The Use of Negative Pressure Wound Therapy with an Automated, Volumetric Fluid Administration: An Advancement in Wound Care

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Management of acute and chronic wounds requires a comprehensive assessment of both patient and wound condition before determining an optimal treatment approach. Patient stabilization is critical prior to implementing a wound management plan, as well as addressing factors that may impair or delay wound closure, such as poor circulation, edema, infection, diabetes mellitus, immobilization, anemia, use of steroids, age, smoking, obesity, coagulopathy, and vasculitis.
Negative pressure wound therapy (NPWT) is an example of active wound-healing technology that has proven effective at facilitating wound closure by promoting tissue granulation, increasing angiogenesis and perfusion, decreasing edema, and removing infectious materials.4-10 In addition, NPWT with instillation (NPWTi) has added automated intermittent irrigation with topical fluids, such as saline, antibiotics, and antimicrobials, to cleanse the wound.11-23 NPWTi has been used as an adjunctive therapy in the management of patients with infected wounds associated with osteomyelitis, diabetes, skin/soft tissue, endoprostheses, and implants.11-23 Studies have shown that adjunctive NPWTi can be effective in reducing bioburden, resolving clinical infections, assisting stalled wounds, and treating painful wounds and wounds at a high risk for major amputation.22-23

An article from 2004 presented a series of case studies on wounds that had stalled in the healing process after use of traditional NPWT, but dramatically improved after switching to NPWTi.22

In the first case, a 41-year-old male presented with osteomyelitis of the right foot and after 21 days of traditional NPWT, plus antibiotics and hyperbaric oxygen therapy, there was only a small area of the wound that showed healthy granulation tissue (Figure 1A). On the day NPWTi was initiated, wound cultures were positive for methicillin resistant Staphylococcus aureus (MRSA) and Klebsiella pneumonia. However, after 7 days of
NPWTi, the wound was nearly 100% filled with granulation tissue (Figure 1B). After 11 days of NPWTi, wound cultures showed only normal flora.22

In the second case, a 62-year-old female presented with an open infected saphenous vein donor site wound from a previous coronary artery bypass graft wound. Wound cultures were positive for *Pseudomonas aeruginosa*. After 11 days of traditional NPWT (Figure 2A), the decision was made to switch to NPWTi due to the persistence of a densely adherent gelatinous material in the wound. After 3 days of NPWTi, the wound showed improved healing, and the gelatinous material was now completely gone (Figure 2B). After 12 days of NPWTi, the wound appeared cleaner with healthy granulation tissue present.22 Both of these cases demonstrate the ability of NPWTi to initiate healing of a stalled wound and should be considered for high-risk wounds, based on expert panel recommendations.20

The next generation of NPWTi combines traditional NPWT with automated, controlled volumetric delivery and removal of topical wound solutions to the wound bed (NPWT/NPWTi, V.A.C.Ulta™ Negative Pressure Wound Therapy, KCI USA, Inc, San Antonio, TX). Improvements to the NPWTi system include a microprocessor/pump that provides automated, volumetric administration of fluid, and enhanced dressings specifically designed for instillation.

This pilot study describes the author’s initial experiences in a consecutive series of patients using the new NPWTi system and advanced reticulated open-cell foam (ROCF) dressings. Case evaluations demonstrating these novel applications also are summarized.

### Methods

The manufacturer’s recommended guidelines for use of all NPWT products were followed. The new NPWTi system was used. Patients were selected if they were candidates for instillation therapy, which included infected or contaminated wounds (Patients 1, 2, and 3); wounds with an exposed foreign body (ie, abdominal wall mesh, Patients 4 and 6); and a wound at high risk for requiring a major amputation due to the extent of the wound and risk factors for the patient (Patient 7). Patient 5 was chosen specifically to compare granulation tissue between the Dressing C and Dressing B. Six wounds received NPWTi while 1 wound was administered traditional

