International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2018; 4(1): 401-405

www.orthopaper.com
Received: 20-11-2017
Accepted: 21-12-2017

Sumit Kumar
Junior Resident, Department of Orthopaedics, Shri Mahant Indresh Hospital, Dehradun, Uttarakhand, India

Mohd Bilal Kaleem
Junior Resident, Department of Orthopaedics, Shri Mahant Indresh Hospital, Dehradun, Uttarakhand, India

Misbah Mehraj
Senior Resident, Department of Orthopaedics, Shri Mahant Indresh Hospital, Dehradun, Uttarakhand, India

Mohit Dhingra
Associate Professor, Department of Orthopaedics, Shri Mahant Indresh Hospital, Dehradun, Uttarakhand, India

Jabreel Muzaffar
Senior Resident, Department of Orthopaedics, Shri Mahant Indresh Hospital, Dehradun, Uttarakhand, India

Puneet Gupta
Head of Department, Department of Orthopaedics, Shri Mahant Indresh Hospital, Dehradun, Uttarakhand, India

Mohd Bilal Kaleem
Junior Resident, Department of Orthopaedics, Shri Mahant Indresh Hospital, Dehradun, Uttarakhand, India

Correspondence
Sumit Kumar
Junior Resident, Department of Orthopaedics, Shri Mahant Indresh Hospital, Dehradun, Uttarakhand, India

Effectiveness of vacuum assisted negative pressure wound therapy in grossly contaminated wounds

Sumit Kumar, Mohd Bilal Kaleem, Misbah Mehraj, Mohit Dhingra, Jabreel Muzaffar, Puneet Gupta and Mohd Bilal Kaleem

DOI: https://doi.org/10.22271/ortho.2018.v4.i1f.60

Abstract
Management of open highly contaminated wound due to high velocity trauma (road traffic accidents) is always a challenging problem for surgeon for primary definite management of fracture. For such grossly contaminated wounds new modalities of treatment are available and are under trail. Here in our study we present the effectiveness of vacuum assisted negative pressure wound therapy for excellent management of wound with gross contamination and more effective granulation tissue formation, leading to reduction of bacterial load which helps in preventing infection and being cost effective.

Keywords: Granulation tissue, Negative pressure wound therapy (NPWT), trauma, fracture

Introduction
Open acute highly contaminated injuries (including degloving injuries, infected wounds, soft tissue injury, open fracture of upper and lower extremity, contamination in form of dirt, pebbles) are a challenging task for surgeon for primary and definite management of wounds mostly over fracture site.

When the wound bed is exposed to sub-atmospheric pressure, the fluid from the extravascular space is removed, helping to reduce both the risk of wound infection and enhancing the formation of granulation tissue.

The way in which this technique is applied is based along several determined steps. In order to achieve NPWT, an open cell structured sponge is cut to the size of the wound adequately and placed inside the wound cavity. The target is for the foam to be in contact with the wound bed and edges to ensure an equal negative pressure distribution to every part of the wound. This also should reduce the possibility of localised high negative pressure to any one area, which might lead to tissue necrosis. This foam should next be covered by a transparent adhesive layer which extends on, and adhering, to the skin surrounding the wound. Next, this seal should be broken at a single point where a drain is placed to allow direct contact to the underlying foam. The plastic membrane nature of the seal prevents the entrance of air and creates a partial vacuum atmosphere. The distal end of the drain is connected to a vacuum source (NPWT Unit), which allows the drainage of the fluid away from the wound; this in turn promotes wound healing [1-3].

Negative pressure wound dressing is a new technology that has been shown to accelerate granulation tissue growth and promote faster healing, thereby decreasing the period between debridement and definite surgical closure in large wounds. Vacuum-assisted wound closure (VAC) is a wound management technique that exposes wound bed to negative pressure and provides a moist wound-healing environment. This technique has been developed and popularized world-wide by Prof. Louis Argenta [4] and Prof. Micheal Morykwas [5] from the USA and by Dr Win Flieschmann from Germany [6].

Materials and methods
This study was carried out in department of orthopaedics, Shri Mahant Indresh Hospital, Dehradun during the period of august 2016 to December 2017. Patients managed till august 2017 were included in the study.

