

Indigenously developed Topical Negative Pressure (TNP) therapy in open fractures and infected traumatic wounds

Singh SH, Jain D, Mahindra P, Mohammad Y

ABSTRACT

Background: The occurrence of complex trauma with soft tissue complications has resulted in high number of plastic surgery procedures and interventions. The topical negative pressure (TNP) therapy is known to hasten granulation, decrease wound size and result in early wound closure. The commercially available devices for this therapy are very expensive and unaffordable for the general population. A TNP therapy was devised out of routinely available material in the hospital.

Aim: To evaluate the efficacy of indigenously developed TNP therapy.

Methods: Twenty three patients with open fractures of the long bones of the lower limb having soft tissue defect after the debridement were considered for TNP therapy. We have used regular foam, plastic tubing and sterile glass bottle used for intravenous fluids. Negative suction is through the normal wall outlet available in the hospital.

Results: The therapy was maintained for an average of 12 days (6-24), with an average of 2.7 changes of the dressing. Advantages were; decrease in number of dressings with less chance of cross infection, early granulation tissue and decrease in size of wound.

Conclusion: It is possible to have a safe and effective topical negative pressure therapy from the sterile material available in the hospital at very low cost.

Key words: vacuum assisted, wound therapy, open fractures

INTRODUCTION

Soft tissue defects have a direct impact on the length of hospital stay, secondary procedures required after fracture fixation and the eventual cost of treatment. Wound healing complications and associated infections are difficult to manage and often require plastic surgery interventions. Topical negative pressure therapy (TNP) was developed by Fleischmann in 1993 and marketed in 1995 as Vacuum Assisted Closure (VACs) system (Kinetic Concepts Inc, San Antonio, Texas, USA).^{1,2} It is known to decrease tissue edema, increase blood flow, hasten granulation, decrease wound size and result in early wound closure.^{3,4,5} It has been accepted as a valuable adjunct in management of limb trauma.⁶ However, these are very expensive and unaffordable for the general population with an average cost around five thousand per day. To address this issue, we devised a low cost TNP therapy out of routinely available material and equipment in the operation theatre and patient ward. This study evaluates the results of our indigenously designed TNP therapy in patients with open fractures and infected traumatic wounds.

MATERIAL AND METHODS

This was a prospective observational cohort study carried out in the department of Orthopaedics at Dayanand Medical College and Hospital, Ludhiana from September, 2010 to January, 2011. The therapy was used in 23 patients (16 men and 7 women) with an average age of 45 years (range 18-65). Patients with open fractures of the long bones of the lower limb having soft tissue defect after debridement and those with infected traumatic wounds were considered for TNP therapy. The indications for application of TNP were open fractures with large wound when coverage was delayed, late presentation of open fracture when primary coverage was not indicated, polytrauma patients with open fracture where coverage procedure was delayed and neglected infected traumatic wounds after debridement. Patients with exposed vessels, split skin grafting in situ or requiring compression bandage for hemostasis were not included in the study. Patients who underwent primary skin coverage procedure were excluded. Informed consent was obtained from all patients. The bony injury was classified as per

AO/OTA classification and soft tissue injury was graded as per Gustilo-Anderson classification. Size of the wound, date of application of TNP dressing, date of change of TNP dressing, coverage procedure with date were sequentially noted. Remarks in the form of granulation, look, size, gram stain, and culture if any were added.

Technique: We have used regular foam available commercially with thickness between 2.5-4 cm. Foams were sterilized in double paper sealed packing as per standard protocol for orthopedic instruments and implants. The tubing had been obtained from negative pressure drainage system commonly used in orthopedic procedures. The sterile glass bottle (500ml) used was an intravenous fluids pack, which was emptied out using a sterile syringe and needle taking all sterile precautions as for intravenous administration. This was used to measure the fluid or blood being sucked out, and in addition acted as a sterile barrier from central suction system. Negative suction is taken through the normal vacuum wall outlet available in the hospital for oral and laryngeal suction. The pressure was adjusted using a gauge and valve installed in the wall outlet. The wound after debridement and irrigation was inspected for any active bleeding. Hemostasis was achieved using electrocautery. The sterile foam was cut in the shape of the wound taking care that size of the foam is in excess of the wound on all sides by about 5 mm. More than one piece of foam was used whenever required for the assembly. The end of the drainage tube to be inserted in the foam was perforated multiple times in its terminal 3- 5 cm. The wounds were covered with sterile gauze, and sterile foam piece(s) were kept. The sterile tubing with perforations was inserted into a split created in the foam. The whole dressing is sealed using sterile stick on drape (e.g. loban™) taking care that the tubing does not kink (Figure 1a). The tubing is inserted into the glass bottle. Another tubing was inserted into the glass bottle and other end of which was plugged into the wall vacuum suction unit (Figure 1b). The whole assembly was checked for leakage. A negative pressure of about 90 to 110 mm of Hg (confirmed by collapse of the foam) was maintained and intermittently released every 3- 4

hours for 15-20 minutes. This application was continued for three to five days, when dressing was inspected in operation room, and it is applied again or coverage procedure performed.