### Table 1. Patient Information.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (Years)</th>
<th>Gender</th>
<th>Wound Type</th>
<th>Therapy</th>
<th>Solution Instilled</th>
<th>Pressure Setting</th>
<th>Method of Closure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>Male</td>
<td>Contaminated complex chest wall wound</td>
<td>NPWTi/Dressing A and B</td>
<td>Microcyn®</td>
<td>-125 mm Hg</td>
<td>Secondary</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>Male</td>
<td>Open infected hip wound</td>
<td>NPWTi/Dressing A and B</td>
<td>Microcyn®</td>
<td>-125 mm Hg</td>
<td>Secondary</td>
</tr>
<tr>
<td>3*</td>
<td>83</td>
<td>Male</td>
<td>Open postoperative contaminated wound at a previous ileostomy site</td>
<td>NPWTi/Dressing A and B</td>
<td>Microcyn®</td>
<td>-125 mm Hg</td>
<td>Secondary</td>
</tr>
<tr>
<td>4</td>
<td>26</td>
<td>Female</td>
<td>Open abdominal wound with exposed biological mesh</td>
<td>NPWTi/Dressing A</td>
<td>¼ strength Dakin’s solution</td>
<td>-100 mm Hg</td>
<td>Primary</td>
</tr>
<tr>
<td>5*</td>
<td>34</td>
<td>Female</td>
<td>Open subcutaneous abdominal wound after peritonitis surgery</td>
<td>NPWT/Dressing C and Dressing B</td>
<td>None</td>
<td>-125 mm Hg</td>
<td>Secondary</td>
</tr>
<tr>
<td>6*</td>
<td>32</td>
<td>Male</td>
<td>Bowel perforation and several subsequent surgeries for abdomen wash out</td>
<td>NPWTi/Dressing A</td>
<td>Microcyn®</td>
<td>-125 mm Hg</td>
<td>Delayed Primary</td>
</tr>
<tr>
<td>7*</td>
<td>70</td>
<td>Male</td>
<td>Open infected transmetatarsal foot wound with osteomyelitis</td>
<td>NPWTi/Dressing A</td>
<td>Microcyn®</td>
<td>-125 mm Hg</td>
<td>STSG</td>
</tr>
</tbody>
</table>

*Indicates case evaluations described below.
NPWT alone. Microcyn® antiseptic solution full strength (Oculus Innovative Sciences, Petaluma, CA) was used as the instillation fluid in 5 wounds. Quarter strength Dakin’s Solution® (Century Pharmaceuticals, Indianapolis, IN) was used in 1 wound. Choice of solution is typically left to the discretion of the treating physician. The author prefers the full-strength antiseptic solution due to its broad-spectrum activity against bacteria and yeast, and the fact that it has virtually no side effects as well as a high safety profile. Patient 4 was treated by a physician other than the author, and the quarter-strength solution was that physician’s preference. Patient wounds included critically colonized/infected wounds (abdomen, hip, a postoperative abdominal and foot, and a complex wound of the chest wall), along with a wound with an exposed biologic abdominal wall mesh. All data were analyzed by the author.

In this patient series, instillation was repeated every 2-4 hours with a 5-10 minute soak time followed with negative pressure at -100 mm Hg to -125 mm Hg. Therapy was discontinued when the patient’s wound was ready for further surgical procedures, the patient was transferred out of the acute care setting, or the wound had progressed to a point that a less advanced wound treatment modality could be used. To investigate if a difference in granulation tissue formation and wound progression could be observed, 1 additional wound received traditional NPWT, with half of the midline abdominal wound filled with Dressing C and the other half of the wound with Dressing B.
Patients were followed until their wounds healed (Patients 3, 4, and 5); the patient moved out of state (Patient 6); died (Patient 1); or had an additional surgery and was subsequently followed by a plastic surgeon (Patient 2). Patient 7 is currently still being followed. Patient 1 died of medical issues unrelated to wound treatment with NPWTi.

**Results**

Six of the seven patients in this study were treated with the new NPWTi system with total length of therapy ranging from 7 days to 54 days. One patient was treated with traditional NPWT. The ages of the patients (2 females, 5 males) ranged from 26 years to 83 years. All wounds were closed by split-thickness skin graft (STSG) or primary, secondary, or delayed primary intention. No complications occurred during the study. Table 1 lists patient demographics and therapy parameters.

**Case Study 1** (Patient 3 in Table 1). An 83-year-old male presented with an open postoperative contaminated wound at a previous ileostomy site (Figure 3A). NPWTi with Dressings A and B was initiated, and the full strength antiseptic solution was instilled until the foam was filled, followed by a soak time of 10 minutes (Figure 3B). Instillation was repeated every 4 hours followed by continuous negative pressure at 125 mm Hg for a total of 12 days (Figure 3C). Therapy was discontinued when the patient transitioned out of the acute care setting and the wound could be treated with local wound care alone (Figure 3D). No complications occurred during therapy.

**Case Study 2** (Patient 5 in Table 1). A 34-year-old female patient presented with an open subcutaneous abdominal wound after surgery for peritonitis (Figure 4A). Dressing C was placed in half of the wound, and Dressing B was placed in the other half of the midline incision with 125 mm Hg continuous negative pressure (Figure 4B). Therapy was continued for 10 days (Figure 4C) and stopped when the wound could be treated with local wound care alone. Appearance was similar in both halves of the wound at the completion of NPWT (Figure 4D), and final healing rates of both halves were similar.

