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TITLE: TO EVALUATE THE ROLE OF NEGATIVE PRESSURE WOUND THERAPY IN COMPOUND FRACTURES AFTER PRIMARY FIXATION

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ABSTRACT

INTRODUCTION: Vacuum-assisted closure (VAC) is a non-invasive, active wound management system that exposes a wound bed to local sub atmospheric pressure, removes fluid from the extravascular space, improves circulation, and enhances the proliferation of granulation tissue. The purpose of this study is to know the rate of wound infection, number of days required for making the wound fit for skin cover procedures, number of days required for formation of uniform granulation tissue bed in the wound healing treated by Vacuum Assisted Closure after primary fixation of fracture.

METHODOLOGY: Patients between 18 to 60 years were included in this prospective randomized controlled trial. Primary internal Fixation of fracture was done as soon as possible followed by VAC application. Functional outcome of cases recorded during each follow up according to Johner and Wruh's (1983).

RESULT: According to this study, 30 patients with open fractures of both bone leg after primary internal fixation with VAC application. During follow up effective decrease (mean ± SD) in wound size after VAC therapy was 9.97±9.59 cm2 with P-value 0.0481. This technique has resulted in the effective decrease in wound size, infection and give a better functional outcome.

CONCLUSION: The greatest advantage of VAC was found to facilitate rapid formation of granulation tissue on wounds with exposed tendons, bones, raw area wounds and exposed implants hence decrease healing time and minimize soft tissue defect coverage procedures.

KEYWORDS:VAC THERAPY,OPEN FRACTURE,WOUND HEALING,JOHNER AND WRUH'S.

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INTRODUCTION:

Negative pressure wound therapy (NPWT) is a new technique in the challenging field of management of contaminated, acute, and chronic wounds. Negative pressure wound therapy (also called vacuum therapy, vacuum sealing ,vacuum-assisted wound closure, or topical negative pressure therapy) is a sophisticated development of a standard surgical procedure and involves the use of a vacuum to remove blood or serous fluid from a wound or operation site.

Negative pressure wound therapy (NPWT) also called vacuum-assisted wound closure and refers to wound dressing systems that continuously or intermittently apply sub-atmospheric pressure to the surface of a wound. The application of controlled levels of negative pressure has been shown to accelerate debridement and promote healing in many different types of wounds. The optimum level of negative pressure appears to be around 120 mmHg below ambient and it is believed that negative pressure assists with the removal of interstitial fluid, decreasing localized edema, and increasing blood flow. This in turn decreases tissue bacterial levels. It involves the application of sterile, open-pore foam dressing directly on the wound. The wound is then sealed with an occlusive drape to create a closed, controlled environment. A fenestrated vacuum tube is connected to a vacuum source; fluid is drawn from the wound through the foam into a reservoir for subsequent disposal. Negative pressure is applied at 125-150 mm/Hg, resulting in a decrease in the local interstitial pressure, and effluent from the wound is drawn out into the collection device. Initially, the vacuum pressure is applied continuously. As the amount of drainage decreases, the vacuum may be subsequently applied on an intermittent basis. The vacuum dressing is usually changed at approximately 48-hour intervals,Wound progress is recorded using parameters in the wound scoring system. The objectivity of assessments used to generate the wound score makes this scoring system ideal for evaluating the treatment and outcome of wounds.

METHODOLOGY:

The study design was a prospective interventional study done in the department of orthopedics of Narayana Medical College and Hospital, Nellore, Andhra Pradesh. The study was conducted on patients who underwent surgery between July 2020 to January 2022.

Inclusion criteria:

1. Patients with ages of above 20 years and less than 60years.
2. Patients with compound fractures of Gustilo Anderson type 2, 3A, and 3B
3. hemodynamically stable patients.
4. Patients agreed for Informed and written consent and follow-up

Exclusion criteria:

1. Patients with ages less than 20 years and more than 60years
2. Closed fractures and Gustilo Anderson type 1 and 3C
3. Patients with pre-existing osteomyelitis in the bone, the neurovascular deficit in the injured limb, diabetes, malignancy, peripheral vascular disease
4. Patients not willing for Negative pressure wound therapy.

