Use of Negative Pressure Wound Therapy in the Treatment of Neonatal and Pediatric Wounds: A Retrospective Examination of Clinical Outcomes

Mona Mylene Baharestani, PhD, ANP, CWOCN, CWS

The clinical effectiveness of negative pressure wound therapy for the management of acute and chronic wounds is well documented in the adult population, but information regarding its use in the pediatric population is limited. A retrospective, descriptive study was conducted to examine the clinical outcomes of using negative pressure wound therapy in the treatment of pediatric wounds. The medical records of 24 consecutive pediatric patients receiving negative pressure wound therapy were reviewed. Demographic data, wound etiology, time to closure, closure method, duration of negative pressure wound therapy, complications, dressing change frequency, dressing type used, and pressure settings were analyzed. All categorical variables in the dataset were summarized using frequency (count and percentages) and all continuous variables were summarized using median (minimum, maximum). The 24 pediatric patients (mean age 8.5 years [range 14 days to 18 years old]) had 24 wounds — 12 (50%) were infected at baseline. Sixteen patients had hypoalbuminemia and six had exposed hardware and bone in their wounds. Twenty-two wounds reached full closure in a median time of 10 days (range 2 to 45) following negative pressure wound therapy and flap closure (11), split-thickness skin graft (three), secondary (four), and primary (four) closure. Pressures used in this population ranged from 50 to 125 mm Hg and most wounds were covered with reticulated polyurethane foam. One patient developed a fistula during the course of negative pressure wound therapy. When coupled with appropriate systemic antibiotics, surgical debridement, and medical and nutritional optimization, in this population negative pressure wound therapy resulted in rapid granulation tissue and 92% successful wound closure. Future neonatal and pediatric negative pressure wound therapy usage registries and prospective studies are needed to provide a strong evidence base from which treatment decisions can be made in the management of these challenging cases, especially pertaining to the safety and efficacy of pressure settings, dressings, and interposing contact layer selection.

KEYWORDS: negative pressure wound therapy, pediatric wound care, vacuum-assisted closure


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The normally rapid wound healing response of pediatric patients can be delayed by a number of factors, including impaired perfusion, infection, prolonged pressure, edema, poor nutrition, and the wound's macro- and micro-environments. Delays in pediatric wound healing can result in increased mortality and morbidity, increased hospital length of stay, and heightened anxiety levels for patients, families, and clinicians. The pediatric element of wound care requires special expertise, precise management, and a clear understanding of the diverse developmental characteristics of each age segment. Distinct intricacies of the neonatal and pediatric populations, such as integumentary immaturity, a high body surface/weight ratio, sensitivity to pain, increased potential for percutaneous absorption, and an immature immune system create an additional level of complexity in treating pediatric wounds. A difficult paradox exists — a dearth of clinical data upon which to guide evidence-based practice in neonatal and pediatric wound care remains.

Limited empirical data are evident in all areas of neonatal and pediatric wound care. Although negative pressure wound therapy (NPWT) has not formally been evaluated in pediatric patients through controlled clinical trials, more than 18 case series and reports have been published supporting its use in this population. The clinical effectiveness of NPWT for the management of acute and chronic wounds is well documented in the adult population. The clinical benefits of NPWT in the management of acute and chronic wounds when compared to standard care and to modern dressings has been documented in the adult population through 13 published randomized controlled clinical trials. While a modulation in bacterial species with a decrease in nonfermentative negative rods to an increase in *Staphylococcus aureus* in NPWT-treated wounds has been reported in some studies, this has not negatively impacted granulation tissue formation or wound healing rates.

Subatmospheric pressure applied to the wound site induces tissue microdeformations that may activate intracellular pathways and upregulate growth factor release. Wound exudates are removed, decreasing inhibitory mediators and matrix metalloproteinases. A proliferation of granulation tissue, an increased rate of contraction through reversed-tissue expansion, and enhanced wound healing with application of the therapy has been shown in multiple studies.

