Received: 22 January 2021 | Revised: 8 March 2021 | Accepted: 9 March 2021

DOI: 10.1111/iwj.13592

ORIGINAL ARTICLE

IWJ WILEY

Experience with negative-pressure wound therapy with instillation in complex infected orthopaedic wounds

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Abstract

Chronic exudative wounds are frequently seen in hospitalised patients, consuming hospital resources and leading to increased morbidity. Negative-pressure therapy (NPWT) with topical instillation "NPWTi" may be used to improve the wound healing process, with the unique features (removal of wound exudate, edema reduction, promotion of tissue perfusion and granulation tissue formation, as well as drawing the edges of the wound to facilitate, in addition to the cyclic cleansing mechanism). This report is a descriptive study of our experience with NPWTi on complex infected orthopaedic wounds as a potential method to decrease the need for multiple surgical debridements required for the closure of such wounds. A prospective observational study was conducted. Twenty patients with complex infected orthopaedic wounds were enrolled in our study. These patients were consulted by the Bone and Joint Infection Service and enrolled to receive NPWTi intraoperatively and to be used during their inpatient stay. Twenty patients with 20 complex infected lower limb wounds were included in our study. Of all the 20 wounds, the etiology was post-surgical in 80% (n = 16) and post-traumatic in 20% (n = 4). None of the patients received previous treatment with conventional NPWT before participation in the study. There were 11 males (55%) and 9 females (45%) with an average age of 57 years (22-83). All wounds were located in the lower limbs, with 25% leg (n = 5), 20% thigh (n = 4), 20% knee (n = 4), 20% foot (n = 4), 10% heel (n = 2), and 5% ankle (n = 1). The average length of treatment with NPWTi was 5.2 days (2-10). Successful wound closure within 6 weeks was achieved in 65% of the cases (n = 13). Of the closed wounds (n = 13), 54% (n = 7) were closed primarily and 46% (n = 6) were closed by secondary procedures (skin graft or skin flap). NPWTi is still considered a novel technique that can be used in the management of complex wounds, and the goal of this prospective study is to report our experience with NPWTi in the management of complex infected orthopaedic lower limb wounds. Randomised control studies with optimally matched wounds comparing NPWTi to the conventional methods of treatment are warranted.

KEYWORDS
infected orthopaedic wounds, negative-pressure wound therapy with instillation, NPWTi

1 | INTRODUCTION

Chronic exudative wounds are frequently seen in hospitalised patients, consuming hospital resources and leading to increased morbidity. Complex wounds definition mandates the presence of at least one or more of the following criteria: extensive loss of the wound integument, bacterial colonisation, compromised tissue viability, circulation impairment, or associated healing impairment as a result of systemic conditions.[1] Factors influencing wound healing can be categorised into local factors and systemic factors, and therefore, effective wound management mandates a comprehensive assessment of the wound as well as the patient.[2,3] Treatment usually involves non-surgical and surgical procedures. Surgical procedures are usually required for faster and more efficient wound healing. Under certain circumstances, when the patient is not fit for surgery or when the wound is not favourable for improvement with surgery, non-surgical procedures are usually necessary to prepare the wounds for a definitive procedure.[2,4] Different types of wound dressing have been described in the literature, yet there is no agreement on the best dressing for exudative wounds. Wound irrigation is defined as a steady flow of a solution across an open wound surface. This guarantees proper wound hydration and debris removal and can ease wound exudation. The irrigation solution's main function is to wash out the wound exudate, cell debris, and metabolic waste products to improve the wound healing environment.[2,5]

Negative-pressure therapy (NPWT) has been established for decades in the treatment of complex wounds. It can help shorten the time of treatment and prepare the wound bed for final closure.[4] The NPWT effects on wound healing depend on several mechanisms of action: wound retraction via negative pressure, granulation tissue promotion via cellular microdeformations, continuous wound cleansing via suction, fewer dressing changes within a sealed hygienic system, and improved nutritive perfusion via reduction of interstitial edema and improvement of microcirculation.[6] NPWT with topical instillation (NPWTi) represents a variation to the traditional NPWT. It was developed in the early 2000s combining the advantageous effects of NPWT with the addition of a controlled local antiseptic wound cleansing system to the wound bed.[6] The NPWTi device allows regulated alternating continuous NPWT and controlled delivery/removal of a topical solution to the wound for short, known intervals. This combination can lessen the bacterial bioburden and improves the therapeutic effect of NPWTi than NPWT alone.[7] It was initially used as a last resort, but lately, it is used to improve the wound healing process with the unique features (removal of wound exudate, edema reduction, promotion of tissue perfusion, and granulation tissue formation, as well as drawing the edges of the wound to facilitate closure, in addition to the cyclic cleansing mechanism).[4]

The goal of this propsective study is to report our experience with NPWTi in management of complex infected orthopaedic wounds.