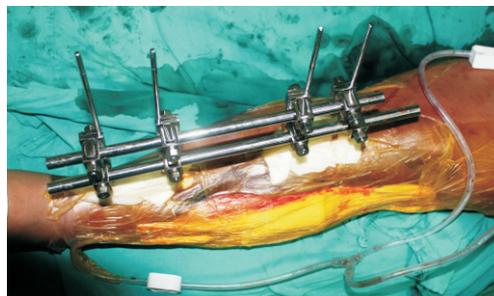


Figure 1a: A patient with Grade IIIB open tibia fracture with external fixator in situ with TNP dressing



Figure 1b: Arrangement of the apparatus in patient care area with the tubing attached to central suction

RESULTS

Of the 23 cases, 12 were open tibia fractures, 4 open femur fractures, 2 failed pelvic fracture fixation, and 3 were neglected trauma with infection. According to Gustilo and Anderson classification, there were 4 Grade II, 6 Grade IIIA, 12 Grade IIIB and 1 Grade IIIC injuries. The therapy was maintained for an average of 12 days (range 6-24) with an average of 2.7 changes of the dressing. Total of 62 TNP therapy applications were performed by four of our team members. Leakage in the system was noted seven times out of which four were sealed and three cases required change of the whole dressing. Of the three patients of neglected trauma, two had application of TNP dressing after insertion of antibiotic cement rod and another had TNP dressing over antibiotic beads after the debridement of the infected site. The following observations were noted:

Dressing change: The number of dressing changes required in patients with open fractures was decreased as we were changing the TNP dressing

every 3-5 days. There was no soiling or soakage of the dressing material from ooze in the wound, thus, decreasing the dressing changes and risk of contamination of the wound from hospital borne bacteria.

Granulation tissue: The wounds with application of TNP dressing had healthy bleeding granulation tissue in one or two changes.

Size of the wound: The decrease in the size was observed in the patients with TNP dressing but the total area and decrease in area was not calculated.

DISCUSSION

The use of negative pressure wound therapy in the form of vacuum-assisted closure has been established as a promising method in the field of wound healing in a variety of wounds including those that are difficult to heal' and studies suggest that suggest that it helps wounds granulate and heal better and quicker.^{7,8}

There are two main factors considered to be responsible for the dramatic response seen in these wounds: removal of fluid and mechanical deformation.³ Removal of fluid decreases edema which decreases the interstitial pressure resulting in increased blood flow. Mechanical deformation causes a wide variety of molecular responses, including changes in ion concentration, permeability of cell membrane, release of second messengers, and stimulation of molecular pathways increasing the mitotic rate of stretched cells. Recently, Scherer et al. have concluded that vascular response is related to the polyurethane foam, whereas tissue strain induced by vacuum-assisted closure device stimulated cell proliferation.⁴ It has been used successfully in a wide variety of wounds including open fractures, soft tissue wounds, infected wounds, and postoperative infections with underlying hardware.⁹⁻¹³

In an average Indian set up, the cost of commercially available VAC is more than five lakhs for the unit and five thousand rupees for every change of dressing.¹⁴ The indigenous TNP therapy devised by us costs around one thousand rupees

for initial application and around five hundred rupees for subsequent change of dressings. As there is a proper central suction system installed in our hospital, the indigenously made TNP Dressing system costs only 20% of the commercially available VAC, even when the initial high cost of installation of the VAC system is not included.

There is controversy regarding duration for change of dressing. DeFranzo et al. advocated the changing at 2 days interval, while Banwell et al. recommend 4-5 days.^{5,15} Our protocol was to change it at 3-5 days interval in the operating room. This practice has also helped us to reduce the number of dressing changes, increase patient comfort and compliance, and reduce the cost of treatment. Although wall suction has been discouraged by Argenta et al., stating large controlled volumes might induce wound desiccation, Shalom et al. used wall suction successfully for 15 patients with complex wounds.^{7,14} We used wall suction with controlled negative pressure, and obtained good results.

Stannard et al, studied the impact of NPWT on severely contaminated open fractures and observed significant difference between the groups for total infections.¹⁶ Our study also demonstrated a trend toward decreased bacterial contamination, although enrolment was not high enough to be significant. DeFranzo et al. reported that, NPWT, when used on wounds with exposed bone and tendon, granulation tissue formed over the exposed areas and in some cases obviated the need for a soft tissue transfer provided the vacuum device was placed on the wound before any infection was present, ideally within 72 h of hardware exposure.⁵ One of our cases with open fracture IIIB tibia illustrated the same. This patient had exposed bone with interlocking tibial nail implanted in situ. A rotation or free flap was being planned in association with plastic surgery team. After application of TNP dressings, marked improvement was noted after four dressing changes and only skin graft was required. We recommend that thorough debridement of all non-viable bone and soft tissue was absolutely essential for success and surgeons should carefully assess the amount of healthy vascularised tissue present prior to using NPWT.