Although the number of publications focusing on pediatric wound care has been increasing over the past 2 years, a need exists for NPWT guidelines with specific focus on the pediatric population. Pediatric-specific clinical practice guidelines would provide practitioners an evidence base from which decisions could be made in the safe and efficacious selection of pressure settings, foam type, dressing change frequency, and interposing contact layer selections.

The aim of this study was to evaluate the clinical outcomes of using V.A.C." Therapy (KCI, San Antonio, Tex) in the treatment of wounds in neonates and children.

**Methods**

A non-randomized retrospective chart review was conducted of 24 consecutive neonatal and pediatric
patients who had received NPWT for management of their wounds. Criteria for inclusion into this retrospective analysis were patients aged 21 years and younger who had received NPWT from 1999 to 2006 at the Schneider Children’s Hospital, New Hyde Park, NY. Patients who met criteria were identified through the Director of Wound Healing’s dedicated vacuum-assisted closure (V.A.C.”) usage database. A master list was provided to the Medical Records department within the hospital. Medical records (MR) were abstracted and data fields were electronically populated. Each patient was assigned a number from 1 to 24 in the order in which the MR was received. All patient data were de-identified and HIPAA compliant.

Demographics, wound etiology, number of NPWT treatment days, closure outcome, dressing change frequency, type of NPWT dressing used, pressure settings, and complications for each patient were entered into the electronic database.

**Patient set.** During initial medical record abstraction, a total of 26 pediatric patients (age range 14 days through 18 years) were identified. Two patients were in multisystem organ failure at the time NPWT was initiated; both expired after a collaborative parental/medical decision was made to withdraw all life-sustaining support. These two patients were excluded from the data set. Each infant had received a total of 3 days of NPWT, one having achieved 100% granulation during that time and the other 5% granulation along the periphery of a Gore-Tex mesh (WL Gore and Associates, Flagstaff, Ariz). Neither patient experienced any complications directly associated with the use of NPWT. The final sample size was 24.

**Additional treatment.** All patients in the dataset received nutritional supplementation as needed. Baseline albumin levels and type of nutrition were recorded in the electronic database. All patients were hospitalized during the entire course of NPWT with the exception of one 6-year-old girl who was followed as an outpatient. She had a lateral malleolar pressure ulcer and was able to ambulate with the use of braces. Her leg braces had been refitted to ensure that pressure was not exerted on the wound site. The patient used the portable MiniV.A.C.” therapy unit (KCI, San Antonio, Tex). The other 23 patients were bed- or crib-bound unrelated to NPWT. All hospitalized patients were on pressure redistribution surfaces as appropriate and turning and repositioning was performed at regular intervals.

**Data entry.** Baseline wound dimensions were entered into the electronic database when they were available in the MR. However, in the majority of cases, wound dimensions were not consistently recorded in the MR; therefore, wound size was excluded from the outcome analyses. The presence of infection at the initiation of NPWT was recorded in the database. Wound infection was determined based on swab culture results coupled with observation of clinical signs. Osteomyelitis was diagnosed based on bone biopsy, magnetic resonance imaging (MRI), or indium scan. Systemic antibiotics were administered in cases of wound infection and osteomyelitis. Antibiotic type and dosage were not recorded in this database.

**Data analysis.** Data analysis was performed using the SAS statistical analysis system V9 (SAS Institute Inc., Cary, NC). Wounds were classified into six different groups (see Table 1) and further subclassified according to FDA-defined pediatric age subgroups 42,43 (see Table 2). Clinical outcomes data were analyzed for the entire sample and per etiology group. Additional evaluation was performed for each type of NPWT dressing used to present data on efficacy and safety. All categorical variables are expressed as frequency, while continuous variables are expressed as the median and range unless otherwise stated.

**IRB approval.** Institutional Review Board (IRB) approval was obtained through the North Shore-Long Island Jewish Health System to perform this study, meeting criteria outlined in the Code of Federal Regulations 45 CFR 46.101 and 21 CFR 56.101.