Key Messages

- infected orthopaedic wounds are complex and difficult to manage
- negative-pressure wound therapy with instillation may be helpful in the management of complex infected orthopaedic wounds

2 | MATERIALS AND METHODS

A prospective observational study was conducted. Twenty patients with complex infected orthopaedic wounds were enrolled in our study. These patients were consulted by the Bone and Joint Infection Service and enrolled to receive NPWTi intraoperatively and to be used during their inpatient stay.

Patients who received the NPWT device within 30 days prior, with active malignancy, or who were younger than 18 years of age were not included in this study. During the initial assessment, the wound dimensions were documented, and wound cultures were sent to the laboratory for cultures.

Patients were scheduled for wound debridement as inpatients. After surgery, all patients received NPWTi using V.A.C. Ulta (KCI, San Antonio, Texas), with Prontosan (B. Braun, Bethlehem, Pennsylvania) wound irrigation solution, and one of these V.A.C. dressings: V.A.C GranuFoam, V.A.C. GranuFoam Silver, and V.A.C. WhiteFoam (KCI, San Antonio, Texas). All dressings were applied in the operating room directly following debridement. Prontosan instillation solution was connected to the system via the spike on the VeraLink Cassette (KCI, San Antonio, Texas). The pre-programmed therapy unit has been set to vacuum-assisted closure (VAC) therapy and was initiated to deliver a 20-minute soak/dwell time followed by 2 hours of therapy with a pressure of −125 mm Hg and medium pressure intensity. The protocol summary is described in Table 1. After initiating therapy, evaluation for any leakage was performed using the seal check tool. Patients received intravenous antibiotics according to the results of the culture, and sensitivity swabs were taken in the clinic. Definitive wound closure for this study is defined as a complete approximation of the wound edges, complete coverage of the wound via tissue transfer or skin graft, or any combination of these definitive techniques that results in complete elimination of the wound bed. Wound recurrence occurs when a wound that has been definitively closed becomes no longer closed (when approximated wound edges separate). Follow-up was scheduled at the interval of 1, 2, 4, and 6 weeks after the termination of Veraflo therapy. The wounds were monitored for healing and recurrence of infection. Healing was identified by complete approximation and epithelisation of the wound edges whether by primary closure or by using a reconstructive procedure (skin graft/flap).

3 | RESULTS

Twenty patients with 20 complex infected lower limb wounds were included in our study. Of all the 20 wounds, the etiology was post-surgical in 80% (n = 16) and post-traumatic in 20% (n = 4) (Table 2). None of the patients received previous treatment with conventional NPWT prior to participation in the study. There were 11 males (55%) and 9 females (45%) with an average age of 57 years (range, 22-83). Most prevalent comorbidities are gathered in Table 3. All wounds were located on the lower limbs, with 25% leg (n = 5), 20% thigh (n = 4), 20% knee (n = 4), 20% foot (n = 4), 10% heel (n = 2), and 5% ankle (n = 1) (Table 4). Fifteen patients had positive culture results, while the culture results came back negative in five patients. Summary of wound culture results is in Table 5. All patients received intravenous antibiotics, either according to their cultures and sensitivity results or according to the

TABLE 1 Protocol summary

System used	V.A.C. Ulta
Dressing	V.A.C. GranuFoam, GranuFoam Silver, and WhiteFoam (KCI, San Antonio, Texas)
Settings	−125 mm Hg, medium intensity
Cycle duration	120 min
Instillation solution used	Prontosan (B. Braun, Bethlehem, Pennsylvania)
Dwell time	20 min

TABLE 2 Wounds etiology

Wounds etiology	Percentage of cases % (N)
Surgical	80% (16)
Post-traumatic	20% (4)

