Original Article

Journal of Trauma & Orthopaedic Surgery 2016; July - Sep; 11(3):30-34

To Study the Effects of Negative Pressure Wound Therapy on Wound Healing and Infection in Heterogenous Group of Wounds

Madhura S Kulkarni[1], Shekhar P Malve[1], Govind S Kulkarni[1], Sunil G Kulkarni[1], Ameya M Sawarkar[1], Ruta M Kulkarni[1]

Abstract

Background: *This research work focuses on the varied uses of negative pressure wound therapy (NPWT) and its advantages in wound healing and control of Infection in different types of wounds.*

Materials and Methods: *This is an observational case series of 47 patients and 49 wounds carried out from May 2013 to May 2015 with various types of Injuries (P value = 0.05). These patients were initially treated as indoor patients and later-on on follow-up. Out of the 47 patients 39 patients were males and 8 were females. Mean age of patients was 44.6 +/- 12.7 years ranging from youngest 13 years to oldest patient of 70 years. Of the forty-nine cases, twenty-six cases comprised of compound fractures and de-gloving injuries, followed by three cases of trophic ulcers and nine cases of amputation stumps of lower limb, seven cases of post-op wounds under skin tension, one case of fasciotomy wound, one case of osteomyelitis and two cases of cellulitis.*

Results: *Out of 49 cases 2 patients did not benefit from the negative pressure wound therapy (NPWT) and required amputation of the limb due to uncontrolled diabetes and other due to infection. The rest of the patients tolerated the procedure well with early further management and salvage of limb (P value = 0.05). The average hospital stay of these patients varied from 7 to 65 days with a mean of 15.5+_ 11.8 days. Nearly half of the population had pre-NPWT infection which reduced to 20% post NPWT. It was observed that the number of days in NPWT differed for the type of wound. 15 patients had 30% reduction in wound size as compared to original wound. In case of amputation stumps more than 50% (5/9) patients had more than 75% reduction in stump swelling.*

Conclusion: *NPWT can be used to treat variety of wounds with faster healing, early patient mobility, and good patient compliance. It also results in better acceptance of plastic surgery procedures like grafting and flaps.*

Introduction

Negative pressure wound therapy (NPWT) has become popular during the last decade for the management of various kinds of wounds from compound trauma to chronic ulcers to incision sites (2, 3). Historically the wounds which were life threatening have now been dealt quite easily with the use of this technique popularized by Morykwas et all(4).

Negative pressure wound therapy (NPWT) (GSK-VAC prasaditi), prepares the wound for soft tissue reconstructive procedures, prevents infection of the underlying structures and allows early fixation and mobilization of fractures.It works by macro-strain and micro-strain (Ilizarov) effect taking place at a cellular level. The interstitial fluid containing inhibitory factors is actively drained, so is the debris.

Thus Orgill et all (5) have suggested that NPWT can be primarily used for wound contraction, stabilization of the wound, reducing edema and removing wound exudates. In our study we have deduced that due to the concept and working of NPWT the patient has an early recovery, less chances of infection, and reduced hospital stay.

[1]Department of Orthopaedics Post Graduate Institute of Swasthiyog Pratishthan, Station Road, Extension Area, Miraj, Maharashtra – 416410, India.

Address for correspondence:
Dr. Madhura S. Kulkarni
Department of Orthopaedics, Post Graduate Institute of Swasthiyog Pratishthan Miraj, Maharashtra-416410
PH- +9922009981
Email.- sagitarius18@gmail.com

Aim

The growing number of trauma cases due to road traffic accidents and farm injuries requires provision for a soft tissue cover as soon as possible without giving a chance for infection. It is however not possible to achieve this due to several factors like severe contamination of the wound and medical co-morbidities delaying the surgeon from operating the patient. Delayed presentation of wounds also results in higher risk of infection. The aim of our study was to evaluate the use of NPWT on a mixed group of wounds in conjunction with debridement and asepsis for the quality of granulation tissue, hospital stay and the wound size.

Objectives

1. To assess the wounds based on the granulation tissue.
2. To observe the role of NPWT in elimination or prevention of infection.
3. To observe the duration of treatment requiring hospital stay.

