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Original Article

Negative wound pressure therapy is safe and useful in pediatric burn patients

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Abstract: Introduction: Negative Pressure Wound Therapy (NPWT) has proven to be a powerful tool in facilitating healing of difficult wounds of a variety of etiologies. The pediatric experience with NPWT has been limited due to concerns about vascular compression and pain associated with treatment. Method: A retrospective review was performed to evaluate the therapeutic effect of NPWT on children with difficult wounds due to burns or soft-tissue trauma. NPWT was instituted in the operating room under general anesthesia using a commercially available system. NPWT was not initiated until all necrotic material was removed from the wounds. Negative pressure applied ranged from 50-125 mmHg continuous suction, with younger children being prescribed less negative pressures. NPWT dressings were changed every 5-7 days, in the operating room. When wounds were clean and had granulated they were closed with split-thickness skin grafts. Results: 29 children with an average age of 9.34 ± 1.95 years (range 2 months to 18 years) were treated with NPWT. Average total wound size was 24.8 ± 8.9 (range 0 to 95) percent of the body surface in those patients who had suffered burns and non-burn injuries. Injury mechanisms included hot liquid (2 children), contact with hot object (4 children), electricity (7 children), flame (9 children), and other non-burn injuries such as abrasion and Stevens-Johnson syndrome (7 children). Over 90% of the patients required central venous or bladder catheters. Perceived benefits of the treatment included reduced numbers of dressing changes and more rapid wound granulation. There were no episodes of bleeding associated with NPWT. All patients healed their wounds, were successfully grafted, and survived. Conclusion: NPWT has a useful role in the pediatric burn unit in facilitating wounds healing and improving life qualities. We also found that a significant correlation between third degree burned wound size and the number of negative pressure therapies received, which indicated that NPWT could be more effective in treating complicated burned wounds. NPWT seems safe and effective when applied to well-debrided wounds. It does not seem to be associated with excessive bleeding or discomfort in children.

Keywords: Negative pressure wound therapy, burn care, pediatric care

Introduction

Burns are among the most complex form of injuries [1]. It is estimated that each year in the United States, at least 500,000 patients visit medical centers through emergency departments for burn wounds care [2]. The etiologies of burns vary across different age groups. According to the National Burn Repository, flame burns and scalding injuries account for 80 percent of etiology of burns, which mainly occur in domestic environments [2]. Children under the age of 5 are at increased risk of scalding injuries, because of limited mobility and limited understanding safety measures appropriate around flame and hot liquid [2].

The physiological and psychological trauma and financial burden resulting from burn injuries are tremendous [2]. Burn care is expensive. In 2014, for patients who were hospitalized for burn care, 96.7% of survived with average hospital costs of $86,146 [2]. For the 3.3% who were severely injured and died despite treatment, average cost per were $285,225 [2]. Patients with burn injuries become immunocompromised because of their wounds and systemic changes, which can elevate the risk for developing various complications such as sepsis, respiration failures, shock and death [2-4]. Children and adults recovering from serious burns are facilitated by prompt wound closure with supportive intensive care and nutritional support [5-7].

Negative Pressure Wound Therapy (NPWT) is a noninvasive therapy that promotes wound granulation and closure [8]. Since its first applica-

Figure 1. Application of negative pressure wound therapy on burned wounds. The occlusive dressing is wrapped over the wound area while connecting to the vacuum pump.

tion in 1995, NPWT has been shown to improve wound closure by establishing a vacuum through sterilized occlusive dressing over the wound sites [9]. Negative pressure is usually maintained between -50 mmHg and -125 mmHg based on the conditions of the wounds [10]. The vacuum maintains a pressure gradient that increases blood flow and immune cells recruitment [10]. Antibiotics and saline can be applied with the therapy in selected circumstances [10]. NPWT has been applied to both acute and chronic wounds, including chronic ulcers. Compared to its conventional treatment with moist wound therapies, negative pressure therapy demonstrates higher rates of wound closure and lower risk of bacterial infections [11]. The use of NPWT has not been widely reported in children. Based on the reported experience, we propose that negative pressure wound therapy is efficient and safe in selected children with complex traumatic or burn wounds.

