

Research Article

Effective Application and Outcome of Negative Pressure Wound Therapy in Management of Complex Wounds with External Fixator

Lubna Maqsud Cheema,¹ Zahid Tayyab,² Sobia Manzoor,³ Romaisa Shamim Khan,⁴ Muhammad Mustehsan Bashir,⁵ Sehrish Ijaz⁶

^{1,6}Department of Plastic Surgery, KEMU/ Mayo Hospital, Lahore

Abstract

Background: Negative pressure wound therapy (NPWT) has been commonly used in the management of complex traumatic wounds of extremities. It reduces oedema, increases perfusion and enhances granulation tissue formation. But presence of external fixator makes it difficult to apply and maintenance of seal in presence of external fixator thus affecting wound healing.

Objective: To study the effective application and outcome of NPWT in the management of complex wounds.

Methods: Retrospective study conducted in Department of Plastic and Reconstructive Mayo Hospital/KEMU over a period of 2 years (June20- June 22). All patients presenting with wounds on either upper or lower limb with external fixator applied during this period were included. After wound debridement NPWT was applied according to our technique. Demographic data of patients, mode of injury, time of presentation after injury and site/size of wound were noted. Outcome of seal (Effective maintenance of suction pressure at the completion of NPWT application and Seal failure as loss of suction within 72 hrs) , no. of NPWT sessions and outcome of wound (skin grafting/flaps) were documented.

Results: In this study, total number of patients was 26. Seventeen were (65.4%) males and 9(34.6%) females. Mode of injury was road traffic accident (69.8%) and machine injury (30.8%). Mean age was 23±14.2 years. Mean wound size 31.3±12.6 in2. Mean time of presentation after injury was 11.8±6.14 days. In 3 patients seal was not maintained. In 23 patients seal was maintained. Skin grafting was done in 21 patients and local/distant flaps in 5 patients.

Conclusion: NPWT has been in use for the management of wounds for many years. But problem arises in its application over wounds with external fixator. There are chances of air leakage and difficulty in maintaining seal. With our technique of application, we have been able to manage this problem. It is a simple, quick and inexpensive technique with overall good results. Use of this technique minimizes the use of major local and free flaps for soft tissue coverage of limbs.

Corresponding Author | Dr. Lubna Maqsud Cheema, Assistant Professor of Plastic Surgery, KEMU/ Mayo Hospital, Lahore.

Email: llubnacheema@gmail.com

Keywords | Complex wounds, NPWT, External fixator, VAC Seal, Skin grafting.

Introduction



Production and Hosting by KEMU

<https://doi.org/10.21649/akemu.v29i2.5505>

2079-7192/© 2023 The Author(s). Published by Annals of KEMU on behalf of King Edward Medical University Lahore, Pakistan.

This is an open access article under the CC BY4.0 license <http://creativecommons.org/licenses/by/4.0/>

Complex wounds present a challenge to the surgeon in operative management, long term care and cosmetic as well as functional outcome. The term complex wound is a wound involving multiple tissues and frequently do not heal in timely manner or fail to heal completely.¹ In recent years, NPWT has been shown to

be effective therapy for the management of large and complex wounds. But it is difficult and time consuming to use it in presence of external fixator.² Hardware used for external fixator interferes with maintaining seal which leads to air leakage.

First described by Argenta and Morykwas in 1997,³ since then it has been widely used in different specialities for wound management. Basic mechanism of NPWT is by mechano-transduction and micro deformation leading to cellular proliferation under hypoxia stress providing an environment for angiogenesis.^{4,5,6} NPWT causes reduction of wound size /volume, faster wound healing, enhancement of graft take, reduction of complications and also minimise the number of local and free flaps.

Many people have described different methods of dealing with this problem of applying NPWT over external fixator. Caputo et al has used colostomy paste to seal the points where they come in contact with drape.^{8,9} Fan and colleagues have used bone wax alone, bone wax versus colostomy paste and found later better.¹⁰

The fact that so many varied methods are described to find solution to this problem demonstrate the need of quick, effective and reliable method to apply NPWT in such patients. More over NPWT application and seal maintenance is difficult in wounds where a bi-planar fixator is in place. This can affect the outcome in patients with bi-planar external fixator. In this study we present our method of application of NPWT that ensures an effective seal around soft tissue wounds in a very simple way. Also sub-group analysis of outcome in patients with uni-planar versus bi-planar external fixators is presented.