Materials And Methods

This observational case series study includes 47 patients

 | pISSN 2278 – 6651

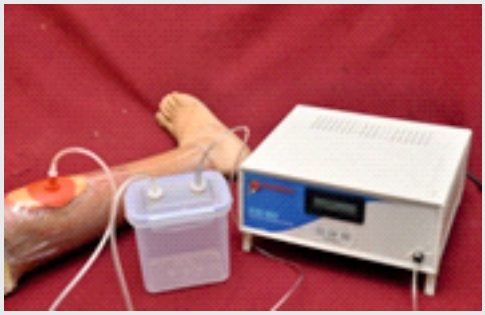

Figure 1: NPWT machine (GSK VAC Prasaditi)

Figure 2: open tibia fracture pre surgery and post grafting procedure following NPWT

and 49 wounds out of which 39 were males and 8 females. They were treated in our hospital from May 2013 to May 2015. 19 (38.7%) cases were of compound tibia fractures grade 3a and 3b. 7 (14.2%) patients had only de-gloving injuries, 3 (6.1%) patients were with trophic ulcers on the foot. 9 (18.3%) patients were selected whose amputation stumps were having sero-sanginous discharge with swelling and gape of 1 cm or more. 7 (14.2%) patients had incisions on operated distal femur plating, proximal tibia and operated acetabular fractures with skin tension unable to close primarily (6). 1 (2%) case of operated femur osteomyelitis was selected due to constant post-operative wound discharge. 2 (4%) cases of cellulitis which were debrided were also treated with NPWT prior to grafting procedures. 1 (2%) case of lower limb fasciotomy was also considered.

Inclusion Criteria (6)-

-Compound trauma grade 2, 3a, 3b (7)

-Diabetic ulcers (8, 9)

-Fasciotomy wounds (10, 11)

-Cellulitis

-De-gloving injuries

-Operated patients with post-op wound in skin tension

-Patients ready for the procedure

Exclusion Criteria

-Infants

-Patients on anticoagulant therapy,

-Abscess

-Wound with directly exposed nerves or vessels

-Untreated osteomyelitis.

Patients were selected according to the inclusion criteria.

The NPWT (GSK VAC-prasaditi) machine consists of a suction machine with an airtight canister connected to the dressing by connecting tubes (fig 1). The NPWT dressings consists of placing a sterile polyurethane ether foam of 400-600 nm pore size cut in perfect shape of the wound, on the wound. A sterile adhesive iodine drape (IOBAN) covers the sponge on the dressing with at least 5-7 cm of the normal skin (12). This sterile dressing is then stabbed in the center and a suction nipple is applied on it. The extra pieces of drape (IOBAN) are used to cover any gaps that may have been left out to make the dressing airtight. The negative pressure exerted by the machine is -125 mm to -200 mm of Hg. This pressure can be increased or reduced as per the state of the wound and age of the patient. The pressure is kept in the intermittent mode with a timer that keeps the machine on for 5 minutes and off for 2 minutes, thus in a 7 minute cycle (13). The dressing is changed at 48-72 hrs depending on the type of wound and reapplied if needed, judging the granulation status and swelling. All patients were treated with a pressure of -125 mm Hg (14).

All the patients having compound trauma were debrided immediately with temporary external fixator application after all necessary blood and X-ray investigations, under all aseptic conditions and NPWT dressing was applied. NPWT can also be applied after the bleeding from the wound reduces thus reducing the cost of repeated NPWT dressings (15). The wound was again examined for granulation, skin maceration, bleeding, infection, necrosis after 48 hours and, if needed the dressing was reapplied.

The wound was classified as per the following criteria (16)-

A- Abundant granulation tissue, adequate for closure.

B- Granulation present but inadequate for closure.

C- No granulation tissue, no gross purulence.

D- Gross purulence, infected wound, no granulation.

The granulation tissue was also judged each time after dressing removal. Patients with signs suggestive of infection were debrided to remove any possible source of infection and then this occlusive dressing was applied.