This study included thirty five patients with total 39 wounds were treated. All the wounds greater than $3cm^2$ with gross contamination and needed skin grafting were included in the study.

Inclusion criteria
1. Wound size greater than $3cm^2$.
2. Wound over lower and upper limb only.
3. Wound with crust and debris.
4. Wound with exposed bone.
5. Patient giving consent for NPWT(negative pressure wound therapy)

Exclusion criteria
1. Active bleeding wounds.
2. Allergies to adhesive drape.
3. Pain and discomfort when suction is applied initially.
4. Excoriation of skin, if foam not correctly cut in size.
5. Fulminant or incipient skin necrosis.

Patient were assessed for fitness for surgery by anaesthetist. Patient consent for participation in study were obtained before applying NPWT.

Prophylactic antibiotic
All patient were giving 1.5gm cefuroxime, 500mg amikacin and 100ml metrogyl i.v half n hour before surgery.

Material used
The classic VAC system comprises the vacuum pump (negative pressure unit), canister, tubing to connect the dressing to the pump and VAC dressing pack (foam and occlusive drapes). Current canisters have a maximum volume of 250 ml; recent pump models now have 500 ml canisters. When the canister is full, an alarm system located on the pump will sound. The alarm will also sound if there are leaks, tube blockage and if the desired pressure is not reached.

Technique for application
Wound Preparation
Any dressings from the wound are removed and discarded. If required, a culture swab for microbiology should be taken before wound irrigation with normal saline. Surface slough or necrotic tissue should be surgically removed (surgical debridement) and adequate haemostasis achieved. Prior to application of the drape, it is essential to prepare the peri-wound skin and ensure that it is dry. A degreasing medical cleansing agent is available to clear the skin of perspiration, oil or body fluids that will make the skin moist, and a skin protectant should be used to protect the skin around the wound.

Placement of Foam
Sterile, open-cell foam dressing is gently placed into the wound cavity. Open-pore, reticulated medical-grade foams are used as they are the most effective at transmitting mechanical forces across the wound and provide an even distribution of negative pressure over the entire wound bed to aid in wound healing. There are two different types of foam available, black (applied into the wound) or white (applied over the wound). Black foam, polyurethane ether (PU), has larger pores, is lighter, easily collapsible and hydrophobic with a pore size of 400 to 600 mm. It is used when stimulation of granulation tissue and wound contraction is required. White foam, polyvinylalcohol (PVA), is used for restricted formation of granulation tissue, as it is denser with smaller pores, requires higher negative pressures to collapse, and is hydrophilic (absorbs exudate) with a pore size of approximately 250 mm. Embedded in the foam is a fenestrated evacuation tube, which is connected to a computer-controlled vacuum pump that contains a fluid collection canister. The amount of pressure applied will depend on which type of foam is used, with the white foam requiring higher negative pressure as it is denser.