Methods

It is a Retrospective study. Data was collected from medical records of the patients. All the patients of either gender and age having post traumatic wounds on upper or lower limb with external fixator were included. Patients with non-traumatic wounds, exposed vessels and nerves were not included in the study. Patients admitted both from emergency and outpatient department were included. Demographic data of patients, mode of injury, time of presentation after injury, dimensions of wound, application of uni -planar or bi-planar external fixator and days of hospital stay were noted. Wound size was measured by graph paper. Outcome of seal, no of NPWT sessions, complications(pain, bleeding and skin mace-

ration) due to NPWT application and outcome of wound (skin grafting/flaps) were noted. Vascularity of limb was monitored after NPWT application. Over all NPWT seal and wound outcome along with Sub-group analysis of outcome in patients with uni-planar and bi-planar external fixator was done.

Data Analysis was done with SSPS 21 version software. Qualitative data like gender and mode of injury site of wound, will be presented in the form of frequency and percentage. Quantitative data like age of patients, number of NPWT sessions, Mean days of NPWT application presented the form of mean \pm S.D. T-test was applied for quantitative data and chi-square test was applied for qualitative data in sub-group analysis.

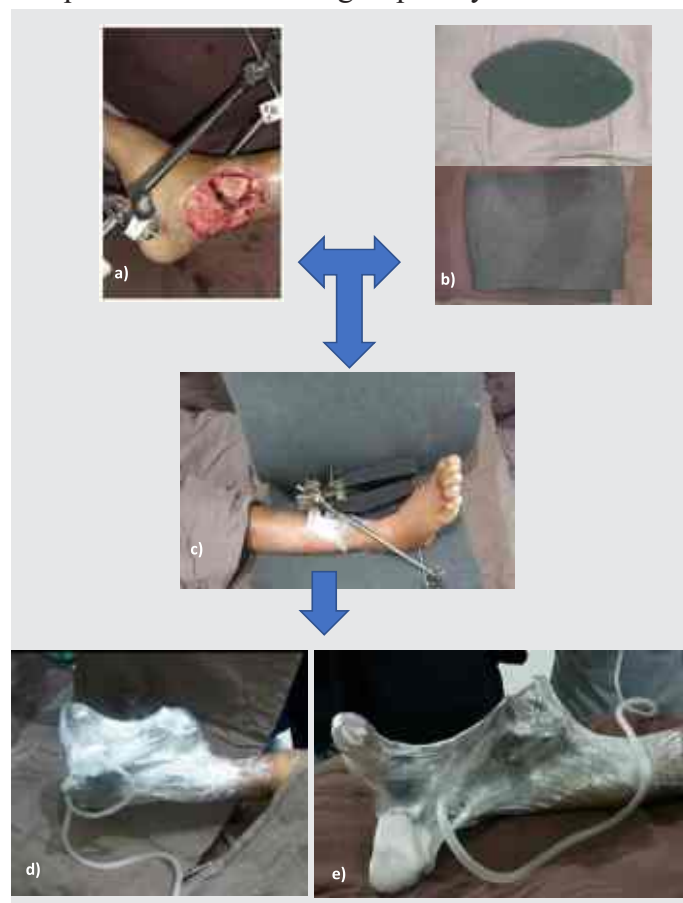


Figure 1: a) Wound after debridement b) Shapes of foams used for application on wound c) Foam placement in two layers. Inner foam directly on wound. Outer foam covering the external fixator. d) & e) Cling film application to seal the foam dressing followed by application of suction to confirm seal.

After base line workup wound debridement was done, all the necrotic tissue was removed and wound edges cleaned. Two foams were used (Figure 1): one foam present in NPWT kit was applied directly over the wound and second sterilized large foam was applied

circumferentially around the fixator including 3-4cm of surrounding healthy tissue (Figure 2). Cling film was then applied around the outer foam to make an effective seal (Figure 3). Pressure of 90-100mm Hg was applied to outer foam. It was removed on 3rd day. After removal of NPWT wound was washed thoroughly and if required it was reapplied.

