www.jmscr.igmpublication.org
Impact Factor (SJIF): 6.379
Index Copernicus Value: 71.58
ISSN (e)-2347-176x ISSN (p) 2455-0450
crossref DOI: https://dx.doi.org/10.18535/jmscr/v6i2.161

IGM Publication
Journal Of Medical Science And Clinical Research
An Official Publication Of IGM Publication

Low Cost Innovative Modification of Vacuum Assisted Wound Therapy

Authors
Prof Dr Om Prakash Shah, Dr Dileep Kumar Singh, Dr Rachit Mehta, Dr Naveen Chauhan, Dr Praveen Garg
Department of Orthopaedics, Rohilkhand Medical College, Pilibhit Bypass Road, Bareilly, Uttar Pradesh
Corresponding Author
Dr Dileep Kumar Singh
Address- Room Number 17, G-Block, Pilibhit Bypass Road, RMCH, Bareilly
Email- drdileepsingh06@gmail.com, Mob No.- 9456633551

Introduction

Management of acute and chronic wounds constitute a significant workload and financial burden for health care organizations and also has a negative impact over the quality of life of patients. Successful management of these problematic wounds should be based on the knowledge of the wound etiology, patient's health status and requires considerable manpower, frequent specialist consultation and knowledge of different features of the various wound care products that are available[1]. Various treatment protocols for acute and chronic wounds exist such as debridement of necrotic or infected tissue, soft tissue management, implant removal, maintenance of moist wound environment, control of infection by antibiotics as per culture sensitivity and provision of nutritional support.[2] Despite these treatment protocols some wounds continue to resist healing. Hence, emerging treatments are being assessed to improve the prognosis of patients with complicated wound profile.

Negative pressure has been used as part of treatment of wound in the form of various drains since 1940s. The treatment technique for open wounds based on negative pressure was developed in Germany and the United states during 1990s and they patented the method with the name Vacuum Assisted Closure (VAC). It is known by various pseudonyms like Negative Pressure Wound Therapy (NPWT), Topical Negative Pressure Therapy (TNPT), and Sub-atmospheric Pressure Therapy (SPDT) etc. The treatment is based on evenly distributed negative pressure applied locally to the wound surface.[3] It involves the application of open cell foam to a suitable wound, adding an airtight seal of adhesive drape and then wound dressing is connected by means of a set of suction tubes to a pressure control unit by which the primary negative pressure on the surface of the wound can be adjusted.[1,3] In the present times use of negative pressure therapy for treatment of wounds has been routinely used and has become an integral part of wound care. Its use in acute, chronic, and complex wounds has been

proven effective and promotes faster healing, provides good quality of life to the patients and is cost-effective.[11,12]

Benefits of NPWT includes rapid granulation tissue formation, reduction in frequency of dressing change, reduced infection risk, reduced treatment cost, control of exudate, simultaneous rehabilitation and better patient tolerance. Currently NPWT has become an established method of wound management and most of the centres use commercially available foam based NPWT systems. These are easily available and affordable in developed countries but in developing countries like ours where the population of poor patients is very high, it is still beyond the reach of the needy patients[4]. Many studies have been carried out to make negative pressure dressing more cost effective and applicable in low resource settings *(Singh et al).*[12] In the present study, we applied the concept of NPWT by using low cost, more easily available materials as compared to commercial NPWT devices. Thereby, we achieved similar results in low resource settings.

Materials and Methods

The study was conducted at Department of Orthopaedics, Rohilkhand Medical College, Bareilly, Uttar Pradesh from July 2015 to August 2017. The NPWT was used in 25 patients (16 male and 9 female) having open wounds from various etiology and involving different anatomical sites. In all cases wound had failed to heal with conventional wound dressing and debridement. In every case before application of NPWT, a proper surgical debridement was done and all devitalized necrotic tissue was removed, sample was collected and sent for culture and sensitivity.