The study protocol was approved by the institutional ethics committee and informed written consent was taken from the study participants. A total of 60 patients who were were diagnosed as per Gustilo Anderson classification and underwent Negative pressure wound therapy.

PROCEDURE:

On admission detailed history of patients was elicited regarding the mode of injury and general information like name, age, sex, occupation, and address were noted. All vitals of the patients were examined. Patients with

compound fractures were divided according to the Gustilo Anderson classification for compound fractures.

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After obtaining the necessary radiographs, Type 2, 3A, and 3B compound fractures were treated by cleaning of the wound with a copious amount of normal saline, and hydrogen peroxide 7 (topical antiseptic) followed by painting the skin around the wound with povidone-iodine and suturing done. The limb was then immobilized till definite fixation was done. Gustilo Anderson type 3C fractures were not included in this study. All patients were operated on as early as possible once the general condition of the patients was stable and swelling subsided. Primary internal Fixation of fracture was done as soon as possible followed by Negative pressure wound therapy application.

Negative pressure wound therapy:

A culture swab for microbiology was taken before wound irrigation with normal saline. The mechanism of action of the vacuum-assisted closure is not completely understood yet. 8 However the following have been observed:

1. Increased blood flow

2. Increased formation of granulation tissue- Morykwas et al in his study found that wounds filled significantly faster with granulation tissue when a negative pressure of 125mmHg was applied to wounds compared with 25mmHg and 500mmHg.

3. Bacterial clearance- Morykwas et al reported a significant decrease in the number of organisms per gram of tissue after 4 to 5 days of treatment of wounds with vacuum-assisted closure system. The application of sub-atmospheric pressure to wounds causes increased blood flow and therefore increased local oxygen levels. This reduces or eliminates the growth of anaerobic organisms the presence of which has been correlated to decreased healing rates. In addition, greater amount of oxygen is available to neutrophils for the oxidative bursts that kill bacteria.

4. Physiologic basis- Two broad mechanisms have been proposed to account for the increased rate of healing for the wounds treated with the Negative pressure wound therapy system a fluid-based mechanism and a mechanical mechanism. The application of a controlled vacuum to the wound interface facilitates the removal of excess interstitial fluid because of the pressure gradient created. This results in a decrease in the interstitial pressure, which falls below the capillary pressure. The capillaries re-open and flow to peri-wound tissue is restored. All nonbound soluble factors will be removed with the fluid. This includes both the factors that inhibit and those that promote wound healing.

The skin (and most tissues) is viscoelastic; it was deformed slowly over time when mechanical force is applied to it. The applied forces deform the extracellular matrix and therefore the cells which are anchored to it. Cell deformation causes a wide variety of molecular responses including ion concentration changes and increase the permeability of membrane ion channels, the release of second messengers, molecular pathways stimulation, and changes in gene expression and therefore increased mitosis. This effect is the basis of tissue expansion and osteogenic distraction.

Negative pressure wound therapy causes deformation of tissues at the wound/sponge interface and also in the peri-wound area. At the site of the wound, the application of vacuum causes the collapse of the sponge, drawing the wound edges together. Tissues in the peri-wound area are also stretched when the vacuum is applied. This distant strain may still result in an increased mitotic rate in these peri-wound areas. Uniform controlled pressure was applied to all tissue surfaces of the wound. The average duration of a Negative pressure wound therapy is 4 to 5 days. The pressure applied an intermittent negative pressure of 125 mmHg.

It is observed that intermittent negative pressure appears more effective than continuous negative pressure, although this is not fully understood. Two possible explanations were advanced by Philbeck et al.They suggested that intermittent negative pressure results in rhythmic perfusion of the tissue which is maintained due

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to the process of capillary autoregulation are not activated. The intermittent negative pressure allows the cells time to rest and prepare for the next cycle. A culture swab for microbiology was taken before we also clinically assesses the wounds for signs of infection and obtained 4–6 mm punch biopsy, samples for histology, and culture.