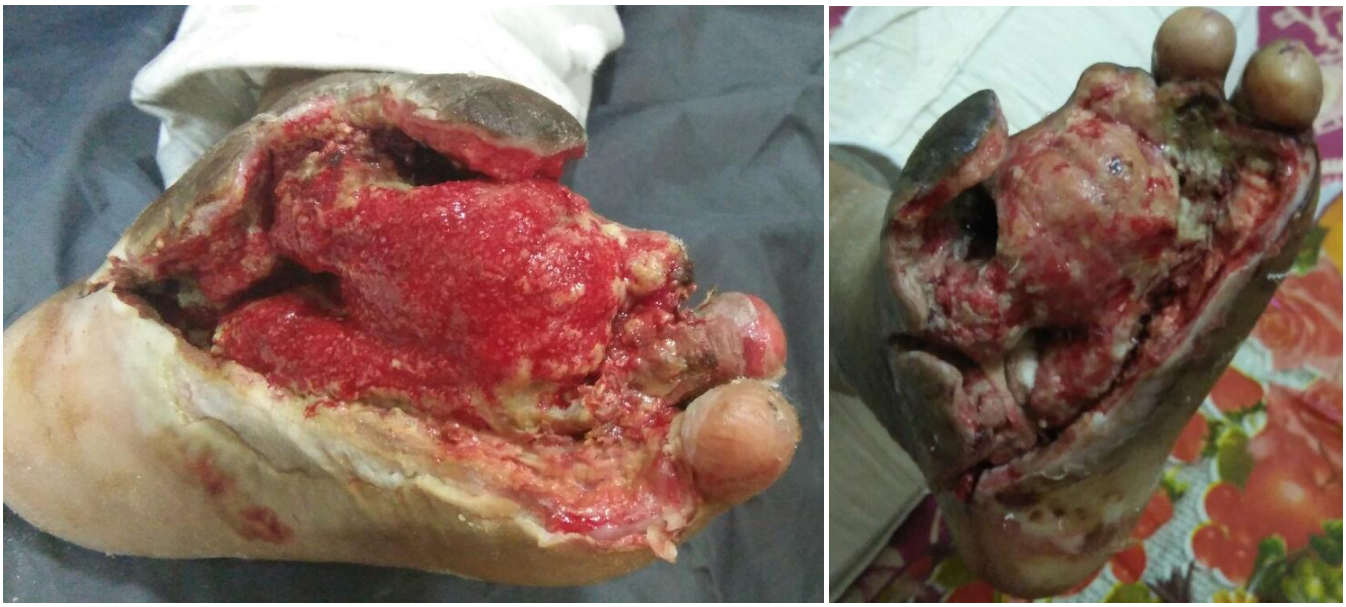
Sealing with Drapes
The site is then sealed with an adhesive drape. There are three main drapes available: commercial VAC dressings with a useful double layer, iodine-impregnated drapes (Ioban, 3M, St. Paul, MN), and anatomical dressings that are specifically designed to mould to the hand or foot.
Drapes should cover the foam and tubing and at least three to five centimetres of surrounding healthy tissue to ensure a seal. The dressings were kept intact for 10 days and wound examined on 10^{th} day. Dressing changes may be done under general or regional anaesthesia in theatre, depending on the location and type of wound. Care must be taken when removing the adhesive drape to avoid irritating the periwound skin. Normal saline solution can be used to loosen the foam for removal from the wound bed. For patients experiencing pain with dressing changes, 1% lidocaine solution may be introduced either via the tubing or injection into the foam with the pump on low pressure.

The Application of Negative Pressure
Controlled pressure is uniformly applied to all tissues on the inner surface of the wound. The foam dressing should compress in response to the negative pressure. The pump can deliver either continuous or intermittent pressures, ranging from 50 to 125 mmHg (adjustable up to 200 mmHg). Intermittent delivery consists of a seven-minute cycle of two minutes off and five minutes on, while the negative pressure is maintained. The ideal pressure setting is 125mmHg, but particularly painful chronic wounds such as chronic leg ulcers are usually managed with lower therapeutic pressures of 50 to 75 mmHg. Higher pressures of 150 mmHg plus are used for large cavity wounds such as acute traumatic wounds, as they produce copious amounts of exudate. The pressure is set to continuous for the first 48 hours and the pressure is changed as required thereafter.
Afterwards the wounds are treated with grafting or normal dressing depending on the dimensions, and wound toilet. After satisfactory dressing patient were discharged and adviced further out patient, in patient for follow up [7].

Results
35 patients with mean age of 36.91years and a total of 37 wounds were treated using NPWT with 37 vacuum dressings. Mean time used for placing NPWT dressing was 57.35 minutes and mean time for total treatment was 38.97 days.

Table 1: Characteristics of patients and dressings.

Variables	characteristics	
Sample size	35 patients; 37 wounds	
Sex	Men	26 (74.28%)
	Women	09 (25.71%)
Age	Range = 15-70years, mean = 36.91years	
Vaccum dressings	Time taken to place the dressings	Range 30-90minutes; mean 57.35minutes
	Drainage volume	Range 0-180ml/d; mean 93.37m/d
	Satisfactory	96.1% (100 dressings in 32 patients)
	Unsatisfactory	3.9% (4 dressungs in 3 patients)
	outcomes	Grafts 81.08% (n= 30) Suture 10.81% (n= 4) Healing by secondary intention5.40% (n=2) Local flap 2.70% (n=1)
Wound size	Range, 2-20cm	Small(≤10cm) (n=6) 16.21% Large(≥10cm) (n=31) 83.78%
Length of hospital stay	Range, 20-25 days ; mean= 22.34days	
Treatment time	Range 1-60days; mean= 38.97 days	



