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The Use of Negative Pressure Wound Therapy in Infected Burn Wounds: Bridging the Gap

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ABSTRACT

Background: Burns represent one of the most devastating modes of trauma with significant morbidity and mortality. Despite advances in burns care, infection remains one of the leading causes of death. Burn excision is mandatory in infected cases and need to be temporarily covered with allografts, however this is not available in many settings. Negative pressure wound therapy (NPWT) has become an integral part of wound management, and is being used in burns with different indications.

Objective: The use of NPWT as a temporary coverage after excision of infected burns for wound bed preparation before autografting, and to compare the outcomes with those of early excision and grafting.

Patients and Methods: Ten patients with 15 burn wounds were allocated to 2 groups; group A patients presented late with infected burns while group B presented early. Group A had excision followed by NPWT and autografting when ready, and Group B had early excision and grafting. Both groups' outcomes were compared in terms of wound size, graft take and laboratory markers.

Results: Both groups included different mechanisms of burns, various age groups, total burn surface area (TBSA) up to 30%. Most Group A patients had a reduction of wound size (mean 5.1%) with using NPWT, and the average graft take was 83.9% and 85% for Group A and Group B respectively. Inflammatory markers were reduced in Group A patients, who also showed an increase in serum albumin compared to Group B.

Conclusions: NPWT should be considered for temporary coverage after excision of infected burns before autografting. It may minimize the size of the wound, and can increase graft take that can be comparable to cases excised and grafted early. Further work is needed to assess NPWT against allografts in infected burns, and to investigate its use with early excision.

Key Words: *Negative Pressure – Burns – Infection – Grafts.*

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INTRODUCTION

Burn injuries are a worldwide burden and are responsible for morbidity and mortality in the acute phase, as well as long term functional, aesthetic and psychosocial consequences **[1]**.

Burn infections and sepsis are the main cause of mortality after the resuscitation phase. Preventative measures include prompt and efficient burn resuscitation, strict infection control, and early excision and coverage of deep burns **[2]**. The treatment of confirmed burn infections includes early recognition, fluid resuscitation, commencement of appropriate antibiotics, and source control which usually involves excision of the infected burn wounds **[3]**.

However, immediate coverage with skin grafts in these cases is not always possible due to questionable wound bed, possible need for further excision, or due to the suboptimal general condition of the patient **[4]**.

While dressings can be used, allografts are preferred as they provide a form of temporary coverage, fight infection, and are a good test for graft take. Unfortunately, allografts are not available in many countries due to cultural, logistic, or economic reasons **[5]**.

Negative pressure wound therapy (NPWT) is a well-established modality in wound management **[6]**. Several studies have reported the use of NPWT in burn wounds, but very few have discussed its use as a form of temporary coverage after excision **[7]**.

The aim of this study was to explore the use of NPWT after infected burn wound excision when local or general conditions were not suitable for immediate autografting, and to compare the outcomes with those of standard early excision and autografting.

PATIENTS AND METHODS

This was a prospective comparative study that was carried out at Kasr Al-Aini Burn Unit over a one-year period. Patients who had a delayed presentation with infected burns were assigned to the NPWT group A, while patients who had early excision and grafting done were used for comparison and assigned to group B. All burns were either full thickness or deep partial thickness burns requiring excision, and included all age groups. Exclusion criteria were burns of the head and neck, total burn surface area (TBSA) more than 30%, patients in irreversible septic shock, and those with known coagulopathies.