**Results**

Of the 24 pediatric patients treated using NPWT, 14 were female (58%) and 10 were male (42%). Their median age was 11 years (range 14 days to 18 years). Table 2 shows the number of
patients treated within each specific pediatric age group. The median patient weight was 38.7 kg (range 2.6 to 68 kg). The most common wound type in this evaluation was traumatic with exposed hardware and bone (see Table 1). All patients with wound infections and osteomyelitis were treated with systemic antibiotic therapy. At baseline, 12 patients (50%) had infected wounds; of those, 11 (92%) healed completely and the wound bed of the one remaining patient was 80% covered with granulation tissue before rehabilitation transfer. All of the six patients (25%) who presented with osteomyelitis at baseline healed. Sixteen patients (67%) were hypoalbuminemic. Reticulated polyurethane GranuFoam® (KCI, San Antonio, Tex) was the most common NPWT dressing used (n = 18, 75%), followed by polyvinyl alcohol V.A.C.® WhiteFoam (KCI, San Antonio, Tex) (n = 5, 21%) and the V.A.C. GranuFoam Silver (KCI, San Antonio, Tex) (n = 1, 4%). All chest wounds were treated with the white foam. Xeroform (n = 2, 8.3%) and Vaseline™ gauze (n = 5, 21%) (both products of Tyco Health Care/Kendall, Canton, Mass) were used as contact layers for seven (29%) of the 24 patients; the remaining 17 patients did not have a contact layer.

Of the 24 wounds, 22 closed in a median time of 10 days (range 2 to 45 days). Of those, 11 were closed by flap (45.8%), three by split-thickness skin graft (12.5%), four secondarily (16.7%), and four primarily (16.7%). The wounds of two patients (8.3%) were granulating but not closed before transfer to rehab. In these two patients, 100% and 80% granulation, respectively, was achieved at the point of discontinuation of NPWT (see Table 3 for treatment days and closure outcomes by etiology).

The most common wound etiology treated was trauma with exposed hardware and bone (n =

<table>
<thead>
<tr>
<th>Wound Classification</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed hardware</td>
<td>6</td>
<td>25.0%</td>
</tr>
<tr>
<td>Newborn</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Infant</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Child</td>
<td>3</td>
<td>50.0%</td>
</tr>
<tr>
<td>Adolescent</td>
<td>3</td>
<td>50.0%</td>
</tr>
<tr>
<td>Abdominal wound dehiscence</td>
<td>4</td>
<td>16.7%</td>
</tr>
<tr>
<td>Newborn</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Infant</td>
<td>1</td>
<td>25.0%</td>
</tr>
<tr>
<td>Child</td>
<td>2</td>
<td>50.0%</td>
</tr>
<tr>
<td>Adolescent</td>
<td>1</td>
<td>25.0%</td>
</tr>
<tr>
<td>Compartment syndrome (LE)</td>
<td>3</td>
<td>12.5%</td>
</tr>
<tr>
<td>Newborn</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Infant</td>
<td>1</td>
<td>33.3%</td>
</tr>
<tr>
<td>Child</td>
<td>2</td>
<td>66.7%</td>
</tr>
<tr>
<td>Adolescent</td>
<td>2</td>
<td>66.7%</td>
</tr>
<tr>
<td>Lumbar/sacral wounds</td>
<td>5</td>
<td>20.8%</td>
</tr>
<tr>
<td>Newborn</td>
<td>1</td>
<td>20.0%</td>
</tr>
<tr>
<td>Infant</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Child</td>
<td>1</td>
<td>20.0%</td>
</tr>
<tr>
<td>Adolescent</td>
<td>3</td>
<td>60.0%</td>
</tr>
<tr>
<td>Sternal wounds</td>
<td>4</td>
<td>16.7%</td>
</tr>
<tr>
<td>Newborn</td>
<td>4</td>
<td>100%</td>
</tr>
<tr>
<td>Infant</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Child</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Adolescent</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Degloving injury</td>
<td>2</td>
<td>8.3%</td>
</tr>
<tr>
<td>Newborn</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Infant</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Child</td>
<td>2</td>
<td>100%</td>
</tr>
<tr>
<td>Adolescent</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pediatric Subgroup</th>
<th>Age Range</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn</td>
<td>Birth to 1 month of age</td>
<td>4</td>
<td>16.7%</td>
</tr>
<tr>
<td>Infant</td>
<td>&gt;1 month through ≤2 years</td>
<td>3</td>
<td>12.5%</td>
</tr>
<tr>
<td>Child</td>
<td>&gt;2 years through ≤12 years</td>
<td>8</td>
<td>33.3%</td>
</tr>
<tr>
<td>Adolescent</td>
<td>&gt;12 years through ≤21 years</td>
<td>9</td>
<td>37.5%</td>
</tr>
</tbody>
</table>
6, 25%); all six patients in this subgroup were male with a median age of 12 years (11 to 16). The median time on NPWT for this subgroup was 9.5 days (range 5 to 42 days) — all of these wounds reached full closure (one by secondary intention, the others [83%] by flap). These wounds were located either on the leg (n = 6, 25%) or lumbar region (n = 3, 50%). Five of the six wounds with exposed hardware were infected at baseline. The median baseline area of the six wounds was 22.4 cm².