TABLE 3 Most common comorbidities

Comorbidity	Percentage of cases % (N)
Hypertension	65% (13)
Diabetes mellitus	40% (8)
Hyperlipidemia	25% (5)
Gastroesophageal reflux disease	20% (4)
Hypothyroidism	20% (4)
Cordonary artery disease	20% (4)
Liver disease	15% (3)
Atrial fibrillation	10% (2)
Chronic obstructive pulmonary disease	10% (2)
End-stage renal disease	10% (2)

TABLE 4 Wound location

Wound location	Percentage of cases % (N)
Leg	25% (5)
Thigh	20% (4)
Knee	20% (4)
Foot	20% (4)
Heel	10% (2)
Ankle	5% (1)

TABLE 5 Summary of wound culture results

Organism	Percentage of cases % (N)
Mixed growth	30% (6)
No growth	25% (5)
Pseudomonas aeruginosa	10% (2)
Serratia marcescens	10% (2)
Staphylococcus aureus	10% (2)
Escherichia coli	5% (1)
Enterobacter cloacae	5% (1)
Corynebacterium	5% (1)

senior author in this study (in culture-negative cases) for at least 6 weeks. Summary of antibiotics used is in Table 6. The average length of hospitalisation for the patients was 13.7 days (range, 7-25). The average days of treatment with NPWTi was 5.2 days (range, 2-10). Successful wound closure before 6 weeks was achieved in 65% of the cases (n = 13). Of the closed wounds (n = 13), 54% (n = 7) were closed primarily and 46% (n = 6) were closed by secondary procedures (skin graft or skin flap).

3.1 | Most common comorbidities

All the details regarding the patient demographics, wound location, wound etiology, cultured organisms, antibiotics used, days of hospitalisation, days of NPWTi, the number of debridements performed, and the end result whether wounds were closed or remained open are summarised in Tables 2 and 3. Two case presentations are described in detail (Figure 1a-d for case A and Figure 2a-f for case B).

TABLE 6 Summary of antibiotics used

Antibiotics used	Percentage of cases % (N)
Multiple	40% (8)
Cefazolin	15% (3)
Ceftaroline	10% (2)
Clindamycin	10% (2)
Meropenem	5% (1)
Nafcillin	5% (1)
Linezolid	5% (1)
Vancomycin	5% (1)
Ciprofloxacin	5% (1)

3.1.1 | Case presentation

Case A

A 55-year-old male with multiple comorbidities (systemic hypertension, insulin-dependent diabetes mellitus, and chronic kidney disease) presented to our clinic with an infected lower extremity wound with active, purulent discharge. Five years prior to presentation, he underwent left total knee arthroplasty for osteoarthritis. His knee became infected, and he underwent multiple trials of salvage procedures (multiple debridements and two failed knee arthrodesis). *Serratia marcescens* organism was isolated in initial culture taken in the clinic visit, and the patient was started on intravenous ceftaroline. Finally, the patient underwent guillotine amputation, and wound vac with NPWT was applied and tested inside the operating theatre. Pressure and settings were applied following the study protocol. Based on the daily assessment, the patient was scheduled for wound closure after 4 days of negative-pressure wound therapy with instillation. The wounds were closed successfully, and the patient was discharged on oral antibiotics. The patient had a good postoperative course for 84 days after closure; then he developed a deep abscess and underwent incision and drainage.

FIGURE 1 A. Intraoperative after Guillotine amputation, Day 0. B. After application of NPWTi, Day 0. C. Intraoperative (2nd surgery), 4 days post initial procedure. D. Intraoperative after successful wound closure. (Used with permission from the Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore)