Application of NPWT: Commercially available Sponge foam which is normally available at hardware stores was sterilized by autoclaving it twice and then was cut to fit the dimensions of wound bed. Cutting of foam was avoided over and near the prepared wound bed because doing so can result in contamination of the wound with foam particles, which can be incorporated into the wound bed and may cause foreign body reaction. Foam should not be tightly packed into the wound bed and size of the foam should be 2 cm larger than the wound periphery for proper coverage of the wound. With the help of sterile surgical blade, a groove was made in the foam, 1 cm away from the margin and 3 cm deep in the foam mass to accommodate the tubing (A suction catheter/ Ryle's tube with adequate number of fenestrations made depending upon the wound size). Tube was fitted in the groove of the foam and this tube fitted surface of foam was in direct contact with wound bed. Pre-op drape (Opsite) was used extending 3 to 5 cm beyond the margin of foam to create an airtight seal. Suction tube was connected to the central vacuum line and pressure was adjusted between -125 to -150 mmHg (Figure 1 (a)- 1(d)). We used to give intermittent negative pressure cycle of 15 minutes ON and 45 minutes OFF for 48 to 72 hours. After 48 to 72 hours dressing used to be removed and wound washed thoroughly with normal saline and again NPWT dressing used to be re-applied. The same process was continued until a satisfactory healthy granulation wound bed was achieved for definitive procedure (skin graft or flap).[5]

Mechanism of action of NPWT

Negative Pressure Wound Therapy achieves its beneficial wound healing effects through multiple mechanisms and different mechanism predominates in healing of different type of wound. However, the primary mechanism of wound healing promotion depending on the type of wound being treated.

Changes in perfusion: Adequate blood flow is essential to wound healing because it delivers oxygen and vital nutrients to the tissue in addition to removal of waste product. There is evidence supporting the stimulation of angiogenesis surrounding the wound bed as one of the beneficial effect of NPWT (as demonstrated by

Xia et al)[8]. Furthermore the amount of blood flow has been shown to be dependent on the amount of pressure applied as well as manner in which this pressure is applied. Morykwas *et al.* were the first to suggest that the beneficial effects of NPWT are increased with intermittent application (cycling between 0 and −125 mmHg) of negative pressure compared to continuous application.[8] Borgquist *et al.* later demonstrated that both intermittent and variable application (cycling between −10 and −125 mm Hg) of negative pressure resulted in a beneficial combination of increased and decreased blood flow.[9] This cycling of hypo and hyper perfusion of the wound stimulates angiogenesis and delivers nutrients, respectively, ultimately enhancing wound healing.

Micro and Macrodeformation: *Ilizarov et al.* showed that applied mechanical stress to tissues stimulated mitosis and resulted in formation of new vessels.[10] NPWT applies an interface material (foam or gauze) to the wound surface in order to evenly distribute the pressure. Microdeformation describes the process of imprinting the surface of the wound bed with the topography of the wound filler. At microscopic level the application of the suction results in wound bed tissue drawn up into the pore of filter, causing mechanical force/strain that modulate cellular behavior such as proliferation through a process called as mechanotransduction. NPWT induces another type of tissue deformation occurring at the wound edge during wound contraction called as macrodeformation. Studies demonstrated that wound tissue pressure increases proportionally with the amount of suction applied causing a compression force around the tissue. This compressive force was a key contributor to the oedema reduction as the compression would physically push oedema fluid away from the wound. The application of suction also exerts a contractile force responsible for wound approximation.

Exudate control: NPWT facilitates the removal of excess interstitial fluids. Improved wound healing by exudate removal is likely because of combination of factors: pressure and perfusion changes facilitating healing in acute and chronic wound and removal of potentially toxic components from the chronic wounds. The exudate in the chronic wound may impair wound healing as the fluid contains elevated levels of corrosive proteases, cytokines and neutrophils. Thus removal of these substances by NPWT would be beneficial in chronic wounds.