Four wounds (17%) treated were secondary to abdominal dehiscence; their median baseline area was 16.4 cm². All were treated at a continuous NPWT setting with pressures ranging from 50 to 125 mm Hg. All four wounds reached 100% granulation. The median time on NPWT was 7.5 days (range 5 to 45).

The anatomical distribution included legs (nine, 37.5% — see Figure 1), lumbar/sacral (seven, 29.2% — see Figure 2), abdomen (four, 16.7%), and chest (four, 16.7%). The mean treatment days were 10.9 (range 5 to 31), 18.3 (range 10 to 42), 16.3 (range 7 to 45), and eight (range two to 14) by anatomical location of leg, lumbar-sacral, abdomen, and chest, respectively. Negative pressure wound therapy dressings were changed every 24 hours for two patients (8.3%), every 48 hours for 11 (45.8%), every 24 to 48 hours for eight (33.3%), and every 24 to 72 hours for three (12.5%). The frequency of dressing changes was individualized based on patient age, concern regarding in-tissue growth, underlying structure, status of underlying tissues, and presence of infection. In cases where wound infection was present or concerns regarding excessive tissue ingrowth into the foam existed, dressings were changed every 24 hours. Otherwise, dressings were changed predominantly every 48 hours.

Negative pressure wound therapy pressure settings selections were 50, 75, 100, and 125 mm Hg for four (16.7%), four (16.7%), four (16.7%), and 12 (50%) patients, respectively. The mean patient age of those receiving NPWT of 50, 75, 100, and 125 mm Hg was 3.4 weeks, 1.7 years, 10.3 years, and 13.3 years, respectively.

Baseline albumin levels of 16 out of the 24 (67%) pediatric patients were below the normal range for their age group. In the presence of hypoalbuminemia, 15 (94%) achieved 100% granulation and 14 (88%) achieved complete closure. Fifteen patients (62.5%) were on non-restricted diets; six (25%) were on total parenteral nutrition (TPN) (of which 67% were hypoalbuminemic), and three (12.5%) received enteral feedings (33.3% were hypoalbuminemic).