The presence of drainage, edema, erythema, exposed bone, or exposed tendon would be documented. Any complications associated with Negative pressure wound therapy would be also documented. Such measurements and findings would be recorded on day zero, day four, and day eight. The pathologist would be noted and quantified the presence of inflammatory cells, bacteria, arterioles, proliferative fibroblasts, excessive collagen formation, and fibrosis in the biopsy samples. Advantages of Negative pressure wound therapy include reduced frequency of dressing changes, thus reducing nursing time for wounds, increasing patient comfort, reduced hospital length of stay, reduced bacterial cell count, removal of interstitial fluid to allow tissue decompression, and provision of a closed, moist wound healing environment.

Functional outcome of cases recorded during each follow-up according to Johner and Wruh's (1983) criteria with modification

Table 1: Johner and Wruh's (1983) criteria with modification

Criteria	Excellent	Good	Fair	Poor
Non union / infection	None	None	None	Yes
Neurovascular injury	None	Minimum	Moderate	Severe
Deformity				
Varus / valgus	None	$2\text{-}5^0$	$6\text{-}10^0$	$>10^0$
Anterior / Posterior	$0\text{-}5^0$	$6\text{-}10^0$	$11\text{-}20^0$	$>20^0$
Shortening	0-5mm	6-10mm	11-20mm	>20mm
Mobility				
Knee	Full	>90%	90 - 75%	<75%
Ankle	Full	>75%	75-50%	<50%
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Mild limp	Significant limp

Fig.1: Preoperative wound condition presenting at the emergency department

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Fig.2: Immediate post-operative wound at the time of primary fixation procedure

Fig.3: Wound condition after 1st Negative pressure wound therapy application

Fig.4: Wound condition after 3r d Negative pressure wound therapy.

Fig.5: Wound after 5 Negative pressure wound therapy with nil infection and abundant granulation tissue which is ready for the definitive secondary procedure (skin graft)

3. OBSERVATION AND RESULTS:

The current study includes patients with compound fractures of both bone legs for which Negative pressure wound therapy was applied in all the cases. demographic details of our study are mentioned in Table 2. A number of Negative pressure wound therapy dressing applications- Total number of Negative pressure wound dressings applied after fixation procedures till definitive secondary procedures are required were shown in the following table (Table 3). Criteria for assessment The assessment of Negative pressure wound therapy is based on the mean decrease in wound size and Johner and Wruh's (1983) criteria with modification (Tables 4 and 5). Definitive secondary procedure After the application of the total number of Negative pressure wound therapy dressings definitive secondary surgery was done for closure (Table 6). Complications As with any wound treatment, clinicians and patients/caregivers should frequently monitor the patient's wound, peri-wound tissue, and exudates for signs of infection, worsening infection, or other complications. 4 of the patient developed pain during Negative pressure wound therapy because foam is wrongly placed on the wound which was subsided by pain killer and change in VAC foam. 6 of the patients developed superficial skin infections, which were treated with daily dressings and appropriate antibiotics after pus culture and sensitivity. However other complications were shown in Table 7.

Table 2: Various details of our study

Variables		Number of patients	Percentage
Sex distribution	Male	40	70%
	Female	20	30%
Side distribution	Right	40	66.67
	Left	20	33.33%
Mode of injury	RTA	50	83.33%
	Fall from height	10	16.67%

Type of injury (gustilo Anderson)	II	8	13.33%
	III- A	32	53.33%
	III- B	20	33.33%
Type of internal fixation	Interlocking nail	48	80%
	Plate	12	20%

Table 3: Total number of Negative pressure wound therapy dressings applied after fixation

No. of NPWT dressings	No. of patients	Percentage
4	28	46.67
5	22	36.67
>5	10	16.67
Total	60	100.00

Table 4: Mean changes in wound size after Negative pressure wound therapy

	Wound size at The initiation of NPWT (in cm^2)	Wound size at The cessation of NPWT (in cm^2)	Decrease in wound size attained by NPWT (in cm^2)	% decrease
Mean ±SD	45.00±22.85	35.45±21.80	9.97±9.59	21.22
t-value	2.034			