The wound is suitable for reconstructive procedures when in grade a or b. Skin grafting or flap was done with fixation done as and when suitable. Thus the patients needed 2-3 surgeries and in-patient admission of an average of 2 weeks (16).

In cases of de-gloving injuries the same protocol of investigations, immediate thorough debridement, followed by NPWT application was done.

Patients with trophic ulcers were treated after ensuring

Figure 3: post NPWT picture of diabetic wound on foot and after well healed skin graft

Figure 4: Pre and post Op wound picture after NPWT and subsequent flap.

fitness for surgery. Color Doppler was done prior to salvage procedure. After thorough debridement of the wound NPWT was applied and changed strictly after 48 hours to prevent any infection. This was accompanied with intravenous 3rd generation cephalosporin and strict control of blood sugar level.

In the cases of amputations, the stumps were not sutured due to tension in the skin and subcutaneous tissue edema. One or two stay sutures were applied. NPWT was applied if the gape was >1 cm with subcutaneous edema and serous discharge. After 2-4 days the machine was removed and secondary suturing was done with no tension and no need for revision amputation (16).

The patients treated with NPWT for post surgical incisions under tension for e.g. Proximal tibia, distal femur, operated fracture of the acetabulum responded well when secondary suturing was done after 3 days of NPWT. NPWT was applied to patients if they had Intra-operative gape of >1.5 cm and post op soakage in dressing with expulsion of blood clots with pain on post op day 2 or 3 (17). All the wounds were assessed for their wound size post debridement and after removal of NPWT. Patients were discharged once the wound had accepted the graft or flap and sutures or staples were removed. In case of incision and amputations patients were discharged after skin was closed by suturing.

All patients were followed up after every 3 weeks for 2 months after discharge then monthly for 6 months.

Case Studies

Case 1:A 55 year old female was brought to the emergency room with compound grade 3 b fracture tibia. She was taken for immediate debridement and NPWT was applied with a temporary external fixate. Her wound size reduced by 30% .She was later on treated by a split thickness skin graft and fracture fixation was done which recovered fully. (Fig2.)

Case 2: A 45 year old female came to us with a non healing ulcer on the heel. After investigating this trophic ulcer Doppler study was carried out and limb salvage decided. After debridement NPWT was applied. 3rd generation cephalosporin and repeated debridements with NPWT and grafting resulted in a successful salvage . Her wound size reduced by 30% and type D wound was converted to type B and then skin graft done. (Fig 3)

Case 3:A 65 year old male was brought to the emergency department with crush injury to the right foot. His wound reduced 45% with wound type C converted to A. He was successfully treated with NPWT and flap. (Fig4)

Case 4: A 58 year old man was in septicemia post a below knee amputation. After surgical fitness and revision amputation NPWT was kept for 3 days then removed to find that the wound size had decreased to 50% with minimal sero-sanguinous discharge. Thus the wound was closed by suturing with no tension in the skin. (Fig 5)

Results

The study consisted of 49 cases which ranged between the age group 13 years - 70 years. The average age of the study population was 44.6 ± 12.7 years.

Total hospital stay for these patients varied between 7 days - 65 days with average 15.5 ± 11.8 days. The hospital stay was more in case of post traumatic wound as compared to amputation stumps and non healing ulcers. Nearly half of the population (25/49) had pre-NPWT infection, which reduced to 20% post NPWT. (P value = 0.05)

It was noted that while only one patient had 0% reduction in the wound size, two of them on the other-hand had 100% reduction of the wound . It was observed that average hospital stay increased with number of days in NPWT dressing. Percent reduction in size of wound was maximum when number of days in NPWT was 2 days. It decreased gradually thereafter. Fig 6

There were nine cases of amputation stumps. Reduction in swelling in these patients ranged from 50-100% with more than 50% (5/9) patients having 75% reduction in swelling and two of them having 100% reduction in swelling and gape.

It was also noted that the treatment of type C wounds (no granulation but no gross purulence) had better outcome than that of type D (gross purulence) in respect to swelling, granulation tissue formation and hospital stay.

