

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KEY POINTS

- Chronic oedema can be effectively treated by use of intermittent pneumatic compression.
- Wound healing can be enhanced by use of negative pressure wound therapy.
- Healing of chronic wounds can be accelerated by use of a combination of negative pressure wound therapy and intermittent pneumatic compression.