Table 5: Johner and Wruh's(1983) criteria with modification

Criteria	No. of patients
Excellent	32
GOOD	14
FAIR	10
POOR	4

Table 6: Definitive secondary procedures required after application of NPWT dressing

Definitive secondary procedure	No. of patients	Percentage
Debridement and secondary closure	6	10
Tissue transfer	4	6.67
Split skin graft	40	66.67
Direct closure	8	13.33
Secondary intention	2	3.33
total	60	100.00

Table 7: Complications after NPW therapy

Complication	No. of patients	Percentage
Ankle and knee joint stiffness	6	10
Knee joint pain	8	13.33
Deep infection	4	6.67
Exposed implant	2	3.33

DISCUSSION:

NPWT has been advocated as a novel method in the healing of wounds and infection control. NPWT is mostly well tolerated, with fewer contraindications and complications, and is becoming a mainstay of modern wound management. Hence, we planned to use f NPWT or the treatment and fast healing of wounds in compound fractures both bone legs. The present study was undertaken to determine the efficacy of the Negative pressure wound therapy in the treatment of the compound fractures of both bone legs after primary internal fixation gives a decrease in wound size. Our study revealed the average age of patients with such injuries to be 40 years (20-60) in which fractures is most common in the age group of 30 - 40th decades of life because of outdoor activity.

The study was conduct with 60 patients in which 40 (70%) patients male and 20 (30%) patients female showing male predominance because of traveling, working in agricultural field and factories.

compound fractures both bone legs are most common long bone fractures in the adult population due to high-velocity trauma. Tibial shaft fractures are the most common long bone fractures in adults, commonly managed by interlocking nailing. However, several studies show that locking plate osteosynthesis is similar and effective in tibial shaft fractures and is associated with fewer complications. In our institute, we have preferred nail in comparison to plates and screw. In the nailing procedure we have given lesser iatrogenic trauma to the patient. In this study, we used an intramedullary nail in most of the patients 48 (80%) and remaining we preferred a plate in 12 (20%)patients.

The main issue dealing with a compound musculoskeletal injury is to restore the outline and healing of the soft tissue as early as possible. Previous studies by Joseph et al., Morykwas and Argenta, and Morykwas et al 18 have shown that VAC was effective in shrinking the widths of the wounds over time compared to standard wound dressings. In the present study, there was a decrease in wound size attained by VAC therapy ranging from 2.8 to 25cm, with an average reduction of 9.97(SD9.59){ 21.22%} cm . Multistaged treatment option in type III compound tibial fractures seems to be a better method for reducing complications and achieving the best results. In our study 32 patients had excellent, 14 patients had good, 10 patients had fair and 4 patients had poor results out of 60 patients.

Sanders et al. 19 indicated that unreamed tibial nailing was an acceptable technique for use in all compound tibial shaft fractures (excluding type IIIC). They also reported that the overall chronic infection rate was 4%, with no infections in type I, II, and IIIA compound fractures and a 13% rate in type IIIB compound fractures. Knee Joint pain was the common complication seen in 10% of the study participants which was followed by stiffness in 13.33% of them. This incidence can be further reduced with an early institution of knee and ankle mobilization exercises.

CONCLUSION:

All patients were clinically evaluated after the primary fixation and then NPWT application, for a period of follow-up of 18 months. The frequency of NPWT dressing application was 4 to 5 days per dressing from the second day of post-operative. There was no need for repeated surgical debridement during NPW therapy. By the analysis of the data collected in the present study, Primary internal fixation with NPWT application in compound fracture both bone leg will suggest newer treatment mobility. This technique has resulted in an effective decrease in wound size, a decrease in infections and give a better functional outcome. The greatest advantage of NPWT was found to increase the formation of granulation tissue on wounds with exposed bones and raw area wounds hence shortening wound healing time and minimizing secondary soft tissue coverage procedures.

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