Decrease in bacterial load: Infection is known to impede wound healing. In many studies, reduced levels of bacteria have been demonstrated in NPWT treated wounds.[12] It has also been demonstrated that NPWT treated wounds require fewer courses of antibiotics relative to conventionally treated wounds.[6]

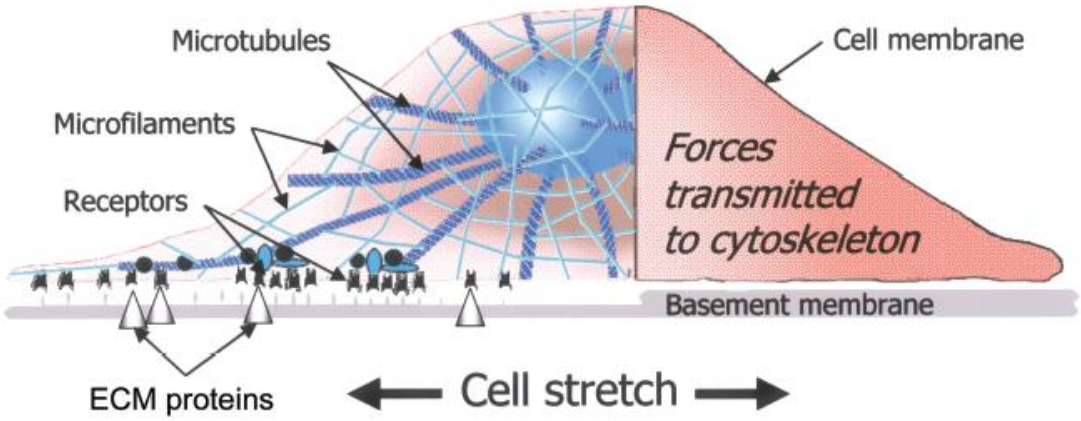

Table 1

S. No.	Indications
1.	Chronic non- healing wounds or ulcers
2.	Wounds requiring grafting or flaps
3.	Pressure Sores or Bed Sores
4.	Osteomyelitis
5.	Burn Ulcers
6.	Spinal Cord Injuries
7.	Diabetic Ulcers
8.	Degloving injuries and skin avulsions
9.	Dehisced surgical wounds with or without exposed bone and orthopaedic implants
10.	Infected wounds

Table 2

S. No.	Complications
1.	Pain
2.	Infection
3.	Blood Loss
4.	Fistula
5.	Fluid Loss
6.	Deep Abrasions
7.	Local Irritation

Table 3

S. No.	Advantages
1.	Less frequency of dressing change
2.	Decreased hospital stay
3.	Decreased bacterial count
4.	Faster Rehabilitation
5.	Controlled way to decrease wound volume
6.	Promotes formation of granulation tissue by increasing vascularity
7.	Better control of odour and exudates
8.	Reduced Nursing time

Table 4

S. No.	Contraindications
1.	Neoplasms
2.	Coagulopathies
3.	Untreated Osteomyelitis
4.	Exposed Nerve and Blood Vessels
5.	Unexplored fistula

Results

A total of 25 patients were included in the study with 16(64%) males and 9(36%) female. The male to female ratio was 1:0.7. The mean age of male patients was 34.5 years and the mean age of female patients was 23.7 years. Majority of the patients in our study were in 2nd and 3rd decade of life. Road traffic accident was the commonest cause found in followed by workplace accidents. In our study leg was the most commonly affected anatomical site followed by forearm. There were 16% patients was diabetic, 40% was smoker and 8% patients was hypertensive. The average number of NPWT dressings applied was 3. The mean hospital stay was 15 days.