**Case Study 3** (Patient 6 in Table 1). A 32-year-old male patient was involved in a motor vehicle accident. He was diagnosed with a colon perforation and underwent a Hartman’s procedure. The patient had several subsequent surgeries to wash out his abdomen; at the final
surgery, his abdomen wall was closed with a biological mesh bridge (Strattice™, LifeCell, Branchburg, NJ) (Figure 5A). He was originally treated using traditional NPWT over the exposed mesh for 14 days but was switched to NPWTi and Dressing A (Figure 5B). No interface layer was used between the foam and the mesh. A full strength antibacterial solution was instilled until the foam was filled, followed by a soak time of 10 minutes. Instillation was repeated every 4 hours followed by continuous negative pressure at 125 mm Hg for 8 days. After 8 days of instillation (with 2 dressing changes) (Figure 5C), surgery was performed to accomplish delayed primary skin closure of the open abdominal wall wound (Figure 5D). Thereafter, NPWT was applied, at -100 mm Hg, over the closed incision line (Figure 5E) for 4 days postoperatively until the first dressing change. The wound was successfully healed on postoperative day 4 (Figure 5F).

Case Study 4 (Patient 7 in Table 1). A 70-year-old male patient was transferred to the author’s facility with an open infected transmetatarsal foot wound (Figure 6A) with associated osteomyelitis. He had previously undergone 2 unsuccessful attempts to open an occluded by-pass graft in the same leg. Necrotic tissue was removed from his foot, resulting in an open transmetatarsal amputation. Hyperbaric oxygen, intravenous antibiotics, and local wound care were initiated. Recommendations were made for a below-knee amputation. NPWTi with Dressing A was initiated (Figure 6B) and antiseptic solution at full strength was instilled until the foam was filled, followed by a soak time of 10 minutes. Instillation was repeated every 2 hours followed by continuous negative pressure at -125 mm Hg for 17 days (Figure 6C). There were 6 dressing changes prior to the patient receiving a STSG (Figure 6D). The STSG was bolstered us-
Transmetatarsal foot wound.

Figure 6a. Infected wound after open transmetatarsal amputation.

Figure 6b. Application of NPWTi/Dressing A.

Figure 6c. Wound after 17 days of NPWTi/Dressing A.

Figure 6d. Wound status improved sufficiently to allow for a split-thickness skin graft.

Figure 6e. Application of NPWT.

Figure 6f. At time of discharge, patient was able to stand and ambulate out of hospital.

Figure 6g. Wound at 8 weeks postoperatively.

Figure 6h. Nearly completely healed wound at approximately 6 months postoperatively.

Figure 6i. Wound has remained healed more than 1 year later.
ing traditional NPWT at -100 mm Hg continuous therapy with a nonadherent layer between the graft and Dressing C for 4 days (Figure 6e). The patient was discharged 6 days later (Figure 6f) and was able to ambulate out of the hospital. The wound continued to heal (Figure 6g) and achieved near complete closure approximately 6 months post-operation (Figure 6h). More than 1 year later, the wound has remained healed. (Figure 6i).

Discussion

This report demonstrates the application and benefits of administering NPWTi to patients with a wide variety of complex wounds.

Previously, gravity-fed adjunctive NPWTi/Dressing C was shown to improve wound healing in contaminated/infected or stalled wounds or in wounds with exposed foreign bodies or hardware.\(^{11-23}\) The author’s experience utilizing NPWTi in the case evaluations presented here further supports this technical approach in specific clinical settings of complex wound treatment.

Previous studies have demonstrated the successful utilization of adjunctive NPWTi for managing patients with infected wounds.\(^{15,16}\) In a pilot study by this author,\(^{12}\) NPWTi was used on 5 patients with a compromised health status, and with contaminated or infected wounds, some in patients who were immunosuppressed. In 2 of the patients, wound improvement was noted after switching their initial therapy from traditional NPWT to NPWTi. Bernstein and Tam\(^{12}\) reported on 5 postsurgical diabetic foot wounds associated with osteomyelitis and treated with adjunctive NPWTi. Both of these studies used locally applied antibiotics in the instillation solution, which facilitated the reduction of wound bacterial bioburden. Other studies have shown the use of NPWTi to manage larger cohorts of patients with infected wounds. Gabriel et al\(^{13}\) reported successful use on a study of 15 patients with complex, infected wounds treated with NPWTi using locally administered silver nitrate and systemically administered antibiotics. Although the types of instillation and NPWTi administration parameters (ie, instillation solution, temporal parameters, and negative pressure settings) differed among studies, these authors independently concluded that adjunctive NPWTi proved beneficial in terms of facilitating wound healing, which supports the current findings in this case series, and proved helpful when utilized in patient populations with significant co-morbidities.

Conclusion

Overall, the author’s experience has shown this new NPWT/NPWTi system to be effective at managing complex wounds, as wound healing was achieved in all patients. Also, no complications were noted in this case series. Ease of use was improved in the initial set-up and management of NPWT with automated volumetric fluid instillation. The enhanced microprocessor unit allows for timely and volumetric administration of the fluid. The drape has a proprietary adhesive that is more effective in maintaining a seal around the wound and decreasing leaks during the instillation function. Additional improvements to the NPWTi system were two open cell reticulated foams that promote granulation tissue and are more hydrophilic. Limitations of this study included a small number of patients, lack of controls, and different wound types. More studies with larger numbers of patients, including a control group, are needed to further understand the benefits of this new NPWTi system when used in diverse wound types.

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References


