Outcome of negative pressure wound therapy in Gustilo-Anderson type IIIa and type IIIb open fracture tibia

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ABSTRACT
Background: Open fracture wound adds significant morbidity to the patients. Soft tissue management and infection control in the era of increasing antibiotic resistance are challenges for doctors. Negative pressure wound therapy (NPWT), also known as vacuum-assisted closure (VAC) has been reported to increase the healing rate, promote wound bed granulation, prepare the wound bed for closure and remove exudates. It is widely used in wound care and promoted for use on complex (open wounds). Negative pressure wound therapy is regarded as a novel and adjunctive therapy that can be used to heal difficult open tibia fracture wounds and many studies have proven its efficacy. **Materials & Methods:** Thirty patients of Gustilo-Anderson type IIIa and type IIIb open tibial fracture were taken up for the study. After thorough debridement of wounds, NPWT was applied for 7 days and different parameters were compared. **Results:** After NPWT wound size decreased significantly from 6.53×4.43 cm^2 to 5.52×3.45 cm^2, the mean CRP level decreased from 4.93 to 2.74. Only 6 (20%) patients in the study population required soft tissue procedures for wound closure. Fractures united with a mean union time of 22.46 ± 7.79 weeks. Superficial infection developed in 2 patients (6.67%) and deep infection developed in 5 patients (16.67 %) in this study. **Conclusions:** The use of NPWT decreases the need for soft tissue procedures like skin grafting and muscle flap overall. The need for flap coverage has been converted into SSG after NPWT and the wounds requiring SSG healed without any procedure after NPWT application. This method can lead to a better outcome by reducing wound surface area. Increased local blood flow to the wounds decreases tissue bacteria levels. NPWT can be used as a prophylactic measure to prevent high-risk wounds from becoming more infected.

Keywords: NPWT, VAC, Open fracture, Tibia fracture, Compound fracture

Introduction

An open fracture refers to an osseous disruption in which a break in the skin and underlying soft tissue communicates directly with the fracture and its hematoma[(1)]. The anteromedial surface of the tibia is subcutaneously located, leading to a high incidence of open

(23%) fractures[2]. This leads to an increased risk of infection, wound complications, and non-union[3]. Open fracture wound requires skeletal stability and soft tissue coverage but the latter remains a problem. Most of these wounds need re-debridement to remove the devitalized tissue. But removing tissue causes soft tissue defects and requires healing through primary closure, delayed primary closure, or secondary intention[4]. Negative Pressure Wound Therapy (NPWT), also known as vacuum-assisted closure (VAC), has been reported to increase the healing rate, promote wound bed granulation, prepare the wound bed for closure and remove exudates. It is widely used in wound care and promoted for use on complex (open wounds). Negative pressure wound therapy is regarded as a novel and adjunctive therapy that can be used to heal difficult open tibia fracture wounds and many studies have proven its efficacy[5].

Materials and Methods

It was a prospective observational study done in a tertiary care hospital in Assam between 2021 to 2022. Thirty patients of Gustilo-Anderson[6] type IIIa and type IIIb open tibial fracture were taken for the study. Permission was taken from the institutional ethics committee and written consent was obtained from the patients before participation in the study.

Inclusion criteria: 1. Type IIIa and type IIIb open fracture tibia of age group more than 18 years 2. All patients willing to participate in the study and gave written and informed consent.

Exclusion criteria: 1. Type IIIc open fracture tibia 2. Age less than 18 years 3. Osteomyelitis 4. Fresh bleeding from the wound site/Need for vascular surgery 5. Malignancy 6. Ischaemic wounds 7. Pregnancy 8. Malnutrition 9. Immunosuppressive therapy 10. Dermatological condition 11. All patients who were not willing to participate in the study

Procedure: Patients with open tibial fractures were subjected to a thorough wound wash with a copious amount of normal saline solution and irrigated with betadine and diluted hydrogen peroxide solution. A broad-spectrum cephalosporin group of antibiotics and one aminoglycoside (gram-negative coverage) were injected instantly. Tetanus toxoid and tetanus immunoglobulin were also injected.

The patients were subjected to thorough debridement of the wound under necessary anaesthesia within 24 hours. Dead, devitalized tissues have been removed. Small fragments of bone which are free of soft tissue attachment have been excised. The medullary cavity was inspected and the foreign body and hematoma were removed. Periosteum was preserved to maintain the viability of the bone. After debridement fracture was fixed as deemed appropriate by the operating surgeon. At this stage, the wound was definitively classified again as per Gustilo Anderson classification[6]. Patients fulfilling the criteria were taken up for the study.

Application of negative pressure wound therapy: The NPWT System applies controlled, localized negative pressure to upgrade wound healing procedures.