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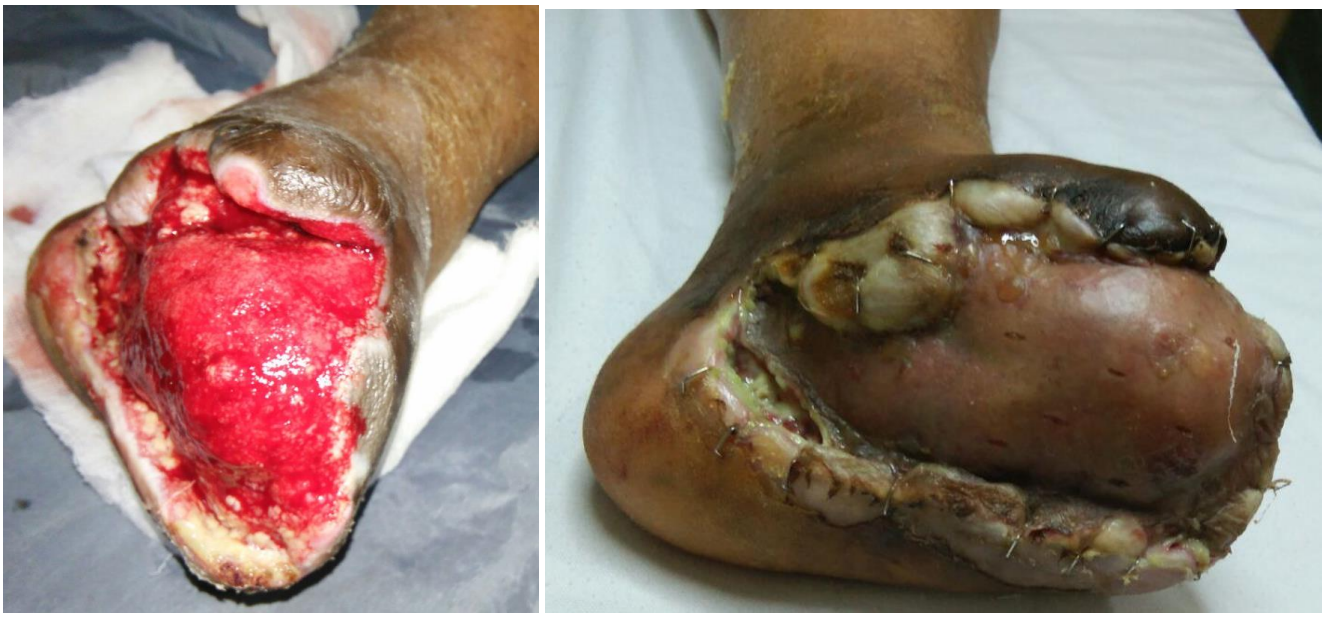

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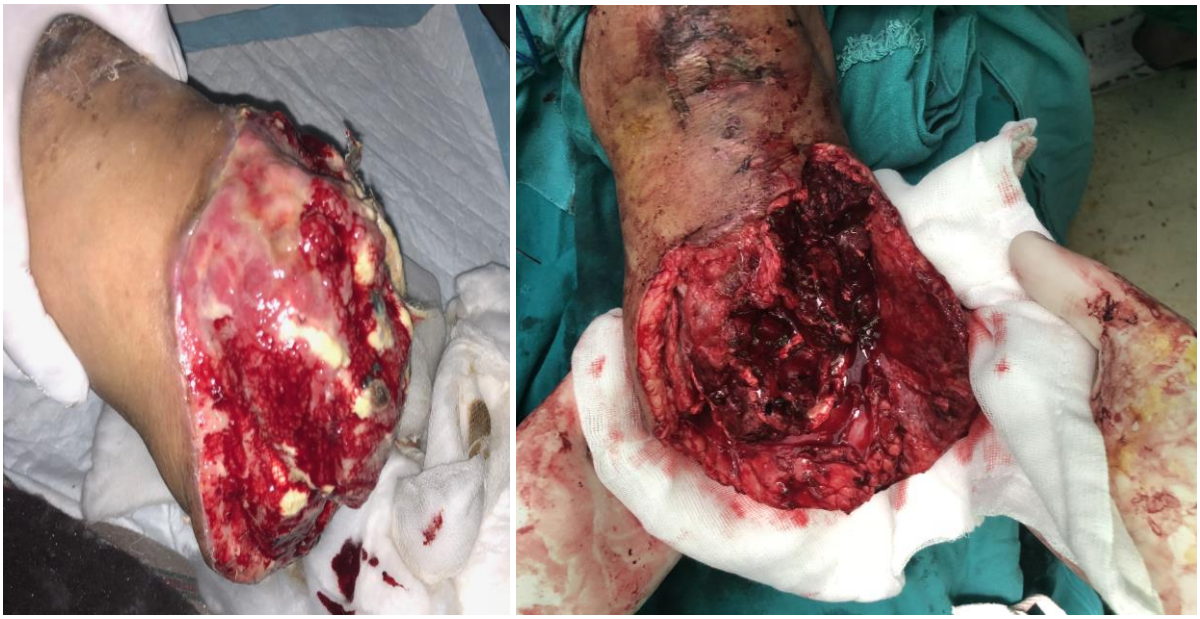
Fig 1: Figure showing A-D before and after use of NPWT vac dressing showing granulation tissue and later performed split thickness skin grafting