One critically ill hypoalbuminemic neonate on TPN developed an enterocutaneous fistula over a prior distal ileal anastomotic site during the course of NPWT. This patient’s abdominal wound was

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**TABLE 3**

<table>
<thead>
<tr>
<th>Negative Pressure Wound Therapy Days, Wound Closure Method, and Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Etiology</strong></td>
</tr>
<tr>
<td>Exposed hardware and bone</td>
</tr>
<tr>
<td>Abdominal wound dehiscence</td>
</tr>
<tr>
<td>Compartment syndrome</td>
</tr>
<tr>
<td>Superficial sternal wound (sternum intact)</td>
</tr>
<tr>
<td>Pressure ulcer</td>
</tr>
<tr>
<td>Degloving injury</td>
</tr>
<tr>
<td>Necrotizing fascitis</td>
</tr>
<tr>
<td>Deep sternal wound (exposed pericardium)</td>
</tr>
<tr>
<td>Flap dehisced</td>
</tr>
</tbody>
</table>

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protected with an interposing contact layer and received negative pressure at a continuous setting of 75 mm Hg using a white foam dressing. This patient achieved 100% granulation of the wound bed after 43 days on NPWT.

Discussion

Although most available literature describes its use in the adult population, NPWT has been used to treat pediatric wounds since its introduction a decade ago.5–22 Clinicians have historically applied the therapy on pediatric wounds using basic principles derived from adult clinical trials, case series, and their own experience. This knowledge transfer is often employed in pediatric wound care, based on the understanding that pediatric patients follow the same wound healing trajectory as adult patients. In general, this transposition of NPWT knowledge from adult to pediatric practice has yielded positive results both in the author’s own practice and in the published literature.

Results of this non-randomized, retrospective, descriptive study should be interpreted cautiously but they are promising. Complete wound closure was achieved in 22 of the 24 patients who were provided NPWT. Of these wounds, 11 were closed by flap, three by split-thickness skin graft, four secondarily, and four primarily. In two patients, wound closure was not achieved while on NPWT (see Table 4).

In 18 cases, NPWT was discontinued when 100% granulation was achieved; then, definitive surgical closure was performed. In four cases treated with NPWT until secondary closure, these infants/children were treated until their wounds were 100% granulated to skin level, contracted, and >99% epithelialized. Two patients with pressure ulcers were transferred to rehabilitation units.

Figure 1. Fasciotomy wound (s/p compartment syndrome). A) Before NPWT; B) NPWT Day 1; C) NPWT Day 26.

Figure 2. Fasciotomy wound (s/p compartment syndrome). A) Before NPWT; B) NPWT Day 8; C) NPWT Day 21.
before their wounds achieved complete closure; they exhibited 100% and 80% granulating wound bases, respectively.

One patient died of multisystem organ failure following completion of the therapy. The death was unrelated to NPWT and the patient’s wound had been successfully and uneventfully closed previously by split-thickness skin grafting.

Fistula development. The one complication reported in the study was an enteric fistula that developed during the course of NPWT. The fistula occurred in a 36-week-old male infant with an abdominal wound dehiscence. The infant was closely monitored in the NICU and the pediatric surgical team provided meticulous NPWT applications. Fistula development is a rare but previously reported complication of NPWT.43,44 However, in this and other cases, determining whether the fistula is caused by NPWT, the multifactorial host risk factors, or a combination of both is difficult.

This neonate was admitted as a transfer from another hospital 2 days after birth with blood cultures positive for Escherichia coli. The neonate presented with anasarca, thrombocytopenia, and neutropenia and was urgently taken to the operating room, where a “blow-out” perforation of the distal ileum with significant stooling of the peritoneal cavity was found; no evidence of necrotizing enterocolitis was present. A distal ileal resection was performed and a mucous fistula and ileostomy created. Postoperatively, the patient was placed on a high frequency oscillatory ventilator (HFOV) for respiratory acidosis. On the fourth postoperative day, the neonate’s wound dehisced and 2 weeks later NPWT was initiated by the pediatric surgical team. The entire wound surface first was covered by a monolayer of fine-meshed, nonadherent dressing (petrolatum-impregnated gauze), followed by application of white, polyvinyl alcohol dressing. Negative pressure was applied continuously at a setting of 75 mm Hg. It would seem that the wound was adequately protected and that the pressure was not excessive. This patient presented with a high probability for fistula development with or without NPWT given his anasarca, hypalbuminemia, critical condition, and history of prior enterotomies. Despite the presence of a fistula, NPWT was continued until wound dimensions decreased, granulation tissue was well established, the patient was medically and nutritionally optimized, and surgical intervention could ensue. After 45 days of NPWT, the infant returned to the operating room for fistula takedown and a successful primary wound closure with acellular human cadaveric dermis.

