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NEGATIVE PRESSURE WOUND THERAPY (NPWT): OUR EXPERIENCE USING HOSPITAL WALL SUCTION

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ABSTRACT **Study Design:** Prospective case series **Introduction:** Delayed wound healing is a significant concern, particularly in complex wounds and the elderly with co-morbidities. It leads to pain, morbidity, prolonged treatment, and requires major reconstructive surgery, which imposes an enormous social and financial burden. Negative Pressure Wound Therapy (NPWT) was used to cover large wounds, decubitus ulcers, and open fractures that cannot be closed either primarily or secondarily and often require a complex reconstructive procedure to protect the injury. NPWT is an alternative method of wound management, which uses the negative pressure to prepare the wound for spontaneous healing or by lesser reconstructive options. **Materials and Methodology:** We applied NPWT on patients with open fractures, decubitus ulcers, neglected wounds, fasciotomies, and large wounds. Compared to the patented VAC system, ours include pre-sterilized PVA foam, cling drape (Surgiwear TM), nasogastric tube or an infant feeding tube, and a hospital wall suction. **Results:** There were three cases of soft tissue injury of the foot with wound defect, one case of fasciotomy for compartment syndrome, one case of the decubitus ulcer, one case of open fractures, and three cases of degloving injuries of the foot. In our study, the NPWT was changed every five days, the average number of NPWT changes was 3-4, length of time NPWT applied before the closure was 14-21 days. The most frequent coverage mode is Split Thickness Skin Graft obviating the need for more complex flaps and microvascular reconstructive procedures. **Conclusion:** Negative pressure therapy stabilizes the wound environment, reduces wound edema/bacterial load, improves tissue perfusion, and stimulates granulation tissue and angiogenesis. NPWT appears to be simple and more effective than conventional dressings for managing complex wounds, reducing wound volume, depth, treatment duration, and cost.

KEYWORDS : Negative pressure wound therapy, Vacuum-assisted closure, Difficult wounds

INTRODUCTION

Over the years, negative-pressure wound therapy has brought a revolution in treating a wide variety of complex wounds. The treatment technique for open wounds based on negative pressure was developed in Germany by Chariker and Fleischmann in the 1990s. It was popularised by Argenta and Morykwas from the United States following their landmark studies published in 1997.[1] Apart from the terminology of vacuum-assisted closure (VAC), it can also be found in the literature as topical negative pressure (TNP), sub-atmospheric wound closure, sub-atmospheric pressure therapy/dressing, a sealed surface wound suction, vacuum sealing, vacuum pack, and foam suction dressing.[2] The generic name Negative Pressure Wound Therapy (NPWT) is most popularly used.[2] The treatment is based on a uniformly distributed local negative pressure applied to the wound surface covered with a special sealed dressing connected through suction tubes to a pressure adjusting control unit. The pressure commonly used is 80-125mm Hg either continuously or intermittently. NPWT aims to protect and manage a wound, prepare it for closure by either delayed primary or secondary intention, improve split-thickness skin graft outcomes, improve patient comfort, and reduce cost.[3] NPWT has been recommended for virtually all kinds of acute and chronic wounds to accelerate healing.[3] The indications include traumatic injuries associated with open fractures with or without soft tissue defects, exposed tendon, bone, joints, and hardware, infected wounds like necrotizing fasciitis, fasciotomy wounds, chronic non-healing wounds like diabetic leg ulcers, ischaemic ulcers, after skin grafting and surgical incisions at risk of breakdown or infection and burns.[3,4] All these wounds are ideal for NPWT after a thorough debridement. The therapy duration varies from a few days to months, which depends on the aim of treatment and the nature of the wound.[3,4]

It is generally not recommended in exposed vasculature, nerves, anastomotic sites, bleeding disorders with abnormal coagulation profile, and infected wounds which have not been debrided.[5]

The purpose of NPWT is to produce mechanical wound deformation, reduce exudate and bacterial load, promote blood flow and facilitate granulation tissue.[1] (Table 1)

Table-1: Mechanism of action: Orgill et al., Huang et al., Bhat et al.[5,6,21]

Blood flow changes: • Not fully understood and could be hypoxia-mediated. • Studies have shown that blood flow decreases at the wound edge but increases immediately with vacuum release, suggesting that intermittent NPWT may further increase blood flow.
Macro deformation: • Macro deformation refers to induced wound shrinkage caused by the collapse of the pores and centripetal forces exerted on the wound surface by the foam. • Polyurethane ether foams exposed to 125mmHg suction can decrease the foam volume by approximately 80% and substantially reduce wound surface area.
Micro deformation: • Micro deformation refers to the undulated wound surface induced by the porous interface material when exposed to suction. • Cell shape has been demonstrated to be a determinant of cellular function. In addition, cells are known to adapt to physical stresses. Therefore, changes in cellular functions can be initiated by dynamic physical inputs like negative pressure suction.
Fluid removal: • Excess oedematous fluid in the extracellular matrix impedes blood flow and increases diffusion distances for oxygen and nutrients. • After fluid removal, improved wound healing ability may be attributed to enhanced nutrient transport, toxins removal, or local blood flow changes.
Maintenance of wound homeostasis: • Covering the wound with a semi-occlusive dressing and using foam with insulation qualities minimizes evaporation, desiccation, and heat loss. • It stabilizes the wound microenvironment by removing inflammatory mediators, toxic molecules, bacteria, and interstitial edema with micromechanical stimulation of cells.