Finally it is observed that different types of wounds require NPWT application for different time periods and wound assessment too differs .(fig 7)

Complications: Twelve patients (24.4%) experienced pain while removing the dressing. Six patients (12.2%) had maceration of the surrounding skin . It was dealt with by doing a dry dressing for next 2-3 days before reapplying NPWT. Four (8.16%) patients experienced bleeding after removal of dressing attributed to the granulation tissue. It did not need any special consideration as it stopped after dry dressing. Six patients (12.2%) had persistence of infection after NPWT dressing. These patients were debrided before re-applying NPWT.

Discussion-

Since the concepts of NPWT was popularized by Morykwas et all. many research articles were published throwing light on its uses , advantages, disadvantages and mode of action (4).

The basic principle of NPWT is based on the macro-strain theory and micro-strain theory. The macro-strain states that the visible stretch that occurs on the sponge after application of negative pressure causes the edges to contract and the sub-atmospheric pressure is equally distributed over the entire area. This suction force removes all the exudates and interstitial fluid responsible for inflammation. This reduces the pressure on the micro-vessels , improving the microcirculation. The wound size too gradually reduces .(18)

The Ilizarov or micro-strain theory focuses on the stimulatory effect of negative pressure on cellular mitogenesis, angiogenesis etc. Hence slow distraction at cellular level causes tissue regeneration (19).

In our practice, the use of vacuum assisted closure has proven to have greater benefit in terms of compliance of patients with better wound healing (20).

Moues et all published a study proving wound surface area reduction but not bacterial load reduction. We have been able to prove the reduction of wound surface area reduction of >70% in 30% population and control of infection of 20% . Many documents have been able to prove that NPWT can be used for infected wounds . (21)

Various pressures can be applied to the wound from -50 to -200 mm Hg. We have applied a pressure of -125 mm Hg to all wounds intermittently. Intermittent pressure has a better result and effect than continuous use of sub-atmospheric pressure as stated by Morkywas et all (13). The granulation increases by 103% when treated with intermittent suction. Thus the need o f tissue perfusion and oxygenation which are crucial for wound healing is satisfied by NPWT.

These dressings being done once in 3-4 days decrease the load on the nursing staff as also reduces the cost required for wet to dry dressing done postoperatively as well as preoperatively. NPWT provides a cleaner and closed environment for the wound hence decreasing the chance of postoperative infection (16).

A recent study has reported deep tissue infection rate after open reduction and fixation o f tibial, pilon, calcaneal fractures (22, 23). Timmers et all have published data that suggesting that NPWT increases perfusion to the skin when applied to an intact soft tissue envelope (24-26). Many high risk post operative wound and incisions have benefited from the use of this dressing, one theory suggests that the semi rigid sponge dressing gives an added mechanical stability to the incision (27-30). According to one study by University of MMissouri, Columbia incisional NPWT should not be used in all incision but should be selected carefully for good results as wounds at different sites have different healing potential (31).

There are certain disadvantages NPWT such as maceration of the skin surrounding the dressing which can be prevented by cutting a slimmer piece of the sponge.

Figure 5: post NPWT amputation stump with 100% reduction in wound gape and discharge. follow up after 1 month

Many patients also experienced pain while removing the dressing as it is adhesive in nature. This can be reduced by applying local anesthetic jelly on the sponge covering the tissue (32). As a rule NPWT should not be a substitute for debridement, on the other hand it compliments debridement by making it better for the patient in terms of wound healing. Certain studies have failed to demonstrate that NPWT may decrease the time necessary for achieving the wound ready for closure but according to our study the time required for the wound to become healthy depends on the type of the wound and the associated infection.

The study had a few limitations with respect to patient follow up and not being a comparative study. Thus we could suggest that a prospective randomized study can be undertaken to see the difference in the granulation tissue in wounds treated with vacuum assisted closure as compared to those treated with wet to dry dressing in the hospital. Also various new types of NPWT should be researched on.

Conclusion

We have thus treated 47 patients successfully with NPWT delivered by the VAC machine with some manageable side-effects. This method of adhesive suction dressing can be used for multiple purposes ranging from compound trauma to chronic ulcers to incision sites with a few complications. It has also helped in reducing infection, swelling of wounds and in-turn resulting in shorter hospital stay.