CONCLUSION

Topical negative pressure dressing using VAC system has proved to improve the results in soft tissue defects with open fractures. The advantages are adequate drainage from the dependent wounds, decrease in size of the wound, early granulation and coverage of part of the bare bone with healthy granulation tissue. From our experience, we strongly feel that, it is possible to have a topical negative pressure therapy from the sterile material available in the hospital at very low cost. It is safe and effective to be used in patient who cannot afford commercial kit for TNP.

AUTHOR NOTE

Harpal Singh Selhi, Associate Professor
 Deepak Jain, Assistant Professor,
 Contact no- 09855607299,
 E-mail: deepakjainorth@rediffmail.com
(Corresponding Author)
 Pankaj Mahindra, Assistant Professor
 Mohammad Yamin, Professor
 Department Of Orthopaedics, Dayanand Medical
 College and Hospital, Ludhiana.

REFERENCES

1. Fleischmann W, Strecker W, Bombelli M, Kinzl L. Vacuum sealing as treatment of soft tissue damage in open fractures. *Unfallchirurg*.1993;96(9):488–492.
2. 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;38:553–562.
3. Morykwas MJ, Simpson J, Pungler K, Argenta A, Kremers L, Argenta J. Vacuum-assisted closure: state of basic research and physiologic foundation. *Plast Reconstr Surg*. 2006;117s:121s–126s.
4. Scherer SS, Pietramaggiore G, Mathews JC, Prsa MJ, Huang S, Orgill DP. The mechanism of action of the vacuum assisted closure device. *Plast Reconstr Surg*. 2008;122:786–797.
5. DeFranzo AJ, Argenta LC, Marks MW, Molnar JA, David LR, Webb LX et al. The use of vacuum-assisted closure therapy for the treatment of lower-extremity wounds with exposed bone. *Plast Reconstr Surg*. 2001;108(5):1184–91.
6. Cross III WW, Swiontkowski MF. Treatment principles in management of open fractures. *Ind J Orthop*. 2008;42:377–386.
7. Argenta LC, Morykwas MJ, Marks MW, DeFranzo AJ, Molnar JA, David LR Vacuum-assisted closure: state of the clinic art. *Plast Reconstr Surg*. 2006;117s:127s–142s
8. Argenta LC, Morykwas MJ. Vacuum-assisted closure: A new method for wound control and treatment: Clinical experience. *Ann Plast Surg*. 1997;38(6):563–576.
9. Dedmond BT, Kortesis B, Pungler 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.
10. Dedmond BT, Kortesis B, Pungler K, Simpson J, Argenta J, Kulp B. 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;21:11–17.
11. Herscovici Jr D, Sanders RW, Scaduto JM, Infante A, DiPasquale T. Vacuum-assisted wound closure(VAC therapy) for the management of patients with high-energy soft tissue injuries. *J Orthop Trauma*. 2003;17(10):683–8.
12. Jones GA, Butler J, Lieberman I, Schlenk R. Negative-pressure wound therapy in the treatment of complex postoperative spinal wound infections: Complications and lessons learned using vacuum-assisted closure. *J Neurosurg Spine*. 2007;6(5):407–11.
13. Mehbod AA, Ogilvie JW, Pinto MR, Schwender JD, Transfeldt EE, Wood KB et al. Postoperative deep wound infections in adults after spinal fusion: management with vacuum-assisted wound closure. *J Spinal Disord Technol*. 2005;18(1):14–7.
14. Shalom A, Eran H, Westreich M, Friedman T. Our experience with “home made” vacuum-assisted closure system. *Isr Med Assoc J*. 2008;10:613–616.
15. Banwell PE, Teotl L. Topical negative pressure (TNP): the evolution of a novel wound therapy. *J Wound Care* 2003;12:28–30.
16. Stannard JP, Volgas DA, Stewart R, McGwin G Jr, Alonso JE. Negative pressure wound therapy (NPWT) following open fractures: a prospective randomized study. In: Podium presentation, 74th annual meeting of the American Academy of Orthopaedic Surgeons; 2007.
17. Parrett BM, Matros E, Pribaz JJ, Orgill DP. Lower extremity trauma: trends in the management of soft-tissue reconstruction of open tibia-fibula fractures. *Plast Reconstr Surg*. 2006;117(4):1315–22.
18. Stannard JP, Singanamala N, Volgas DA. Fix and flap in the era of vacuum suction devices: What do we know in terms of evidence based medicine? *Injury*. 2010;41:78-786.
19. 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.
20. Mirza MA, Gill NA, Hameed A. Negative pressure therapy for lower limb complex wounds. *Eur J Plast Surg*. 2011;34:161-166.