METHODS:

All VACs were applied and changed under aseptic conditions. The patient was taken to the operating room for debridement of the wound, and the affected limb was prepped and draped. Thorough debridement of all devitalized tissues was done. A complete excisional debridement was performed, followed by a copious wash. Intraoperative cultures were obtained during the debridement. The wound was then prepared for the application of NPWT. We use a white PVA of 15mm as filler. It is readily available, cost-effective, mouldable, and large sheets can be used. Suction was applied using a 16 French Ryle's tube placed superficial to the filler, and the wound was sealed with a cling drape (Surgiwear TM) (Figure-1).

Figure-1: Materials for Negative Pressure Wound Therapy (NPWT).

We use Leucoplast TM to seal around pin sites if suction is inadequate. The tube was connected to a simple inward central wall suction device that can apply pressure between 0-760 mmHg. The central suction device has a meter to monitor and a key to control the pressure at desired levels of 75-100 mmHg (Figure-2,3,4). This is applied cyclically for 20 minutes, followed by an off period of 2 hours. The tube was then connected to the suction to check if the foam collapsed. If not, we looked for any unsealed area and then sealed it with more plaster tapes. This dressing is changed every five days or earlier if the patient is taken up for elective surgery. Once a clean wound bed was obtained, the wound was covered definitively with a split-thickness skin graft. The material cost of this whole system works out to be less than a thousand rupees for each change of dressing. The commercially available systems cost around 5-7 times more than the above for each dressing change.

Figure-2,3,4: Hospital central suction device.

RESULTS

From August 2020 to January 2022, ten patients underwent negative pressure wound therapy (NPWT) in hospital wall suction. There were eight males and two females. The mean age in the study was found to be 42 years. Three cases of soft tissue injury of the foot with wound defect, 1 case of fasciotomy for compartment syndrome, one case of the decubitus ulcer, two cases of open fractures, and three cases of degloving injuries. The mean duration of NPWT was found to be 19 days, the average number of NPWT changes was 3-4, length of time NPWT applied before the closure was 14-21 days. The mean pre-wound size was found to be $17.3cm^2$, mean post-wound size was $12.6cm^2$. The most frequent coverage mode is Split Thickness Skin Graft obviating the need for more complex flaps and microvascular reconstructive procedures. There were no failures from NPWT (Table-1). No significant complications were noted, but two patients needed prolonged hospital stay for the definitive procedure, one patient with uncontrolled type-2 diabetes mellitus with a non-healing ulcer over the leg and another one with a postoperative case of trimalleolar fracture with wound necrosis, need 6 NPWT changes, thus prolonging the stay in the hospital. Both patients were managed with split skin grafting during the prolonged stay. One patient developed postoperative hand stiffness post fasciotomy for compartment syndrome of the forearm. The stiffness has resolved after intensive hand therapy and anti-edema strapping.

Table-1: Demographic, Injury, Treatment data.

Age	Sex	Diagnosis	NPWT changes	Pre wound measurement (cm^2)	Post wound measurement (cm^2)	Definitive Procedure	Complications	Outcomes
39	M	Soft tissue injury of the right foot	3	15	8	SSG	Nil	Good
36	M	Degloving injury of the right foot	3	12	7	SSG	Nil	Good
72	M	Left forearm compartment syndrome	4	36	27	SSG	Postoperative hand stiffness	Good
66	M	Non-healing ulcer over the left leg	6	45	40	SSG	Prolonged hospital stay	Good
35	M	Degloving injury of the left foot	3	10	5	SSG	Nil	Good
40	M	Grade-3B bilateral calcaneum fracture	4	Right-9.5 Left-10	Right-7 Left-8	SSG	Nil	Good
44	M	Soft tissue injury over the left foot	3	7	4.5	SSG	Nil	Good
29	M	Soft tissue injury over the right foot	2	6.5	5	SSG	Nil	Good
30	F	Degloving injury over the left foot	4	12.5	10	SSG	Nil	Good
29	F	Postoperative wound necrosis	6	20	18	SSG	Prolonged hospital stay	Good

Figure-5,6,7: Multiple patients who underwent NPWT with healthy granulation tissue. The soft tissue defect was covered with Split Thickness Skin Graft (SSG).