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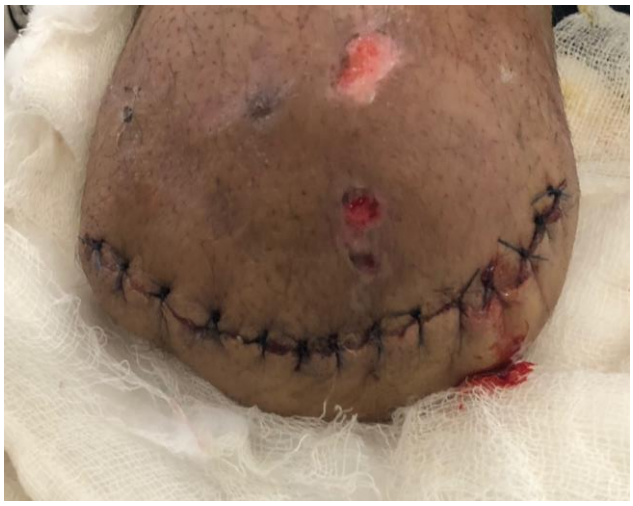

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Fig 2: Figure showing A-C with pre and post application of NPWT vac dressing and later closure done in case of traumatic amputaion

Sex distribution: There were 9(25.71%) female and 26(74.28%) male cases.

Mode of injury: The predominant mode of injury was road traffic accident that lead to open injury.
Associated illness: out of all patients 6(17.14%) patients were hypertensive, 3(8.57%) patients were having diabetes mellitus and none of the patient had other comorbidity.
Duration of NPWT: 10-15 days (mean=12 days)

Follow up: All patients were followed for a period of 6 months.

Complication: NPWT resulted in minimal complication, with most commonly skin maceration [8-11]. There are few complication related to use of simplified vacuum dressing system, total complication rate range from 0-18% [4, 12, 13-16].
Later after removal of NPWT 30 wounds were manged by skin graft, 4 wound with suture, 2 wound were let for healing by secondary intension and 1 wound with local flap and it resembles great importance of NPWT in plastic surgery dressings.

Discussion

In this study we summarize the use of vacuum therapy in open contaminated wounds that resulted in faster improved healing compared to conventional moist gauze therapy. In our study we demonstrated about cost effective excellent healing results followed by primary initial debridement and it showed that it prevents multiple debridements and it is the most important advantage of therapy.
Mechanism of action that has attributed to TNP therapy are increase in blood flow, promotion of angiogenesis, reduction of wound surface area in certain types of wounds, modulation of the inhibitory contents in wound fluid, induction of cell proliferation [17].
Cost of vacuum therapy per person cost around Rs.1200 INR which is quite economical for patient and provides excellent results for surgeon and saves time.

Conclusion

In our study in treating open grossly contaminated wounds primarily followed by injury with topical negative pressure dressing has a definite advantage over conventional saline dressing. There is better formation of granulation tissue and

finally better survival of graft palced and reduced bacterial loads. Negative pressure wound therapy has made wound healing more comfortable and cheaper and time saver for both patient as well as surgeon.

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