Methods

A retrospective review was performed to evaluate the therapeutic effect of NPWT on children with difficult wounds due to burns or soft-tissue trauma. NPWT was instituted in the operating room under general anesthesia using a commercially available system.

The vacuum pump used in this study is the KCI Negative Pressure Wound Therapy, V.A.C.® (**Figure 1**). NPWT was not initiated until all necrotic material was removed from the wounds by surgical excision. The V.A.C.® Simplace™ Dressing is a foam dressing applied to selected deep wound sites and connected to the vacuum pump. Negative pressure applied ranged from 50-125 mmHg continuous suction, with younger children being empirically prescribed less negative pressures to potentially reduce discomfort. NPWT dressings were changed every 5-7 days, in the operating room. When wounds were clean and had granulated they were closed with split-thickness skin grafts. Wound sizes and depth, length of hospital stay, number of operating room visits, ventilator days, and intensive care units days were recorded. One way analysis of variance, 2 sample t test, and correlation regression were used to analyze the data.

Results

29 children, 12 females and 17 males, with an average age of 9.34 years (range 2 months to 18 years) were treated with negative pressure wound therapy. Average burn size was 27.62 ± 9.83 (range 1 to 95) percent and average third degree burn size was 20.27 ± 7.58 (range 1 to 72) of the body surface (**Figure 3**). Perceived benefits of the treatment included reduced numbers of dressing changes and more rapid wound granulation. There were no episodes of bleeding associated with NPWT. All patients granulated their wounds, were successfully grafted, and survived. **Table 1** and **Figure 2** demonstrate patient demographics, injury levels, and the types of treatments received by the pediatric patients. NPWT use increased during the interval of time, presumably as staff became more comfortable with the safety and efficacy of the therapy in children. The most common age range was 10-15 years and most common mechanism was electrical or mechanical soft tissue injury.

Burns etiologies included flame (3 children), electrical burns (7 children), hot liquids (2 children), contact (4 children), electrical with secondary clothing ignition (6 children), and other non-burn mechanical soft-tissue injuries such as abrasions and degloving trauma (7 children).

Discussion

Length of hospital stays and mortality for burns has decreased in recent decades. Nevertheless, many challenges remain in helping patients

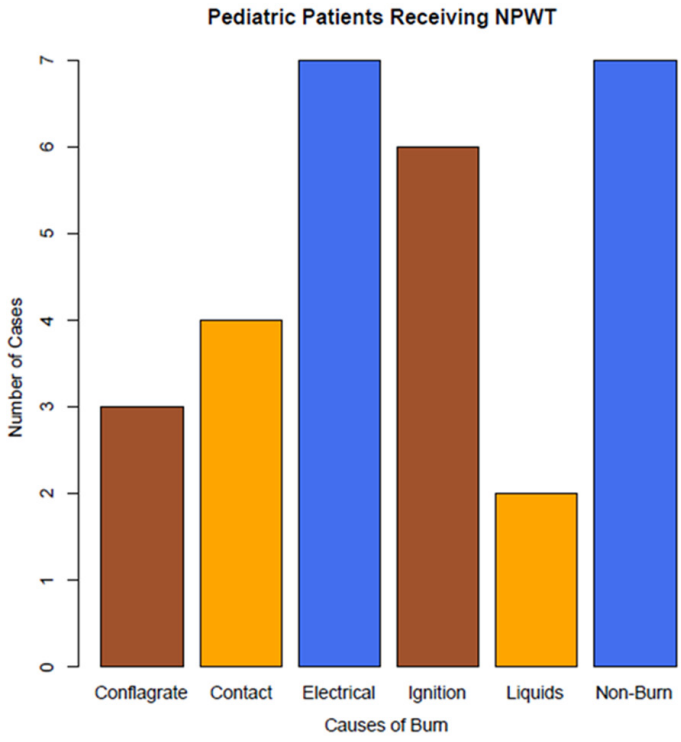

Figure 2. Burn injury etiologies. Histogram demonstrates the number of patients in each burn injury etiology. From left to right: flame, contact, electrical, electrical with clothing ignition, hot liquid burns, and other trauma.