NPWT Group A patients usually had a delayed presentation and showing clinical and laboratory signs of burn wound infection. After initial assessment, fluid resuscitation was done as needed and patients were commenced on empiric intravenous antibiotics according to microbiology advice until swab culture results were obtained. Excision of the infected burn was performed according to the depth of infected tissues; haemostasis was achieved by adrenaline-soaked gauze or electrocautery. When indicated, antimicrobial dressings were used to dress the wounds until NPWT was applied. NPWT was used in all cases using sterile sponge rather than gauze, and the pressure setting was fixed at -125mmHg in the intermittent mode. Wounds were checked every 72 hours in the operating room under a general anaesthetic or sedation, and the size of the wound and condition of the wound bed were documented. Further excision was done if needed, and NPWT was reapplied until the patients' general condition was corrected and the wound bed was ready for autografting. On the other hand, Group B patients presented early within 24 hours of the burn injury, and were assessed and resuscitated according to guidelines. Burns that required excision were excised and grafted within one week.

For both groups, split thickness skin grafts (STSG) were harvested using a power dermatome and expanded with a mesher device. Grafts were secured with staples and covered with paraffin gauze and bulky absorbent dressings as a bolster. Graft check was done at day 3, and subsequent dressings planned according to wound status with documenting any signs of infection. Graft take was recorded at 10 days, as percentage of the grafted surface area.

All patients had full blood work done including complete blood count (CBC), C-reactive protein (CRP), and serum albumin; and these were followed-up during the course of treatment. Blood transfusion requirements were also recorded for both groups, and length of stay (LOS) at hospital was documented upon discharge. Data collected was analysed using IBM SPSS statistics (Statistical Package for Social Sciences) software version 18.0, IBM Corp., Chicago, USA 2009; where the level of significance was taken at p-value <0.050.

RESULTS

This study included 20 patients with a total of 30 wounds. They were divided into two study groups: Group A included 10 patients with 15 wounds that were managed using negative pressure wound therapy (NPWT); and Group B included 10 patients with 15 wounds that underwent early excision and immediate autografting. Both groups included male and female patients, and the mean age for group A and group B was 19.6 years (range 1-45y) and 16.5 years (range 1-50y) respectively. Different mechanisms of burns were represented in both groups, with more flame and electric burns in group A, and more scald burns in group B. Total burn surface area (TBSA) had a median value of 16.5% (range 5.0-30.0%) for group A, and 15.2% (range 5.0- 25.0%) for group B. The depth of burn was matched between the two study groups as all wounds were either full thickness or deep dermal burns, all of which required excision (Table 1).

Table (1): Demographics and Wound Characteristics in both groups.

	Group A (NPWT) (N=10)	Group B (N=10)	
Age (years):			
Mean ± SD	19.6±14.6	16.5±22.0	^
Range	1.0-45.0	1.0-50.0	0.715
Sex:			
Male	8	4	#
Female	2	6	0.170
Mechanism of burn:			
Scald	2	4	#
Flame	4	3	0.735
Electric	4	3	
TBSA %:			
Mean ± SD	16.5±9.0	15.2±6.5	^
Range	5.0-30.0	5.0-25.0	0.717
Degree of burn:			
Deep Partial Thickness	0	2	#
Full Thickness	10	8	0.473

^Independent *t*-test. #Fisher's Exact test. *Significant.

All patients in group A (NPWT) had a delayed presentation with an average of 10 days post burn (range 7-18 days), while all patients in group B presented within 24 hours of the burn injury. Burn wounds were excised between day 1 and day 5 post-presentation (mean 2.7 days) in group A, while in group B burn wounds were excised between day 3 and day 7 post-presentation (mean 5 days). In group B, excision and grafting was done in the same session, while in group A, NPWT was applied on the burn wound after excision at 4-7 days post-presentation and was kept on the wound for a mean of 12.7 days (range 7-27 days) until the wound bed was suitable for grafting. This made the time to grafting in group A at a mean of 17.1 days post-presentation (range 11-32 days). Tangential excision was used in all wounds of group B while in group A it was used in 13 wounds (87.0%), and fascial excision used in the other 2 wounds (13.0%).