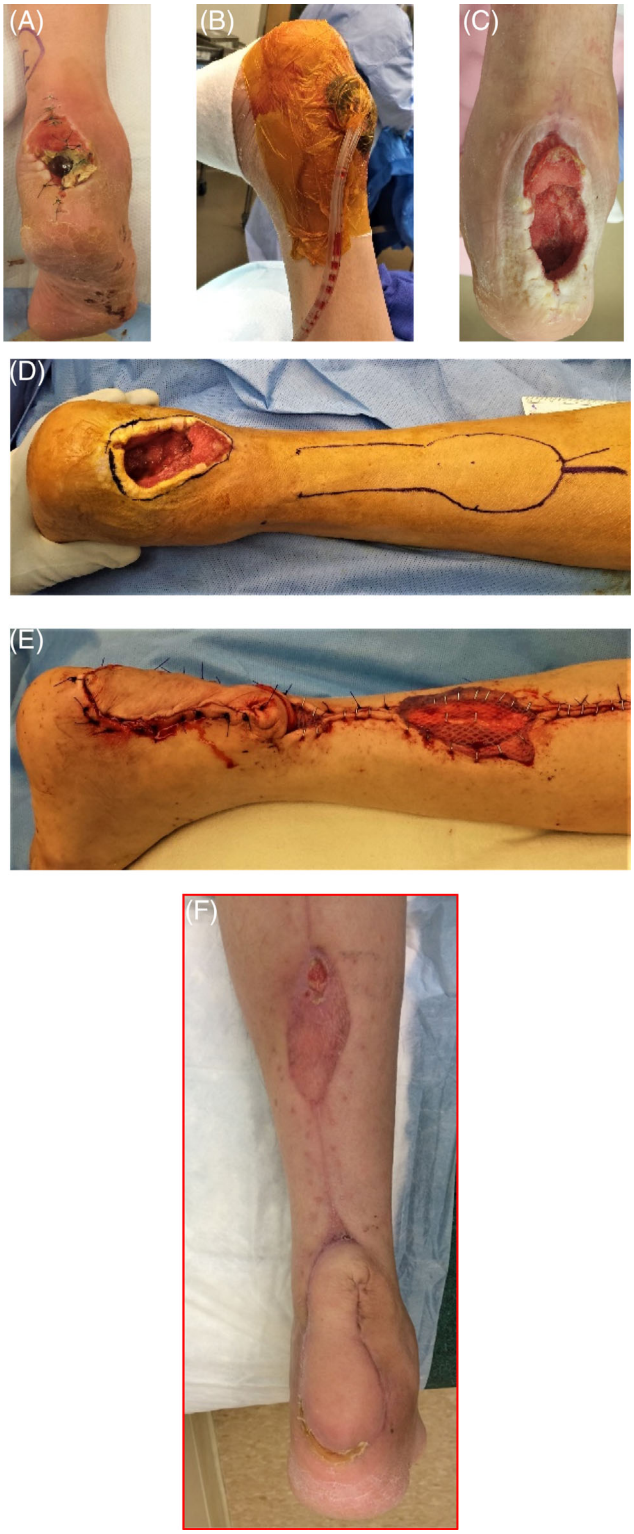

FIGURE 2 A. Heel wound before intervention. B. Intraoperative with NPWTi applied, Day 0. C. Day 7, with healthy granulation tissue formation. D. Day 7 intraoperative, after debridement. E. Intraoperative with reverse flap. F. Follow-up at 6 weeks with healed flap. (Used with permission from the Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore)

Case B

A 59-year-old male was referred for postoperative wound dehiscence after a left calcaneus fracture managed by open reduction and internal fixation with a screw. The first surgery involved the removal of the screw, partial calcanectomy with the application of wound VAC. Multiple organisms were cultured (*Proteus mirabilis*, *Enterobacter cloacae*, *Enterobacter asburiae*, and *Providencia rettgeri*), and the patient was started on two antibiotics (Cefepime/Ciprofloxacin). After debridement, NPWTi was applied for 7 days per protocol. The patient was discharged home on a home VAC. Twenty-six days after Veraflo treatment, the patient underwent a reverse sural flap to cover the skin defect with calcium sulphate beads to fill up the bone defect. Wounds were completely healed without complications during the follow-up period.

4 | DISCUSSION

Managing complex wounds requires the elimination of infection and regain of wound vascularity and integrity to promote healing and facilitate closure.[1] Infected non-healing wounds especially continue to be a major challenge for patients and health care providers. Historically, the treatment for these types of wounds mandates debridement, intravenous antibiotics, delayed wound closure, and frequent change of dressing and usually has a lengthy hospitalisation.[2] The introduction of NPWT revolutionised the standard care of such difficult wounds. NPWT had the clinical advantage of wound reduction by the promotion of granulation tissue formation. This is achieved through its ability to remove the debris, reduce edema, draw the wound edges together, promote tissue perfusion, and enhance cell stretching, which favours wound healing.[8] One of the disadvantages of NPWT is its lack of debriding ability.[9] In an animal study, Lessing et al[10] suggested that NPWTi with saline has a faster rate of wound regeneration when compared with NPWT alone.[10] In the early 2000s, NPWTi was introduced to the market in the United States, with its unique feature of regular cleansing, NPWTi combines the advantage of the introduction of intermittent and timed delivery of a desired instilled topical solution to the wound bed with the advantages of the standard NPWT.[11] With the instillation factor added to NPWTi, the benefit of regular cleansing between the dressing changes is achieved.[5]