Results

A total of 26 patients were included in this study. Seventeen (65.4%) Male and 9 (34.6%) female patients. Eleven patients had age < 15 years and 15 patients had age > 16 years. Mean age was 23±14.2 years. Age range was

Table 1: Main Clinical Features

Patient characteristics	Uni-plane Fixator (%)	Bi-plane Fixator (%)	Total (%)	P value
Patient Number	16 (61.5)	10 (38.5)	26 (100)	
Age of Patient				
≤15 years (9.91 ± 2.9)	7 (43.7)	4 (40)	11 (42.3)	0.8
>16 years (33.3± 10.6)	9 (56.3)	6 (60)	15 (57.7)	
Gender				
Male	10 (62.5)	7 (70)	17 (65.4)	0.6
Female	6 (37.5)	3 (30)	9 (34.6)	
Clinical data				
Cause of injury:				
Road traffic accident	12 (75)	6 (60)	18 (69.2)	0.4
Machine injury	4 (25)	4 (40)	8 (30.8)	
Duration of wound:				
≤7 days	13 (31.2)	3 (30)	16 (23.1)	0.008
>8 days	3 (18.8)	7 (70)	10 (38.5)	
Site of wound:				
Hand, Wrist and forearm	6 (37.5)	3 (30)	9 (34.6)	0.6
Foot, Ankle and leg	10 (62.5)	7 (70)	17 (65.4)	
Dimensions of wound:				
≤ 25 Inch ²	7 (43.7)	4 (40)	11 (42.3)	0.1
25-50 Inch ²	7 (43.7)	5 (50)	12 (46.2)	
> 50 Inch ²	2 (12.6)	1 (10)	3 (11.5)	
Depth of wound:				
Exposed muscle	5 (31.2)	2 (20)	7 (26.9)	0.5
Exposed bone	11 (68.8)	8 (80)	19 (73.1)	
Surgery data				
No. of NPWT sessions:				
≤ 2	5 (31.2)	2 (20)	6 (23.1)	0.03
2-4	9 (56.3)	4 (40)	14 (53.8)	
>5	2 (12.5)	4 (40)	6 (23.1)	
Complications				
Pain	9 (56.3)	4 (40)	13 (50)	---
Bleeding	1 (6.25)	---	1 (3.8)	
Macerated skin	7 (43.7)	4 (40)	5 (19.2)	
None	9(56.25)	5 (50)	14(53.84)	

Table 2: Outcome Data

Characteristics	Uni-plane Fixator (%)	Bi-plane Fixator (%)	Total (%)	P value
Effectiveness of NPWT seal:				
Yes	16 (100)	7 (70)	23 (88.5)	0.08
No	---	3 (30)	3 (11.5)	
Coverage option used:				
Split skin grafting	15(93.7)	6(60)	21 (84.6)	
Flap coverage	1(6.25)	4 (40)	5(23.07)	
Number of days of hospital stay				
15-30 days	15 (93.7)	6 (60)	21 (80.8)	0.03
>30 days	1 (6.3)	4 (40)	5 (19.2)	

5-57 yrs. Mode of injury was road traffic accident in 18 (69.2%) of cases and machine injury in 8(30.8%) of cases. Seventeen had wound at lower limb and 9 had wound over upper limb. Mean wound size was 31.3±12.6 in 2. Mean time from injury to presentation at plastic surgery department was 11.8±6.14 days. Mean hospital stay was 24.5±6.12.

Table 1 & Table 2 illustrates important results of our study and also sub-group analysis of outcome in patients with uni-planar versus bi-planar external fixators.



Figure 2: a) Post traumatic wound right medial malleolus. b) After debridement c) Wound after 2 sessions of NPWT ready for grafting. d) Wound coverage with Skin graft.

In patients with grafting there was partial loss of graft in 2 patients. In these cases, wounds were conservatively managed and skin grafting was done later. In patients with flaps distal epidermolysis in 2 cases.