References

1. Payne C, Edwards D. Application of the Single Use Negative Pressure Wound Therapy Device (PICO) on a Heterogeneous Group of Surgical and Traumatic Wounds. Eplasty. 2014;14:e20.
2. Birke-Sorensen H, Malmsjo M, Rome P, Hudson D, Krug E, Berg L, et al. Evidence-based recommendations for negative pressure wound therapy: treatment variables (pressure levels, wound filler and contact layer)-- steps towards an international consensus. J Plast Reconstr Aesthet Surg. 2011;64 Suppl:S1-16.
3. Vig S, Dowsett C, Berg L, Caravaggi C, Rome P, Birke-Sorensen H, et al. Evidence-based recommendations for the use of negative pressure wound therapy in chronic wounds: steps towards an international consensus. J Tissue Viability. 2011;20 Suppl 1:S1-18.
4. Morykwas MJ AL, Shelton-Brown EI, et al. Vacuum-assisted closure: a new method for wound control and treatment: animal studies and basic foundation. Ann Plast Surg. 1997;38(553):62.
5. Orgill DP, Bayer LR. Advancing the treatment options of chest wounds with negative pressure wound therapy. Ostomy Wound Manage. 2005;51 (2A Suppl): 39S-43S.
6. Schlatterer D, Webb LX. Orthopedic indications for negative pressure wound therapy. Ostomy Wound Manage. 2005;51 (2A Suppl):27S-8S.
7. Kanakaris NK, Thanasas C, Keramaris N, Kontakis G, Granick MS, Giannoudis PV. The efficacy of negative pressure wound therapy in the management of lower extremity trauma: review of clinical evidence. Injury. 2007;38 Suppl 5:S9-18.
8. Lavery LA, Murdoch DP, Kim PJ, Fontaine JL, Thakral G, Davis KE. Negative Pressure Wound Therapy With Low Pressure and Gauze Dressings to Treat Diabetic Foot Wounds. J Diabetes Sci Technol. 2014;8(2):346-9.
9. Meloni M, Izzo V, Vainieri E, Giurato L, Ruotolo V, Uccioli L. Management of negative pressure wound therapy in the treatment of diabetic foot ulcers. World J Orthop. 2015;6(4):387-93.
10. Lee JY, Jung H, Kwon H, Jung SN. Extended negative pressure wound therapy-assisted dermatotraction for the closure of large open fasciotomy wounds in necrotizing fasciitis patients. World J Emerg Surg. 2014;9:29.
11. Wilkin G, Khogali S, Garbedian S, Slagel B, Blais S, Gofton W, et al. Negative-pressure wound therapy after fasciotomy reduces muscle-fiber regeneration in a pig model. J Bone Joint Surg Am. 2014;96(16):1378-85.
12. Karadsheh MJ, Nelson J, Wilcox R. The Application of Skin Adhesive to Maintain Seal in Negative Pressure Wound Therapy. Wounds. 2015;27(9):244-8.
13. Malmsjo M, Gustafsson L, Lindstedt S, Gesslein B, Ingemansson R. The effects of variable, intermittent, and continuous negative pressure wound therapy, using foam or gauze, on wound contraction, granulation tissue formation, and ingrowth into the wound filler. Eplasty. 2012;12:e5.
14. Collinge C, Reddix R. The incidence of wound complications related to negative pressure wound therapy power outage and interruption of treatment in orthopaedic trauma patients. J Orthop Trauma. 2011;25(2):96-100.
15. Kim YH, Hwang KT, Kim JT, Kim SW. What is the ideal interval between dressing changes during negative pressure wound therapy for open traumatic fractures? J Wound Care. 2015;24(11):536, 8-40, 42.
16. Stannard JP, Volgas DA, Stewart R, McGwin G, Jr., Alonso JE. Negative pressure wound therapy after severe open fractures: a prospective randomized study. J Orthop Trauma. 2009;23(8):552-7.
17. Stannard JP, Volgas DA, McGwin G, 3rd, Stewart RL, Obremskey W, Moore T, et al. Incisional negative pressure wound therapy after high-risk lower extremity fractures. J Orthop Trauma. 2012;26(1):37-42.