In group A where NPWT was used, the study showed that the mean TBSA was 16.5% (range 5.0%-30.0%) before NPWT application, while after NPWT it reached 13.4% (range 2.0%-20.5%) with a mean reduction in size of 5.1% (Fig. 1). This reduction in wound size was observed in 9 patients (Fig. 2). As for graft take, the study demonstrated that the average graft take in group A was 83.9% (range 60%-95%) as compared to 85% (range 70%-98%) in group B. No wounds needed re-grafting among the two studied groups, and no signs of gross infection were noted (Fig. 3).

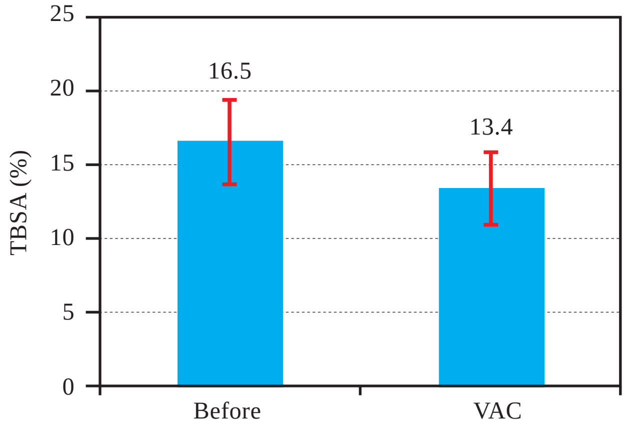

Fig. (1): Mean TBSA% changes before and after application of NPWT in Group A patients.

Fig. (2): 1 year old male patient with a delayed presentation of full thickness scald burn that was complicated by infection: (A): Upon presentation. (B): After fascial excision. (C): After NPWT for 17 days showing wound size reduction. (D): STSG at 10 days showing 90% take.

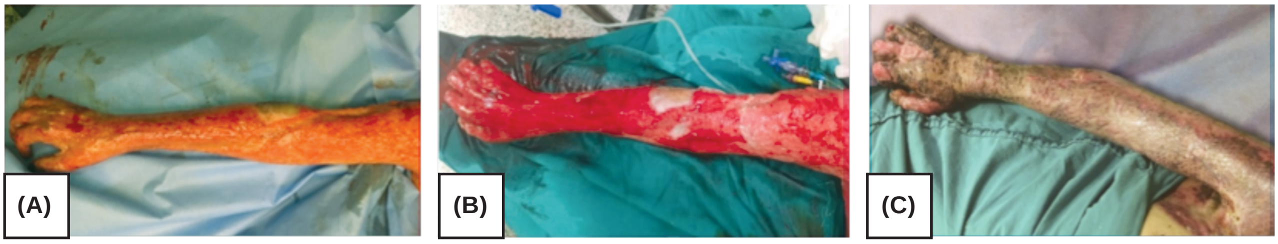

Fig. (3): 28-year-old female patient with a delayed presentation of infected full thickness flame burns: (A): 2 days after burn excision. (B): 15 days after NPWT application showing healthy granulation tissue. (C): STSG at 2 weeks with more than 95% graft take.

The mean value was calculated for all recorded laboratory parameters. For group A, it was calculated before application of NPWT (4 to 7 days post-presentation) and during use of NPWT (7 to 27 days). While in group B, it was calculated before early excision and grafting (3 to 7 days post-presentation) and during the postoperative period (average two weeks post-grafting). The recorded values showed that the mean haemoglobin levels increased in 4 patients among group A (40%), while in group B all patients showed decreased haemoglobin levels after intervention. However, this comparison was confounded by blood transfusion requirements that, although did not reach statistical significance, was slightly higher in group A where 6 patients were transfused versus 4 patients in group B.