In all 25 cases we achieve healthy granulation wound bed for definitive management either by skin graft or flap. Due to less number of cases, the efficacy cannot be commented upon but the results of this modification of NPWT were highly satisfactory and are suitable for developing countries where most of the patients are economically very poor and health care system provides very limited funds for the use of commercial devices. (Figure 2 (a)- Figure 5 (d))

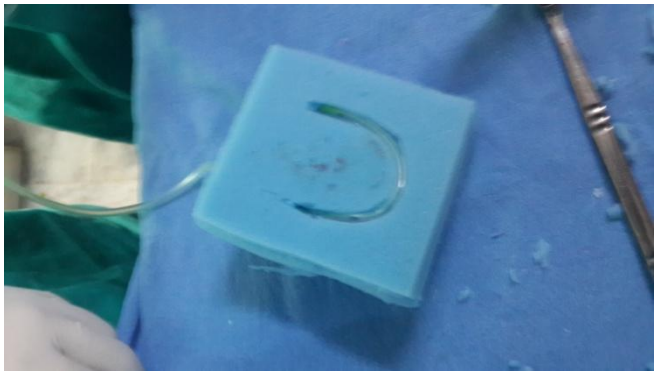

Fig 1 (a)

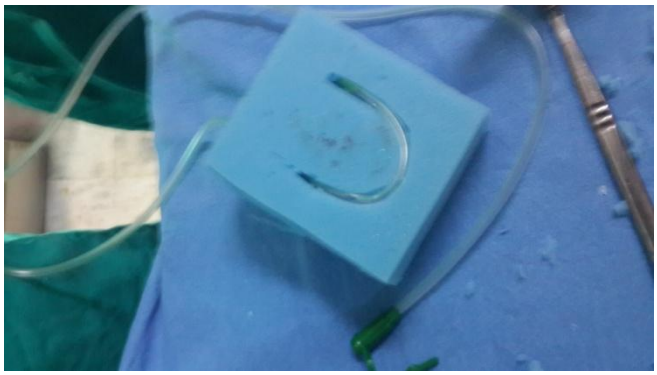

Fig 1 (b)

Fig 1 (c)

Fig 1 (d)

Fig 2 (a)

Fig 2 (b)

Fig 3 (a)

Fig 3 (b)

Fig 4 (a)

Fig 4 (b)

Fig 5 (a)

Fig 5 (b)

Fig 5 (c)

Fig 6 (d)

Discussion

Wound healing is a complex process involving many cellular interactions, biochemical mediators release, changes in the local microenvironment and extracellular matrix resulting in structural and functional restoration of the wound. Since last few years, NPWT is developing as a new therapeutic strategy for treatment of infected acute and chronic wounds resistant to treatment by conventional methods.[2] Application of negative pressure in controlled manner helps the formation of granulation tissue on the wound bed but this therapy does not replace the surgical wound debridement, measures to improve blood circulation and treatment of infection by antibiotics as per pus culture sensitivity. [1]

Argenta et al., Armstrong and Lavery in separate studies concluded that the use of negative pressure therapy for infected wounds from various etiology resulted in increased rate of granulation tissue formation compared to saline gauze dressing and reduces the patients hospital stay and cost burden. Our results are comparable to these studies.[2] Ford et al. in his study reported that the negative

pressure created by NPWT dressing facilitates the antibiotic penetration from the surrounding capillaries into the bone and give improved results in chronic osteomyelitis cases and reduces the cost burden of antibiotics. We found similar results in two of our patients of chronic osteomyelitis of tibia following road traffic accident.

Singh et al. applied NPWT using Romovac or similar 18 fr drain in seven patients with infected complex non healing wounds. The dressing was applied 24 hours after surgical debridement of necrotic tissue. After few modifications, they obtained satisfactory results. They described it as a simple and effective method of NPWT which should benefit the larger population where the standard equipment is not available. *Hussain A et al.* used similar device in four patients and achieved promising results.[11]

Mody et al. used a bellows which generated 75 mmHg negative pressure and had to be compressed every 8 hours. They applied it on 24 patients with 26 wounds. They described it to be safe and feasible for use in low resource settings.[2]

Siddha L V, Shetty S K et al in their study on 100 patients applied the modified vacuum dressing. They used the autoclaved simple sponge available at hardware store and opsite or tegaderm for airtight seal, suction catheters as tubing and portable electrical suction machine to create vacuum and proved that modified

vacuum assisted therapy is more beneficial when compared to the conventional moist betadine dressings in terms of granulation tissue formation, clearance of the infection over the wound, decreasing the duration of hospital stay and cost effectiveness. Results of our study are comparable with this study.

