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Study of effects of negative pressure wound therapy in contaminated wounds

Atin Kundu, Satyendra Phuljhele, Nitin Wale*, Harjot Singh Gurudatta, Vimal Agrawal

Department of Orthopaedics, Pt. J.N.M Medical College, Raipur, Chhattisgarh, India

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***Correspondence:**
Dr. Nitin Wale,
E-mail: nitinjaywant30@gmail.com

ABSTRACT

Background: Negative pressure wound therapy is an advanced wound therapy technique that helps in healing the wounds and accelerates granulation tissue as well as wound closure.

Methods: Prospective randomized interventional study was done in Dept. of Orthopedics, Dr. BRAM Hospital, Pt. JNM Medical college, Raipur during period from January 2016 to December 2016 involving 25 patients with open fractures up to Gustilo Anderson grade IIIB. All were subjected to this wound technique and response was observed as granulation, size of wound and closure duration.

Results: There was up to 10 to 20 mm reduction in wound size with each dressing in half the patients and up to 10 mm in other half of the patients. There was significant reduction in the bacterial growth in all patients and closure was attained in all the subjects after a few therapies.

Conclusions: Negative pressure wound therapy is a promising technique to reduce the size of the wound in large wound associated with compound fractures and hasten the healing of wound and its closure.

Keywords: Vacuum assisted closure, Negative pressure wound therapy, NPWT, Closure, Dressing

INTRODUCTION

Negative pressure wound dressing (NPWT), being illustrated to accelerate granulation tissue growth and promote faster healing, is being established as a definite closure mode and healing of tissues with faster and rapid tissue regeneration post debridement and reduction in durations of debridements. Wound bed is subjected to negative pressure and provides a moist wound-healing environment. The NPWT was first investigated by Morykwas and Argenta et al in 1997.[1] It is known by many pseudonyms—TNP (topical negative pressure) SPD (sub-atmospheric pressure) VST (vacuum sealing technique) and SSS (sealed surface wound suction), vacuum assisted closure (VAC). An open cell foam is applied to the wound, followed by application of adhesive sea, and negative pressure controlled sub atmospheric pressure.

Negative pressure wound therapy induces angiogenesis owing to intermittent or sustained application of negative pressure over wound, that simultaneously results in decline of edema, promotes edge approximation, collagen and soft tissue synthesis (Figure 1).

It has always been a challenge to manage Gustilo Anderson compound grade IIIB fractures, as they have extensive soft-tissue damage, definite periosteal stripping, massive contamination & the fractured ends are exposed. Unlike other open fractures primary closure is not possible. Soft tissue injuries are managed by conventional methods like regular wound debridement, saline dressing, dry dressing etc. Disadvantages according to a study by caudle and stern are incidence of infection was 59%.[2]

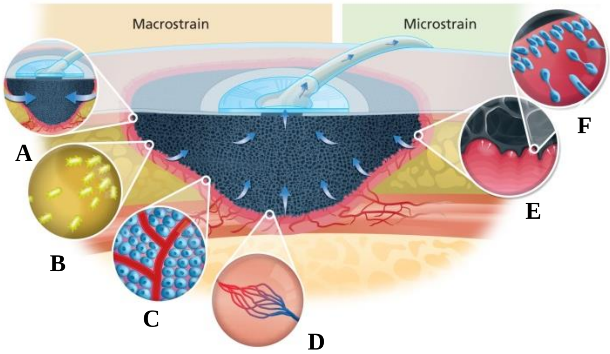

Figure 1: Mechanism of action of negative pressure wound therapy.

A): Draws wound edges together; B): removes infectious material; C): reduces edema; D): promotes angiogenesis; E): foam contact with tissue under negative pressure creates tissue micro-deformation that leads to cell stretch; F): cell stretch under negative pressure stimulates cellular activity that results in granulation tissue formation.

The purpose of this study is to evaluate the results of this therapy for the management of patients presenting with open musculoskeletal injuries.