(a) Wound preparation: Haemostasis of the wound should be achieved. The wound is cleaned with normal saline and betadine. A nanocrystalline silver gauge is placed over it. The edge of the wound is dried so that adhesive sticks over it.

(b) Placement of foam: The foam has been trimmed according to the size of the wound bed. Precaution should be taken not to apply the foam directly over the skin as this may cause skin maceration.

Fig 1: Foam Dressing

(c) Sealing with adhesive dressing: The adhesive dressing must form a complete seal around the wound margin to create a vacuum. The wounds around a fixator are to be sealed, care is taken to include all the pin sites in the seal. The adhesive occlusive dressing is applied over the gauze pieces to ensure an airtight seal.

(d) Connecting tubes: A hole is made over the adhesive dressing so that it is placed over the centre of the wound. Then a layer of adhesive is again placed over it so that there is no leakage. The tube is then connected to a canister. Y-connector connects two different tubes to a single one for two wounds at anatomically different sites.

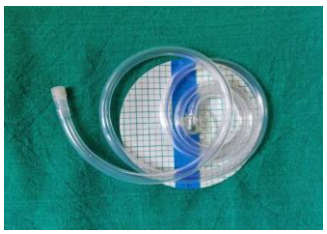

Fig 2: Track pad & Tube

(e) Negative pressure source: The suction tube is connected to a negative pressure source which requires a power supply. It usually generates negative pressures of around -125 mmHg.

(f) Canister: It collects the exudate that is drawn from the wound bed. Canisters used in this study can hold a quantity of liquid exudate up to 500 ml.

Fig 3: Negative pressure source

Aseptic measures are taken throughout the procedure. Continuous negative pressure is to be adjusted in the system. After 48 hours of continuous negative suction, it can be converted into intermittent mode. In some of our patients, NPWT is applied in the OT just after emergency surgery.

Fig 4: Canister

During treatment: All the cases were subjected to NPWT therapy for up to 7 days. For the first 48 hours, the wound was kept in a continuous mode that is -125 mm of Hg while for the rest of the duration, kept in an intermittent mode that is between -125 mm of Hg and -85 mm of Hg. The canister was checked daily for any spillage of secretion. After 7 days of therapy dressing was removed. Dressings will commonly need to be changed after 6-7 days[7].

After treatment: The presence of granulation tissue over the wound bed and wound size was noticed and compared with the pre-NPWT wound. Swab from the wound was taken and sent for bacterial culture. CRP level was measured and compared with that before.

Discharge: Patients were discharged from the hospital depending on the status of the wound. Wounds requiring soft tissue procedures were transferred to the plastic surgery department.

Follow up: All patients were followed up at an interval of 7 days and 1,3 and 6 months and at all visits patients were assessed clinically regarding ankle and knee range of motion, walking ability, fracture union, deformity, and shortening.

In the case of any soft tissue procedure, patients were categorized under skin grafting and muscle flap. Graft site dressing was done. The regression of wound size was assessed. The wound was assessed for superficial and deep infection. Patients were taught to take proper pin tract care in case of an external fixator. X-ray of the involved leg with knee and ankle was done to assess fracture union. After clinical and radiological bony union in the case of external fixation, the fixator was removed and a walking cast was applied. The time to achieve union was recorded.

Statistical analysis: Continuous variables were presented in terms of mean ± standard deviation. Categorical variables were presented in terms of counts and percentages. P-values were calculated by using the paired t-test for continuous variables and Fischer's exact test for the categorical variables. A p-value of < 0.05 was considered statistically significant. All analyses were done using the computer program, Statistical Package for Social Sciences (SPSS for Windows, version 20.0. Chicago, SPSS Inc.) and Microsoft Excel 2010.

Results

The present study was undertaken on 30 subjects. The mean age of the population was 38.27 ± 14.11 years.

Table 1: Patient Data

Patient data		Number	Percentage (%)
Gender	Male	22	73.33
	Female	8	26.67
Mechanism of injury	RTA	26	86.66
	Fall from height	2	6.67
	Sports	1	3.33
	Physical assault	1	3.33
Side involved	Right	19	63.33
	Left	11	36.67
Location of the wound	Anteromedial	14	46.67
	Anterolateral	3	10
	Medial	7	23.37
	Lateral	1	3.33
	Circumferential	5	16.67
AO-OTA Classification	42-A1	1	3.33
	42-A2	3	10
	42-A3	12	40
	42-B1	1	3.33
	42-B2	1	3.33
	42-B3	2	6.67
	42-C1	1	3.33
	42-C2	6	20
	42-C3	3	10
Gustilo-Anderson Classification	Type IIIa	13	43.33
	Type IIIb	17	56.67

Location of fracture	Upper one-third diaphyseal	4	13.33
	Middle one-third diaphyseal	17	56.67
	Lower one-third diaphyseal	9	30.00
Mode of fixation	External Fixator	12	40
	Nail	17	56.67
	Plate	1	3.33

After the application of NPWT, the mean length of the wound became 5.25 cm from 6.53 cm and, the mean breadth became 3.45 cm from 4.43 cm.