Pressure setting considerations. In the author’s experience, a difference worth noting between adult and pediatric application of NPWT is a lower recommended pressure setting for the pediatric population and the need for closer monitoring for fluid loss and dehydration. Highly exuding wounds or large wounds in relation to patient size should be monitored in an intensive care setting. Negative pressure wound therapy allows for easy quantification and qualification of wound drainage, which is especially critical in managing fluid loss replacement in neonates. Decreased evaporative fluid losses from the wound bed also have been reported with this therapy.5

### TABLE 4

**CLOSURE METHODS BY WOUND ETIOLOGY**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compartment syndrome</td>
<td>3</td>
<td>12.5%</td>
</tr>
<tr>
<td>Flap</td>
<td>1</td>
<td>33.3%</td>
</tr>
<tr>
<td>Split-thickness skin graft</td>
<td>1</td>
<td>33.3%</td>
</tr>
<tr>
<td>Primary</td>
<td>1</td>
<td>33.3%</td>
</tr>
<tr>
<td>Necrotizing fasciitis</td>
<td>1</td>
<td>4.2%</td>
</tr>
<tr>
<td>Flap</td>
<td>1</td>
<td>100.0%</td>
</tr>
<tr>
<td>Open chest (sternum not intact)</td>
<td>1</td>
<td>4.2%</td>
</tr>
<tr>
<td>Flap</td>
<td>1</td>
<td>100.0%</td>
</tr>
<tr>
<td>Abdominal wound dehiscence</td>
<td>4</td>
<td>16.7%</td>
</tr>
<tr>
<td>Secondary</td>
<td>1</td>
<td>25.0%</td>
</tr>
<tr>
<td>Primary</td>
<td>3</td>
<td>75.0%</td>
</tr>
<tr>
<td>Open chest (sternum intact)</td>
<td>3</td>
<td>12.5%</td>
</tr>
<tr>
<td>Flap</td>
<td>3</td>
<td>100.0%</td>
</tr>
<tr>
<td>Degloving injury</td>
<td>2</td>
<td>8.3%</td>
</tr>
<tr>
<td>Split-thickness skin graft</td>
<td>2</td>
<td>100.0%</td>
</tr>
<tr>
<td>Exposed hardware &amp; bone</td>
<td>6</td>
<td>25.0%</td>
</tr>
<tr>
<td>Flap</td>
<td>5</td>
<td>83.3%</td>
</tr>
<tr>
<td>Secondary</td>
<td>1</td>
<td>16.7%</td>
</tr>
<tr>
<td>Flap dehisced</td>
<td>1</td>
<td>4.2%</td>
</tr>
<tr>
<td>Secondary</td>
<td>1</td>
<td>100.0%</td>
</tr>
<tr>
<td>Pressure ulcer</td>
<td>1</td>
<td>12.5%</td>
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<tr>
<td>Not closed</td>
<td>2</td>
<td>66.7%</td>
</tr>
<tr>
<td>Secondary</td>
<td>1</td>
<td>33.3%</td>
</tr>
</tbody>
</table>
Pressure settings used in this case series (see Table 5) and are consistent with other reported pediatric pressure settings in published literature. Clinical decisions regarding pressure settings were based on patient age, pain response, nutritional status, coagulatory ability, underlying structure, and type and quality of tissue over which the therapy dressing is placed. In all infant applications, the negative pressure was set at 50 to 75 mm Hg. Specifically, the lowest negative pressure of 50 mm Hg was used for both superficial (sternum intact) and deep (exposed pericardium) sternal wounds in neonates. Pain. Degloving injuries in children were managed at slightly lower pressure (100 mm Hg) than adult recommended settings (125 mm Hg) in order to address pain issues. Pain was evaluated/recorded consistent with institutional protocol. Three of the four patients with abdominal wounds secondary to dehiscence were managed at negative pressures of 75 to 100 mm Hg based on patient age, nutritional status, assessed risk for fistula development, and type of dehiscence (superficial versus complete). Compartment syndrome of the leg was managed at 75 mm Hg in a case where the patient was experiencing significant pain.