METHODS

A prospective interventional study was done in Dept. of Orthopedics, Dr. BRAM Hospital, Pt. JNM Medical college, Raipur during period from January 2016 to December 2016. Study included 25 patients, out of whom, 18 had lower limb injury and seven had upper limb injuries.

Inclusion criteria

Inclusion criteria were Gustilo Anderson compound Grade III B fractures.

Exclusion criteria

Exclusion criteria were pathological fractures; chronic osteomyelitis; wounds with exposed neurovascular structures.

As a first step, fracture fixation was done by external fixator application and surgical debridement of damaged tissue was performed. Wound was then filled with polyurethane sponge inserted with drainage tube and sealed using transparent polyurethane dressing. Tube is connected to machine using vacuum with pressure range of minus 125 mm Hg. Fluid from the wound gets drawn through the foam and gets collected in canister which can be disposed subsequently.

Contra-indications of NPWT

- Malignancy with the wound.
- Untreated osteomyelitis within the wound.
- Non-enteric and unexplored fistula.
- Necrotic tissue with eschar present (debride first).

Precautions

- Active bleeding, difficult wound haemostasis, anticoagulant therapy.
- Close proximity to blood vessels/organs (ensure cover with tissue or protective barrier).
- Care with irradiated or sutured blood vessels or organ.

Negative pressure wound therapy techniques and steps:

NPWT uses medical grade open cell polyurethane ether foam. The pore size is generally 400–600 mm (thought optimal for tissue growth).[3] This foam is cut to fit and closely applied to the selected wounds. Evacuation tube with side ports, which communicate with the reticulated foam, is embedded in it. Adhesive drape is then applied over the area with an additional 3–5 cm border of intact skin to provide an intact seal and securing vacuum.

Wound preparation involves debridement of Necrotic tissues and adequate haemostasis and wash. A culture swab for microbiology was taken before wound irrigation with normal saline.

Placement of foam: Sterile, open-pore foam (35 ppi density and 33mm thick) dressing was gently placed into the wound cavity. Such sizes of pores provide an even distribution of negative pressure over the entire wound bed to aid in wound healing.

Sealing with drapes: The site was then sealed with an adhesive drape covering the foam and tubing and at least three to five centimeters of surrounding healthy tissue to ensure a seal.

The application of negative pressure: Controlled pressure was uniformly applied to all tissues on the inner surface of the wound. The pump delivered an intermittent negative pressure of −125 mmHg.

Figure 2: KCI complete VAC machine set with machine, negative suction tube, drape and foam.

In this study, standard VAC machine and material provided by KCI were used (Figure 2).

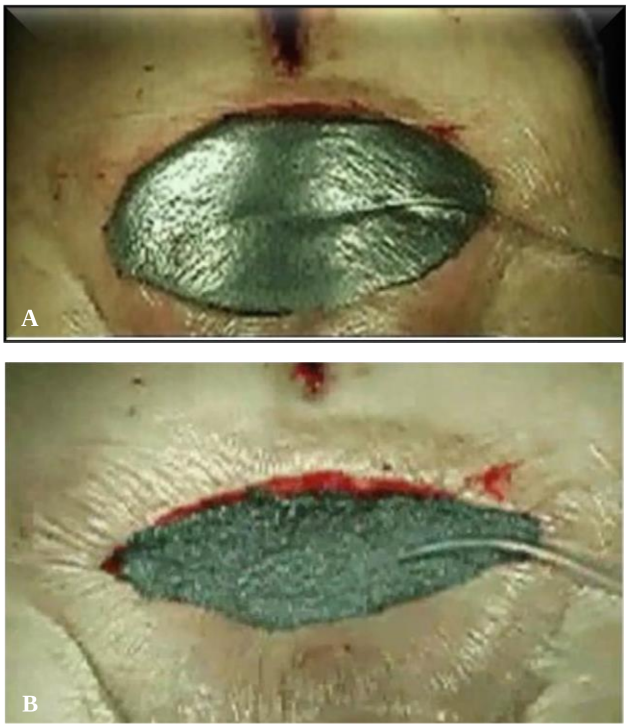

Figure 3 (A and B): Reduction in edema and wound shrinkage.