Many authors have reported their experience with NPWTi in multiple studies.[7,8,11-14] Lehnar et al[12] reported in his multicentre observational study, 32 patients with both acute and chronic infected orthopaedic implants were treated only with NPWTi; 86.4% of the acute infection group and 80% of the chronic infection group retained their implants at 4 to 6 months of follow-up.[12] Also, in 2008, Gabriel et al[11] published his prospective pilot study including 15 patients treated with NPWTi for complex infected wounds and compared them with a retrospective group of 15 patients treated with moist wound-care therapy. The NPWTi group showed a significant decrease in mean time to bioburden reduction, clearance of infection, wound closure, and hospital discharge. They suggested that NPWTi may help to reduce the cost and decrease the inpatient care requirement for complex infected wounds.[11] Goss et al in 2014[7] concluded that NPWTi can reduce the post-debridement bioburden in chronically infected lower extremity wounds than NPWT alone in a prospective randomised single institute study comparing two groups of eight wounds each.[7] In this prospective study, Brickert et al[8] studied 131 wounds receiving NPWTi for 12 to 19 days followed by debridement and trial of wound closure with 98% successful closures. He proposed that the use of NPWTi with saline for a limited period has a positive role in the closure of complex wounds.[8] According to Kim et al[13] in 2014, negative-pressure wound therapy with instillation is more effective than the standard NPWT in the treatment of acute and chronic infected wounds that require hospitalisation.[13] In 2016, Omar et al[14] compared the impact of additional saline instillation in NPWTi with NPWT alone. They recruited 10 patients with acute lower limb wounds for the NPWTi group and compared them with a matched control group of 10 patients previously treated by NPWT alone. They found that the NPWTi group had a decreased time of hospitalisation and accelerated wound healing compared with the other group, but without statistical significance. They concluded that NPWTi of saline is a promising method that needs further randomised control studies to compare it with the conventional NPWT alone.[14] NPWTi can be used as a method to decrease the bacterial load and to promote wound healing.[11,12]

This is a descriptive study with some limitations; although we had inclusion and exclusion criteria, the wounds selected were not standardised for comparative groups or comparative studies. We classified the wounds according to their location (thigh, knee, leg, ankle, and heel) and etiology (surgical wounds vs traumatic wounds) to address heterogenicity. In our study, we had 20 patients with complex infected lower limbs orthopaedic wounds. A different approach was attempted in the management of these wounds by using NPWTi as an effective adjuvant therapy to aid with infection eradication and promotion of wound healing. Finally, with its unique features and ability to reduce the bacterial load in complex wounds, NPWTi can serve as a successful tool in the management of complex orthopaedics wounds with potential benefits of cost reduction and a decrease in the need for multiple debridement procedures.

NPWTi is still considered a novel technique that can be used in the management of complex wounds; the goal of our prospective study was to report our experience with NPWTi in the management of complex infected orthopaedic lower limb wounds. Randomised control studies with optimally matched wounds comparing NPWTi to the conventional methods of treatment are warranted.

CONFLICT OF INTEREST

This study was supported by an Investigator-Initiated Research Grant from KCI USA, Inc. JDC reports the following disclosures: Bonesupport (consultant), Smith&Nephew (consultant), Zimmer Biomet (consultant), Biocomposites (fellowship support), and the University of Florida (spouse receives royalties). The following organisations supported the corresponding institution's annual course (the Baltimore Limb Deformity Course) for orthopaedic surgeons: Biocomposites, DePuy Synthes Companies, MHE Coalition, Orthofix, OrthoPediatrics, Pega Medical, Smith & Nephew, Stryker, and Zimmer Biomet (all authors).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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How to cite this article: Elhessy AH, Chaudhry AR, Hammouda AI, Giacobbe SD, Gesheff MG, Conway JD. Experience with negative-pressure wound therapy with instillation in complex infected orthopaedic wounds. *Int Wound J*. 2021;18:902–908. https://doi.org/10.1111/iwj.13592