As for inflammatory markers, there was a significant difference in the drop of white blood cell (WBC) count between the two groups in favour of group A where 8 patients (80.0%) showed a decreased mean WBC count during use of NPWT versus 5 patients (50.0%) in group B after the procedure. All patients in group A showed a decrease in CRP levels compared to 5 patients (50.0%) in group B, this being statistically significant. (*p*-value 0.0325). Mean serum albumin levels increased more frequently in group A (6 patients) when compared to group B (4 patients), however this difference was not significant. Length of stay (LOS) in hospital was comparable between the two study groups where the mean LOS in group A was 25 days (range 21 days - 42 days) and 22.7 days (range 12 days - 47 days) in group B.

DISCUSSION

Burns are among the most complex form of injuries and have a major impact on society, however the evolution of burn treatment has led to a major decrease in the mortality rates [8].

The biggest impact on survival, however, has been the shift in the approach to deep burn wound management. While in the past full thickness burns were left to spontaneously separate, today early excision and grafting has become the standard procedure as until the burn is covered, the patient will be left in a hypermetabolic state, immunocompromised, and liable to life threatening infections [9]. Despite all these advances in burns management, infection is still a major cause of mortality in the burn patient [10].

Although the management of the infected burn patient can be daunting, it would usually involve source control by excision of the burn in addition to some form of coverage either permanent or temporary. The standard protocol in many burn units is to cover these wounds with allografts as a preparatory stage before skin autografting. Allografts will serve to achieve temporary cover, combat infection, and to test the preparedness of the wound bed for graft take while allowing time for stabilisation of critical patients [11]. Harvesting cadaveric allograft in Egypt is currently not acceptable due to cultural and legislative reasons, and obtaining imported allografts is faced with economic and administrative challenges, in addition to lack of the facilities for storage and screening of cadaveric skin. The standard treatment of delayed septic burns with excision and application of allografts is therefore not possible.

Since its introduction, NPWT has become a popular and widely accepted method of wound management. Several studies have reported their experience using NPWT in management of burn wounds, and systematic reviews have been conducted [12,13]. While some studies assessed the use of NPWT in the management of acute burns [14], most studies have used it as a bolster dressing over STSG or dermal substitutes [15,16,17]. Others have also investigated the use of NPWT as a form of an all-body dressing in large burns [18,19] and as a dressing over STSG donor sites to promote healing [20]. Recently, NPWT with instillation has been used in management of complex infected wounds [21,22]. This was used in burns in only one case study that reported successful management of extensive infection of a skin graft [10].

However, according to a systematic review, there was very limited data about the use of NPWT to bridge the gap between excision and coverage of burns [23]. Although a few studies have used NPWT as a bridging therapy before grafting in burn patients, they have not applied this after excision of infected burns [24,25].

Sahin et al., [24] had used NPWT in four patients after excision of fourth degree burns in the extremities mostly after high voltage electrical injury. They reported good outcomes in terms of wound bed preparation, and achieved complete closure by grafting in most cases within 50 days.

Teng [25] had similarly used NPWT after excision of deep burns in five patients who were victims of an explosion. Successful grafting by Meek technique was done when the wound bed was ready, however there was no data regarding time to healing. Both these studies used NPWT after early excision of non-infected burns, and did not present control groups.

Our study aimed to investigate the use of NPWT as a form of temporary coverage after excision of delayed infected burns, to give a chance to optimise both the general condition of these patients, and of the wound bed in preparation for autografting. In the absence of a true control group for these patients due to lack of allografts in Egypt, the study used the known standard management of acute burns using early excision and autograft for comparison. Although these are different groups in terms of time of presentation, metabolism, and infection load, the study hypothesis proposes that management of delayed infected burn wounds using NPWT may eventually achieve similar outcomes to acute uncomplicated burns treated by early excision and autografting in TBSA up to 30%. Moreover, we had realised the potential of NPWT in the management of infected burns early in comparison to repeated dressings for extended periods, and therefore found it unjust to have the latter as a control group. Each group included 10 patients with 15 wounds with a variety of burn mechanisms, although the NPWT group showed slightly more flame and electrical burns which matches groups in the similar studies [25,26].