With few exceptions, adult NPWT pressure settings of 125 mm Hg were used in the treatment of adolescents. All pediatric patients were placed on continuous therapy versus intermittent due to pain sensitivity and a resulting intolerance of NPWT in the intermittent mode. Some general guidelines for pediatric pressure settings were developed in tandem with this manuscript (see Table 5).

**Dressing changes.** A major benefit of NPWT in pediatric wound management is expedited wound closure, decreased frequency of dressing changes compared to more frequent daily conventional dressing and decreased pain associated with the dressing changes. Wound assessments were performed during each dressing change. The frequency of dressing changes was individualized based on patient age,
concern regarding tissue in-growth, underlying structure, status of underlying tissues, and presence of infection. In cases where wound infection was present or concerns regarding excessive tissue ingrowth into the foam existed, NPWT dressings were changed every 24 hours. Otherwise, dressings were predominantly changed every 48 hours.

**Dressing types.** Three different types of dressings were used with NPWT in this case series: black, polyurethane ether foam (n = 18), white polyvinyl alcohol foam (n = 5), and black polyurethane ether foam microbonded with silver (n = 1). Each of the dressings was tolerated by the pediatric patients and no complications were reported with any of the dressings. All chest wounds were treated with the white foam dressing and an interposing contact layer. When the goal was to achieve a more rapid rate of granulation tissue formation, the reticulated polyurethane dressing was utilized. In cases where tunneling and/or undermining were present, the white foam dressing was utilized given its greater tensile strength. The white polyvinyl alcohol foam also is utilized as designed in situations where a more restricted rate of granulation tissue formation is desired and when protection over exposed structures is needed.

**Infection.** Half (n = 12) of the wounds in this series were noted to be infected at the initiation of NPWT. All of the patients with infected wounds received systemic antibiotic therapy in tandem with NPWT. Eleven of the twelve (92%) wounds that presented with infection at baseline achieved complete closure after treatment with systemic antibiotics and NPWT. The one remaining patient achieved 80% granulation before transfer. The six patients (25%) with osteomyelitis at baseline all achieved complete closure (see Figure 3). Similar findings were reported by Shilt et al.\(^\text{15}\) when NPWT treatment outcomes (n = 16) were compared to historical controls (wound-to-dry dressings or Xeroform gauze) in children with complex soft tissue injuries; wherein, free flaps were required in 19% of NPWT-treated patients (n = 15) versus 53% in the control arm. Patients in both the NPWT group and the control group were treated with antibiotics and none developed soft tissue infections.

**Conclusion**

Anecdotally, outcomes suggest faster wound closure with NPWT compared to other advanced and traditional methods of treating complex pediatric wounds. Implementing NPWT in pediatric and adult care has been reported to contribute to a downstaging\(^\text{45}\) of required operative procedures; in some cases at the author’s facility, it has obviated the need to return to the operating room for operative closure. Neonates, infants, children, and adolescents with diverse anatomical wounds of varying etiologies have benefited from this therapy. Consensus at the author’s institution is that this adjunctive therapy addresses many critical needs of pediatric patients and is a safe, optimal treatment for a variety of complex pediatric wounds. Additional research that documents similar findings will proliferate confidence in NPWT use.

**References**