Figure 3: Post traumatic wound Right arm. a) Volar aspect b) Dorsal aspect c) & d) Volar and dorsal aspect of wound after debridement followed by NPWT application e) Wound after three sessions of NPWT f) Abdominal flap elevation for coverage of wound g) Flap inset on wound h) & i) After division of flap: Volar and dorsal aspect

Discussion

High speed motor vehicles accidents are frequently associated with significant injury to both soft tissue and bone. In this scenario, open fractures are often managed with external fixator device. Traumatic soft tissue wounds with or without associated fractures, generally respond very well to NPWT with respect to reducing risk of infection and accelerating the healing process. Control of Infection and soft tissue coverage over exposed bone has a vital role in its overall outcome.



Figure 4: a) Post traumatic wound right forearm b) After debridement c) Wound after 2 sessions of NPWT ready for grafting. d) Wound coverage with Skin graft.

Use of NPWT has been well established in successful management of hard-to-heal wounds. It is used as adjunct to surgery for wide range of wounds with aim to decrease morbidities, duration of hospital and patient comfort. It promotes reduction of bacterial load, eliminates dead space and increases fluid drainage which leads to decrease in wound size and enhances wound healing thus preparing wound for spontaneous healing/ by a reconstructive option down the ladder.^{12,13,14,15} At the same time reduces the need for frequent dressing change.¹⁶ But presence of fixator and poor adherence between plastic drape and pins cause difficulty in maintaining seal. Air leakage causes continuous flow of air over the wound surface leading to tissue desiccation and formation of eschar. This eschar seals the wound with retained exudate and leads to worsening of wound. Thus affecting overall management and outcome of patients.¹⁷



Figure 5: a) Post traumatic wound right ankle b) After debridement c) Wound after 2 sessions of NPWT ready for grafting. d) Wound coverage with Skin graft.

Several studies have explored different methods to solve this problem. These include wrapping of rubber bands around pins outside the drape², use of hydro-colloid gel at pin site.¹⁹ Luigi et al used cling film around external fixator with cotton wool roll over rods and pins.²⁰ Lemmon used foam pieces particularly around prominence of pins and rods.¹⁷ According to all of these studies their methods have been effective in maintaining seal of NPWT thus improving outcome of patient, decreasing morbidity, cost and duration of hospitalization.

In our study, we used two foams, one directly over wound and second circumferentially around the fixator and then wrapped it with cling film. We found this technique very effective in maintaining seal in wounds with external fixator which had a positive effect on outcome of patient. Sub- group analysis of outcome in patients with uni-planar versus bi-planar external fixators also endorse this. Seal maintenance is difficult in patients with bi-planar external fixators. But our technique overcomes this problem and 60% of wounds were covered with graft. In one patient pin of external fixator protruded through the outer foam leading to air leakage. It was reapplied in this case with extra padding over the pins. NPWT enhances granulation tissue. Most of exposed bones were covered with healthy granulation tissue after 2-4 sessions of NPWT, 21 patients underwent grafting and only 5 patients needed flaps. (Figure 2&3). Patients in whom Flaps were done wound size was reasonably decreased. (Figure 4&5).

Conclusion

NPWT has been in use for the management of wounds for many years. But problem arises in its application over wounds with external fixator. There are chances of air leakage and difficulty in maintaining seal. With our technique of application, we have been able to manage this problem. It is a simple, quick and inexpensive technique with overall good results. Use of this technique minimizes the use of major local and free flaps for soft tissue coverage of limbs.

Ethical Approval: Given

Conflict of Interest: The authors declare no conflict of interest.