Table 2: Wound size before & after NPWT

DEFECT SIZE	BEFORE NPWT		AFTER NPWT		*p-value*
	Mean	± *S.D.*	*Mean*	± *S.D.*	
Length (cm)	6.53	2.41	5.25	2.11	0.0323
Breadth (cm)	4.43	1.57	3.45	1.28	0.0103

Fig 5: Wound before NPWT

Fig 6: Wound after NPWT

The mean CRP value before the application of NPWT was 4.93 ± 5.50 and it decreasedto 2.74 ± 1.58 after the application of NPWT.

Table 3: Mean CRP before & after NPWT

	BEFORE NPWT		AFTER NPWT		*p-value*
	Mean	± *S.D.*	*Mean*	± *S.D.*	
CRP (mg/L)	4.93	5.50	2.74	1.58	0.0406

Among 30 patients 4 patients (13.33 %) needed split skin grafting and 2 patients (6.67%) needed muscle flap as a soft tissue procedure after NPWT application. The maximum number of cases that is 24 (80%) did not require any soft tissue procedure. These wounds healed without any intervention after NPWT.

After the application of NPWT 22 patients (73.33%) stayed in the hospital for a duration of 8-14 days, 7 cases (23.33%) stayed for more than 14 days and one case (3.33%) stayed less than a week. The mean hospital stay was 12.03 ± 3.47 days.

In this study, in 16 patients (53.33%) fractures united within 15-20 weeks, in 7 patients (23.33%) united within 21-25 weeks, and in 2 patients (6.67%) united within 26-30 weeks. Among the others, one took 31-35 weeks, one took 36-40 weeks and one took more than 40

weeks for the union. Non-union occurred in rest two cases where further intervention was required. The mean union time is 22.46 ± 7.79 weeks.

In this study, before NPWT, all cases (100%) showed positive culture. After NPWT among 30 cases, 17 cases (56.67 %) show negative culture, rest 13 cases (43.33%) remained positive. Here p-value was < 0.05. Superficial infection developed in 2 patients (6.67%) and deep infection developed in 5 patients (16.67 %) in this study.

Discussion

Open fracture wound adds significant morbidity to the patients. Soft tissue management and infection control in the era of increasing antibiotic resistance are challenges for doctors.

This study shows a significant decrease in wound size after NPWT. This correlates with the study of Virani et al[8]. The level of C Reactive Protein decreased significantly after the application of NPWT. Luo et al got similar results in their study[9]. After NPWT amongst 30 patients, 4 patients (13.33 %) needed split skin grafting and only 2 patients (6.67%) needed muscle flap. The wounds healed without any intervention in most of the patients (24 patients, 80%) after NPWT. Arti et al in their study found that among the NPWT group (45 patients), 5 patients (11.11%) needed split skin grafting, and 1 patient (2.22%) needed muscle flap. Rest 39 patients (86.67%) did not require any intervention which is similar to the present study[10]. In this study, the mean duration of hospital stay is 12.03 ± 3.47 days. Arti et al found the mean duration of hospital stay of 9.7 ± 2.3 days among the study group (NPWT group)[10]. In this study, the mean union time is 22.46 ±7.79 weeks which is similar to the study of Park et al who found the mean union time of 25 weeks (Range 16-50 weeks)[11]. In the present study, 2 patients (6.67%) developed a superficial infection and 5 patients (16.67 %) developed a deep infection. Dedmond et al in their study found superficial infection in 4 patients (8%) and deep infection in 10 patients (20%) which is approximately the same as the present study [12]. In the present study, before the procedure, all cases showed positive culture. After the NPWT 17 patients (56.67 %) showed negative culture and this outcome is significant. Sinha et al in their study among 15 patients in the NPWT group found culture-negative results in 9 cases (60%) after eight days [4].

Conclusions

Tibia open fracture is more common in the 30 - 40 years age group, males are commonly affected with the highest mode of injury being RTA. Mid-diaphyseal fractures are commonest with most of the wounds on the anteromedial side. The use of NPWT appears to decrease the need for soft tissue procedures like skin grafting and muscle flap overall. The need for flap coverage has been converted into SSG after NPWT and the wounds requiring SSG healed without any procedure after NPWT application. This method can lead to a better outcome by reducing wound surface area. Increased local blood flow to the wounds decreases tissue bacteria levels. NPWT can be used as a prophylactic measure to prevent high-risk wounds from becoming more infected.

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