Depending on the size of wound, some patients required two and some required three sessions of therapy. One session had three to four days of negative pressure therapy. Subsequent reduction in swelling in adjacent area was noted in all cases with vacuum pull seen as illustrated (Figure 3).

RESULTS

All the subjects who got negative pressure wound therapy had their wounds healed with healthy granulation tissue and bone cover within three sessions of therapy. There were 21 male patients and four female patients, with age of patients ranging from 15 years to 67 years; mean being 37.7 years The size of wound determined the number of dressing sessions with average two dressing sessions among our subjects with mean of seven days of therapy in total in all subjects. Five patients opted for split skin grafting while rest healed with dressings. 64 percent wounds also converted from being contaminated to sterile with negative pressure wound therapy (Tables 1-3).

Table 1: Size of wounds.

Wound dimensions (max. dimension; length/breadth)	Total number
10-15 cm	08
15-20 cm	13
>20 cm	04

Table 2: Mean decrease in wound dimensions.

Wound size	Mean reduction in wound size with each VAC		
	0-10 mm	10-20 mm	>20 mm
10-15 cm	05	03	00
15-20 cm	08	04	01
>20 cm	02	01	01

Table 3: Bacterial clearance and appearance of granulation tissue.

	Positive wound culture	Granulation tissue
Before VAC	25	00
After VAC	09	25

Figure 4: Pre and post VAC photographs of wound in compound grade IIB fracture of tibia with external fixator in situ.

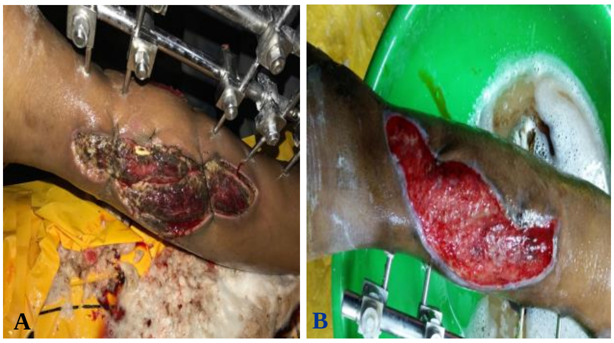

Figure 5: Pre and post VAC photographs of a grade IIB contaminated wound with external fixator in situ.

DISCUSSION

Management of soft tissue plays a very important role in Gustilo Anderson compound fractures.[4] Many factors play a coordinated role in wound healing like the wound environment the composition of the wound which includes physical characters of the wound, chemical composition of the wound, biological structure of the wound etc. all these play an important role in the healing.

The goals of soft tissue management are

- Controlling bleeding.
- New granulation tissue should replace the soft tissue defects.
- The soft tissue defect should be covered by SSG or flap cover as soon as possible.

Morykwas and Argenta et al first proposed NPWT in 1997.[1] As per their study, the peak blood flows as measured by Doppler ultrasonography was with an 125 mmHg vacuum setting. Flows gradually decreased after this. Later, they reported clinical experience of 300 chronic wounds and recommended an initial 48 h continuous administration followed by the standard intermittent regime. Banwell et al have found immediate application of the VAC following injury/debridement to produce good results on acute wound and recommend change of dressings every four to five days.[3]

Mechanisms of action

Blood flow increases and bacterial colonization of wound decreases following the application of subatmospheric pressure to wounds.[5] Any increase in circulation and oxygenation to compromised or damaged tissue enhances the resistance to infection.[6]

Localised oedema

It can compress the vascular and lymphatic systems in a wound. The NPWT removes excess fluid and, therefore, is thought to restore the vascular and lymphatic flow.[3] This system allows collection of the removed fluid for analysis.