The ages in both groups were as young as 1 year old, as there were no contraindications to the use of NPWT on paediatric patients in the light of multiple studies [26,27].

A systematic review on the use of NPWT in paediatric patients with burns reported that patients were as young as 2 months, and highlighted the advantages of being less painful and allowing earlier mobilisation when compared to regular daily dressings [28].

The current study results showed a significant reduction in wound size after using of NPWT (mean 5.1% TBSA). This reduction in wound size minimized the graft donor site size and subsequently its morbidity, and can be explained by two mechanisms. The first is that NPWT may prevent the progression of partial thickness burn injury and/or promote its healing during the course of treatment. This was observed in mixed depth wounds where unexcised deep partial thickness wound edges showed accelerated healing with NPWT, and accordingly did not need grafting. A similar effect for NPWT was discussed by Kamolz et al., [14] where NPWT was compared to silver sulfadiazine (SSD) to dress patients with partial thickness burns of the hand, and reported that NPWT limited the progression of burn depth with less need for skin grafting. The second mechanism of wound size reduction is the macro-deformation effect of NPWT that is exerted on the excised wound edges, as was previously demonstrated in several studies [29,30].

Preparation of the wound bed by NPWT has been seen to improve graft take by increasing vascularity, promoting granulation tissue formation, and decreasing infection; however this was reported in wounds of different aetiologies [31]. In our study, NPWT was applied after excision of infected burns until the general and local wound conditions were favourable for grafting. Graft take after NPWT reached 95% (average 83.9%) which was comparable with graft take in cases managed with early excision and grafting (average 85%). These results confirm the other studies that showed high graft take after burn wound bed preparation with NPWT [23,24].

Further possible improvement in graft take might be achieved by applying NPWT as a bolster dressing on skin grafts which we did not explore in this study [32].

An advantage of early excision and grafting is limiting blood loss [33], and this was demonstrated in the study by the increased blood transfusion requirements in group A that had a more delayed excision. The extended use of NPWT is also expected to add to this through the repeated blood loss during dressing changes, although this output was not measured in our study. Appropriate temporary burn wound closure would need to simulate the functions of the skin in terms of homeostasis and acting as a barrier against infections, explaining why the standard of care of deep burns is excision and closure **[3]**.

NPWT seemed to achieve some of these functions, where there were no cases of gross reinfection after excision, further confirmed by the decrease in WBCs and CRP levels in this group. Serum albumin decreases with burns and sepsis, and is a predictor of morbidity and mortality in these patients **[34]**. Our results showed that serum albumin increased after covering the excised burns with NPWT, again to support control of infection and the homeostatic advantage that this technique may present. This concept of simulation to skin or its substitutes had not been discussed in the literature for burns patients.

This study was not without limitations, the most important of which would be the number of cases that need to be increased to reach more reliable conclusions. A more accurate comparison would also need to be done with a group managed by allografts as a temporary cover after excision of infected burns. In addition, bacterial counts pre and post excision, and during the course of NPWT application, may present a more objective method to demonstrate clearance of infection. Results might also need to be adjusted to %TBSA so that any cut-off points can be identified. Further, the effects of delayed grafting in the NPWT group, that had exceeded one-month post-burn in some cases, had not been followed up enough to be able to comment on the occurrence of contractures and on the aesthetic appearance in terms of hypertrophic scarring and keloid formation. Finally, the cost-effectiveness of this technique will need to be evaluated against the standard management of infected burn wounds in different settings.

Conclusion:

NPWT was demonstrated to be a viable option that can be considered in infected burn wounds with a delayed presentation. In addition to the known advantages in wound bed preparation and how that reflected on the wound size and STSG take, temporary coverage with this closed system may present a method to meet the homeostatic and barrier functions of autografts and allografts, allowing these compromised patients to recover. More work will need to be done to further explore the effects on hypermetabolism, that might pave the way for the use of NPWT after early excision of larger burns where STSGs are in shortage.

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