For the treatment of infected acute and chronic non healing wound, many studies are available in literature where workers have tried to reduce the cost of commercially available NPWT by using various low cost materials and devices for the betterment of poor patients in the developing countries. Taking inspiration from them we have done an innovative modification by using the concept of negative pressure wound therapy and have found highly satisfactory results in terms of granulation tissue formation, infection control, requirement of antibiotics, duration of hospital stay and cost effectiveness.

Conclusion

The very first step in wound care is to remove the factors that impair wound healing. Many wounds will heal with good wound care i.e. removal of necrotic tissue, maintenance of moist wound environment, control of infection and provision of nutritional support. Once the primary factors are addressed some problematic non healing wounds will benefit further from adjunctive therapies like Negative Pressure Wound Therapy. NPWT is a relatively new technique in developing countries and is very effective in promoting wound healing. However, the installation cost of NPWT is very high as compared to the affordability of the health care system of developing countries. There is shortage of reliable research data on effectiveness of NPWT. Available evidence indicates that the effectiveness of such therapy is at least better than conventional wound treatment. This calls in the need for an inexpensive home-made negative pressure suction device system that is affordable to all. Further studies are needed to validate its effectiveness. Also, there is a need to encourage the government to conduct studies to approve these results and hence lead to widespread adoption of NPWT in national wound care.

References

1. P. Vikatmaa, V. Juutilainen, P. Kuukasjarvi, A. Malmivaara. Negative Pressure Wound Therapy:A Systematic Review on Effectiveness and Safety. *Eur J Vasc Endovasc Surg* 2008; 36(): .
2. Sanjay K. Tripathi, Saurav N. Nanda, C.R. Reddy, Sachin T. Raatchhanvir, Sawan K. Pawar, Amit Kohli, Shahrookh V . Vacuum Assisted Closure Dressing in Spine: An Emerging Trend. *The Journal of Spinal Surgery* 2016; 3(2): .

3. K.V. Lambert, P.Hayes, M. Mccarthy. vacuum assisted closure: A review of development and current applications. *european journal of vascular endovascular surgery* 2005; 29(): .
4. Akhlak Hussain, Kuldip Singh, Mohinder Singh. Cost Effectiveness of Vacuum Assisted Closure and Its Modifications: A Review. *International Scholarly Research Network Plastic Surgery* 2013;(): .
5. Muhammad Ahmad, Saleem A Malik. Vacuum Assisted Closure Therapy: Role in Modern Plastic Surgery. *Journal of Liaquat University of Medical and Health Sciences* 2010; 09(02): .
6. Shadi Lalezari, Christine J Lee, Anna A Borovikova, Derek A Banyard, Keyianoosh Z Paydar, Garrett A Wirth, Alan D Widgerow. Deconstructing Negative Pressure Wound Therapy. *International Wound Journal* 2016; (): .
7. Endre Nagy, Istvan Juhasz. Negative Pressure Wound Therapy- An Effective, Minimally Invasive Therapeutic Modality in Burn Wound Management. *International Journal of Clinical Medicine* 2015; (6): .
8. 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;38:553–62.
9. Borgquist O, Ingemansson R, Malmsjo M. The effect of intermittent and variable negative pressure wound therapy on wound edge microvascular blood flow. *Ostomy Wound Manage* 2010;56:60–7.
10. Ilizarov, G. A. The tension-stress effect on the genesis and growth of tissues: Part II. The influence of the rate and frequency of distraction. *Clin. Orthop.* 239: 263, 1989.
11. Akhlak Hussain, Kuldip Singh, Mohinder Singh. Cost Effectiveness of Vacuum Assisted Closure and Its Modifications: A Review. *International Scholarly Research Network Plastic Surgery* 2013;():
12. M. Singh, R. Singh, S. Singh, V. Pandey, and D. Singh, "Vacuum assisted closure in wound management-Poor man's VAC©," *Internet Journal of Plastic Surgery*, vol. 6, no. 1, 2009.