Funding Source: None

References

1. Emam AE, Khallaf AN, Attia MA. The use of negative pressure therapy for the treatment of lower extremity wounds. *AIMJ* 2020; 1 (4):1-11.
2. Sun D, Ju W, Wang T, Yu T, Qi B. Vacuum Sealing drainage therapy in the presence of an external fixator device: A case report. *Medicine* 2016; 95(46): 1-3.
3. Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method of wound control and treatment: clinical experience. *Ann Plast Surg.* 1997;38(6):563-76.
4. Agarwal P, Kukrele R, Sharma D. Vacuum assisted closure (VAC)/ negative pressure therapy (NPWT) for difficult wounds: A review. *J Clin Orthop Trauma.* 2019; 10(5):845-848.
5. Saxena V, Hwang CW, Huang S, Eichbaum Q, Ingber D, Orgill DP. Vacuum assisted closure: microdeformation of wounds and cell proliferation. *Plast Reconstr Surg.* 2004; 114(5):1086-96.
6. C Haung, T Leavitt, LR Bayer, DP Orgill. Effect of negative pressure therapy on wound healing. *Current problems in Surgery.* 2014; 51(7):301-331.
7. Dedmond BT, Kortesis B, Pungner K, Simpson J. Argenta J, Kulp B, et al. Subatmospheric pressure dressings in the temporary treatment of soft tissue injuries associated with type III open tibial shaft fractures in children. *J Pediatr Orthop.* 2006; 26(6):728-32.
8. Caputo GG, Marchetti A, Governa M, Dalla Pozza E. A novel inexpensive technique to seal Negative Pressure Wound Therapy on External Fixation Devices. *J Orthop Trauma.* 2019; 33(1):24-26.
9. Hendricks N, Hendricks J, Hoffmann K. Hemprich A, Halama D. Using medical silicone to ensure an airtight negative pressure wound therapy dressing seal in challenging wounds: A case series. *Ostomy wound manage* 2014; 60(8):40-46.
10. Bulla A, Farace F, Uzel AP, Casoli V. Negative pressure wound therapy and external fixation device: a simple way to seal the dressing. *J Orthop Trauma.* 2014; 28(7): 176-7.
11. Cheryle Nease. Using low pressure, NPWT for wound preparation & the Management of split-thickness skin graft in 3 patients with Complex Wounds. 2009; 55(6): 32-34.
12. Patro BP, Khuntia S, Sahu NK, Das G, Patra SK. Negative Pressure Wound Therapy Assisted Closure: An Effective Mode of Management for Infected and Contaminated Wound with Non-Union Fracture Femur.

- 2020; 12(7):2-7.
13. Hassan MY, Teo R, Nather A. Negative-pressure wound therapy for management of diabetic foot wounds: a review of the mechanism of action, clinical application, and recent developments. *Diabetic Foot Ankle* 2015; 6(1):1-9.
 14. M Slavkovic, D Zivanovic, S Ducic, V Lasic. Comparison of Negative Pressure Wound Therapy (NPWT) and Classical Wet to Moist (WtM) in the Treatment of Complicated Extremity Wounds in Children. *Children* 2023,10 (2),298. Doi.org/10.3390/children10020298.
 15. A Agarwal , Evolution of Negative Pressure Wound Therapy in Orthopaedic Trauma. *Journal of Orthopaedic Trauma*. 2022;6(1):54 DOI: 1097/BOT0000000000 002431.
 16. LEE, HJ., Kim, JW., Oh, CW.et al . Negative pressure wound therapy for soft tissue injuries around the foot and ankle. *J Orthop Surg Res*.2009;4(14): [https:// doi.org/ 10,1186/ 1749-799x-4-14](https://doi.org/10.1186/1749-799x-4-14).
 17. Morykwas MJ, Argenta LC, Shelton-Brown EI, McGuirt W. Vacuum-assisted closure: a new method for wound control and treatment: animal studies and basic foundation. *Ann Plast Surg*. 1997; 38(6):553-62.
 18. Jonathan V, Vijay J, Rao T, Lingam P. Use of hydrocolloid dressing to achieve seal in vacuum-assisted closure therapy in anatomically challenging regions. *J Curr Res Sci Med* 2022; 7(2):119-22.
 19. Annacontini L, Verdura V, Cecchino LR, Lembo F, Florio AM, Parisi D, et al. Cling wrap technique: An Inexpensive and simple way to Seal Negative Pressure wound Therapy on External fixator device. *J Orthop Trauma* 2021; 35(10):389-391.
 20. Lemmon JA, Ahmed J, Ghavami A, Bidic SM. Vacuum-assisted closure over an external fixation device. *Plast Reconstr Surg*. 2008;121(4):234-35.