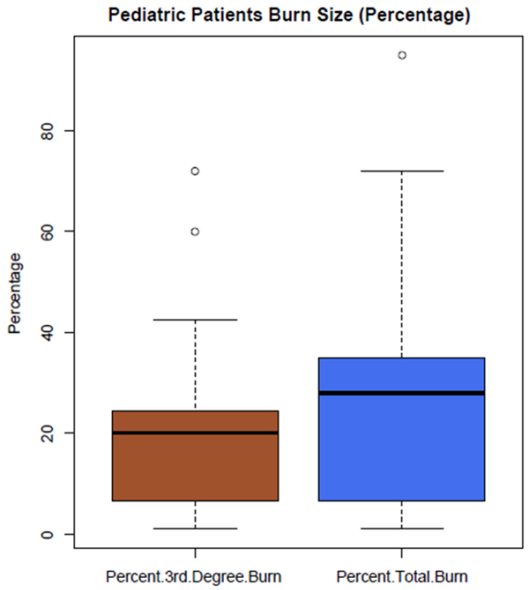

Figure 3. Burn size. Box plot demonstrates the percent of third degree burns (median 20%) and the percent of total burn areas (median 28%).

fully recover from their injuries. Prompt closure of very deep localized wounds remains a problem that often extends hospital stays. Any therapy that can reduce healing time of such difficult wounds would be useful.

A currently available commercialized form of negative pressure wound therapy is Vacuum Assisted Closure Therapy (VAC®, Kinetic Concepts Incorporated, San Antonio, TX), which has been increasingly used in treating complex wounds, diabetic ulcers, and open abdominal cavities [11, 12]. Previous research has demonstrated that when applying NPWT to patients with chronic ulcers, the rates of tissue granulation greatly increased while the risk of tissue necrosis declined [11]. Patients with diabetic foot ulcer who underwent 4 months of active NPWT showed a significant increase in wound healing rates and reduced needs for lower extremity amputations [12]. When compared to patients who underwent moist wound therapies, patients who received negative pressure therapy exhibited a greater chance of complete diabetic wound healing and shorter times to healing [13]. NPWT therapy was shown to decrease the volume and the depth of diabetic ulcers beyond that of traditional moist gauze dressings, lowering the risk of bacterial and fungal infections in these wounds [14]. NPWT has proven useful in controlling sepsis and tissue necrosis after laparotomy [15, 16]. Comparative study also indicates that patients who were recovering from primary abdominal wall reconstruction surgery exhibited decreased risk of skin dehiscence, hernia, and other common post-surgical complications when treated with incisional Negative Pressure Wound Therapy [17, 18]. Recently, the efficacy of NPWT in controlling acute phase infections and improving skin healing was suggested among patients with blunt trauma and lower extremities fractures [18].

Although NPWT has proven to be an advantageous tool in closing various wounds, there are still concerns about potential side effects [18]. There have been reports of high levels of pain associated with NPWT, particularly when negative pressure was set above 125 mmHg [19]. Due to reports of ischemia in patients after

Table 1. Negative pressure therapy and other treatments length

	Cases	Mean ± SEM	Median	Interquartile Range
Age	29	9.43 ± 2.03	10.25	7.29
% Total Burn size	26	27.62 ± 9.83	28	27.88
% 3rd degree Size	25	20.27 ± 7.58	20	18
Length of Stay	29	45.93 ± 12.19	44	44
OR Visits for NPWT	29	7.52 ± 1.56	8	6
Ventilation Days	27	4.56 ± 4.48	0	0.5
ICU Days	27	14.37 ± 6.34	8	23
Central Venous Catheter Days	26	17.96 ± 8.26	8	29.5
Foley Catheter Days	26	8.77 ± 5.50	2	9.75

Negative Pressure Therapy Summary: It shows the general information on burn wound sizes, number of operating room visits, and other treatments received by the patients.

receiving NPWT, physicians have been cautious when applying negative pressure in pediatric patients [20]. Children may be more prone to vascular compression related to negative pressure, causing insufficient blood flow and loss of sensations in local wound sites [21].

Our review demonstrated the safety and efficacy of negative pressure therapy in children with localized complex wounds. Study limitations included its retrospective nature and small numbers of patients. A controlled study would be ideally performed. However, our date demonstrate that negative pressure wound therapy can be safely and effectively utilized in managing localized deep wounds in children.

Disclosure of conflict of interest

None.

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