Reduction in levels of bacteria

NPWT causes a reduction in bacterial load and also leads to reduced need of debridements and faster healing of wounds.[1] It is due to multiple factors: the positive effect of removing excess wound fluid on local blood and lymphatic flows, greater amounts of oxygen made available for the bacteria killing oxidative bursts and the closed nature of the system. Mehbod et al and Mooney et al showed drastic decrease in infection when compared with saline dressing also the duration of hospital stay was reduced, number of debridement required were also few the indirect effects of VAC therapy are reduced morbidity, earlier return to work and cost effectiveness.[7,8]

Reduction in wound size

Thomas first postulated that application of mechanical stress would result in angiogenesis and tissue growth. Unlike sutures or tension devices, the NPWT can exert a uniform force at each individual point on the edge of the wound drawing it toward the centre of the defect by mechanically stretching the cells when negative pressure is applied.[9] This allows the NPWT to move distensible soft tissue, similar to expanders, towards the centre of the wound, thereby decreasing the actual size of the wound.[10]

In our study 15 wounds showed mean decrease of 0-10 mm (60%), 32% (8 wounds) showed mean decrease between 10-20 mm and rest 2 (08%) wounds showed reduction more than 2 cm. Sinha et al found in their study a decrease in size of 10 to 19.9 mm in 46.66% of patients of NPWT group and only 6.66% in control group.[11] A decrease in size of more than 25 mm was seen in 13.33% in NPWT group. Ford et al found 42.1% reduction in wound volume in diabetic foot ulcers.[12]

Mullner et al conducted prospective study in 45 patients with NPWT application.[13] There was no control group and again the recommendations on settings for the NPWT were based on anecdotal evidence but an 80% reduction in size during the period of study in 12 of the 17 pressure sores studied was found. Furthermore, all of the 12 soft tissue injuries responded well enough to allow early grafting.

Formation of granulation tissue and clearance of bacteria from wound

The highly significant increase in the rate of granulation tissue formation of subatmospheric pressure-treated wound is postulated to be due to transmission of the uniformly applied force to the tissues on the periphery of the wound. These forces both recruit tissues through viscoelastic flow and promote granulation tissue formation. Currently, the Ilizarov technique and soft tissue expanders both apply mechanical stress to tissues to increase mitotic rates.[14] In our study all patients treated with NPWT showed presence of granulation tissue after 7 days of therapy which further healed secondarily (07 pt.) or with skin grafting (17 pt.). There were 64% wounds without bacterial growth at day 7 after NPWT Therapy. Kushagra Sinha et al showed in their study in VAC group after day 4, there were 20% of patients who had no bacterial growth, and on day 8 there were 60% of patients who had no bacterial growth, whereas in saline-wet-to-moist patients only 20% of patients had no bacterial growth on the 8th day.[11] There have been similar studies by Morykwas and Argenta, Banwell et al, and Morykwas et al which showed clearance of bacteria from infected wounds using NPWT therapy.[1,3,5]

In a study by Moss et al, granulation tissue appeared in 26 (92.85%) patients by the end of week 2 in NPWT group in contrast to 15 (53.57%) patients by that time in conventional group.[15]

Easy compliance and reduced number of dressings

As there is a gap of few days between dressings and also there is less frequency of debridements, an improved patient compliance is expected as the patient suffers less often pain and inconvenience.

Cost-effectiveness

Considering the overall cost benefit ratio and reduced recovery time, overall treatment cost is noted to be lowered down despite the initial higher cost of VAC.[9]

CONCLUSION

Vacuum assisted closure therapy appears to be a valuable adjunct for the treatment of open musculoskeletal injuries as it decreases wound size, enhances granulation tissue and clearance of bacteria. Our study had the limitation of having small study size and no control group. Yet, it can be firmly said that Negative pressure wound therapy allows for definitive primary external fixator application or conversion to definitive fixation with wound healing. Patient compliance is better as there is no need of intermediate debridements, reduced number of dressing change, less pain and discomfort to patients. Use of this therapy appears to decrease the need of flap grafting for soft tissue defects.

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Ethical approval: The study was approved by the institutional ethics committee

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