DISCUSSION

In developing countries like India, with more than 60 percent population living in rural areas and no proper tertiary care centers available, and people belonging to low socioeconomic status, the situation is further complicated by late presentation, wounds already improperly debrided, and other centers. Thorough surgical debridement remains the primary option for all open wounds, without which no other adjunctive procedure will work. NPWT helps us, surgeons, with the effect of continuous negative pressure on wound healing by removing fluid, increasing circulation, and stimulating granulation tissue and regeneration.[5-6] The basis for VAC is based on various animal and human studies.[7-8] An ICL lecture on VAC in open tibial fractures in an AAOS meeting in 2004 reported 44 patients; randomized to standard wound protocol versus VAC and found the following, drainage was lessened with VAC at 3.1 days versus 1.6 days (p=.003), infection 16% versus 8% in patients with VAC.[9] A study reported 10^7 bacterial countdowns to 10^2-10^3 per gram of tissue on the fourth and fifth day with VAC treatment but emphasized that this does not prevent the need for adequate debridement of traumatized soft tissues. Furthermore, it simplified the care of complex soft tissue wounds as it required less dressing change, and more complex flaps to cover soft tissues became less frequently used.[10]

A study noted an increased tissue O_2 perfusion using 125 mmHg a few cm from wound edge but included hypoperfusion in the immediate vicinity to wound edge; thus, intermittent makes more sense in that ebb-flow mechanism allows recovery recommended 75 to 100 mmHg as optimum.[11] In our study, we used 75-100 mmHg and found no negative effect of VAC with this pressure setting. Furthermore, patients were generally comfortable and did not report any pain while the suction was on.

Recent literature has favored the use of VAC for patients with open infected wounds.[12] They have used the VAC to decrease the size of traumatic wounds in 21 patients with high-energy soft tissue injuries. They could preclude free tissue transfer with VAC or regional muscle transfer in selected patients. They describe using the VAC to assist wound closure in 75 patients with severe lower extremity wounds with exposed bone. Our experience also confirmed the usefulness of this technique.

A review article further emphasized the advantages of VAC as a method of reducing bacterial counts in wounds, as a bridge until definitive bony coverage, for treating infections, as an adjunct to wound bed preparation, and for bolstering split-thickness skin grafts, dermal replacement grafts, and muscle flaps.[13] The article states that NPWT is an adjunct to the mainstays of wound management. No significant complications have been noted in the categories of NPWT discussed in this review. In addition, evidence supports a decrease in complex soft tissue procedures in grade IIIB open fractures when NPWT is employed. NPWT appears to provide clinical benefits for treating these complex lower extremity wounds.[14-16]

A review of 290 open tibia-fibula fractures Gustilo grade III, from 1992 till 2003, demonstrated a change in practice, with a trend down the reconstructive ladder, currently using fewer free flaps (20% from 1992-1995, 11% from 1996- 1999 to 5% from 2000-2003) and more delayed closures and skin grafts with frequent use of the vacuum-assisted closure sponge which he started using from 1997.[17]

Two papers emphasize a statistically significant decrease in the median time required to complete the healing of acute and chronic wounds.[18-19] They found a median time to complete healing of 16 days with VAC versus 20 days in the control group (P=0.32)[18] and 29 days with VAC versus 45 days in the control group (P=0.001)[19].

Two studies described the changes in wound surface area.[18,20] One study reported a median reduction in wound surface area of 0.3 cm^2 per day with VAC versus 0.1 cm^2 per day in the control group (P=0.83).[18] Whereas others reported a reduction in wound surface area in all 15 patients treated with VAC versus 13 of those in a gauze treatment group.[20] The mean reduction in wound surface area was 3.8 percent per day with VAC compared to 1.7 percent per day with gauze (a difference of 2.1 percent per day). Unfortunately, in the study, they could not measure the surface area and depth of the wound before VAC application.

Some authors reported a median time for the wound bed to be ready for surgery of 7 days with VAC versus 17 days in the control group.[19-20] They reported a median time for the wound bed to be ready for surgery of 6 days for the VAC group versus seven days for the gauze-treated group (P=0.19). 14 to 21 days were required before closing the wound in our study. It may be because of delays in VAC changes in hospitals because of the unavailability of operating room time.

CONCLUSION:

The advent of negative pressure wound therapy systems has changed how we treat acute and chronic wounds. Negative pressure therapy stabilizes the wound environment, reduces edema/bacterial load, improves tissue perfusion, and stimulates granulation tissue and angiogenesis. VAC therapy appears to be simple and more effective than conventional dressings for managing complex wounds, reducing wound volume, depth, treatment duration, and cost. We conclude that our modifications did not show detrimental effects and work as well as the original VAC system. Besides, the components are readily available, and it is much cheaper than the original VAC system.

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