18. Mendez-Eastman S. Negative pressure wound therapy. Plast Surg Nurs. 1998;18(1):27-9, 33-7.
19. Webb LX, Pape HC. Current thought regarding the mechanism of action of negative pressure wound therapy with reticulated open cell foam. J Orthop Trauma. 2008;22(10 Suppl):S135-7.
20. McNulty AK, Schmidt M, Feeley T, Villanueva P, Kieswetter K. Effects of negative pressure wound therapy on cellular energetics in fibroblasts grown in a provisional wound (fibrin) matrix. Wound Repair Regen. 2009;17(2):192-9.
21. Moues CM, Heule F, Hovius SE. A review of topical negative pressure therapy in wound healing: sufficient evidence? Am J Surg. 2011;201(4):544-56.
22. Dedmond BT, Kortesis B, Punger K, Simpson J, Argenta J, Kulp B, et al. The use of negative-pressure wound therapy (NPWT) in the temporary treatment of soft-tissue injuries associated with high-energy open tibial shaft fractures. J Orthop Trauma. 2007;21(1):11-7.
23. Mehrotra S, Anand S. Letter to the Editor: Negative Pressure Wound Therapy in Grade IIIB Tibial Fractures: Fewer Infections and Fewer Flap Procedures? Clin Orthop Relat Res. 2016.
24. Timmers MS, Le Cessie S, Banwell P, Jukema GN. The effects of varying degrees of pressure delivered by negative-pressure wound therapy on skin perfusion. Ann Plast Surg. 2005;55(6):665-71.
25. Scalise A, Tartaglione C, Bolletta E, Calamita R, Nicoletti G, Pierangeli M, et al. The enhanced healing of a high-risk, clean, sutured surgical incision by prophylactic negative pressure wound therapy as delivered by Prevena Customizable: cosmetic and therapeutic results. Int Wound J. 2015;12(2):218-23.
26. Scalise A, Calamita R, Tartaglione C, Pierangeli M, Bolletta E, Gioacchini M, et al. Improving wound healing and preventing surgical site complications of closed surgical incisions: a possible role of Incisional Negative Pressure Wound Therapy. A systematic review of the literature. Int Wound J. 2015.
27. Webb LX, Laver D, DeFranzo A. Negative pressure wound therapy in the management of orthopedic wounds. Ostomy Wound Manage. 2004;50(4A Suppl):26-7.
28. Stannard JP, Robinson JT, Anderson ER, McGwin G, Jr., Volgas DA, Alonso JE. Negative pressure wound therapy to treat hematomas and surgical incisions following high-energy trauma. J Trauma. 2006;60(6):1301-6.
29. Reddix RN, Jr., Leng XI, Woodall J, Jackson B, Dedmond B, Webb LX. The effect of incisional negative pressure therapy on wound complications after acetabular fracture surgery. J Surg Orthop Adv. 2010;19(2):91-7.
30. Manoharan V, Grant AL, Harris AC, Hazratwala K, Wilkinson MP, McEwen PJ. Closed Incision Negative Pressure Wound Therapy vs Conventional Dry Dressings After Primary Knee Arthroplasty: A Randomized Controlled Study. J Arthroplasty. 2016.
31. Suissa D, Danino A, Nikolis A. Negative-pressure therapy versus standard wound care: a meta-analysis of randomized trials. Plast Reconstr Surg. 2011;128(5):498e-503e.
32. Agrawal V, Wilson K, Reyna R, Emran MA. Feasibility of 4% Topical Lidocaine for Pain Management During Negative Pressure Wound Therapy Dressing Changes in Pediatric Patients: A Case Study. J Wound Ostomy Continence Nurs. 2015;42(6):640-2

Conflict of Interest: NIL
Source of Support: NIL

How to Cite this Article

Kulkarni SM, Malve SP, Kulkarni GS, Kulkarni SG, Sawarkar AM, Kulkarni RM. To Study the Effects of Negative Pressure Wound Therapy on Wound Healing and Infection in Heterogenous Group of Wounds. Journal of Trauma and Orthopaedic Surgery. July - Sep 2016;11(3):30-34.