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Functional outcome of Vacuum Assisted Closure (VAC) dressing therapy for the management of non-healing wound and traumatic wound

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Abstract
Introduction: Wound healing is a complex, dynamic process and delayed wound healing significant health problem in India. Various type of surgical methods have been developed for wound healing such as Advanced Wound Care Therapies (AWCT)/ Vacuum-Assisted Closure (VAC) and myo-cutaneous or fascio-cutaneous tissue transfers, Stander dressing therapy etc. VAC Therapy is a Non-Invasive therapy. This therapeutic technique using for the management of large chronically infected wounds more recently used in the treatment of traumatic wounds and non-healing wounds.
Aim: Aim of this study is to evaluate functional outcome of vacuum-assisted closure (VAC) dressing therapy for the management of non-healing wounds and traumatic wounds.
Materials and methods: Our study was conducted on 30 patients in the Department of Orthopaedics, Kamineni Hospital, LB Nagar Hyderabad from May 2017 to June 2018. Out of 30 patients 18 male and 12 females, Mean age ranging from 19 to 58 for males and 20 to 60 for females. In our study, maximum cases were reported Road traffic accident 20 (67%) patients, followed by machinery injury in 6 (20%) patients and 4 (13%) patients had a fall from height. Vacuum Assisted Closure (VAC) dressing therapy applied for non-healing wounds and traumatic wounds.
Results: Out of 30 wounds taken in the study, 20 wounds reduced in area & were resurfaced with split thickness skin grafting and 5 wounds showed reduction in area & were subjected to secondary closure. During start of VAC dressing therapy, all wounds were infected. At the end of VAC dressing, all wounds became swab negative during course of VAC dressing therapy, no patient required surgical debridement and there was gradual decrease in size of wound.
Discussion: Our study showed that in VAC dressing therapy after day 3, there were 40% of patients who had no bacterial growth, and on day 7 there were 88% of patients who growth, whereas in saline-wet-to-moist patients only 10% of patients had no bacterial growth on the 8th day. Our study showed that VAC dressing therapy increases the vascularity and rate of granulation tissue formation compared to standard wound dressing therapy.
Conclusion: VAC dressing provides sterile and controlled environment to large, educating wound surfaces by controlled application of sub-atmospheric pressure and prepares wounds for closure through split skin grafting and secondary closure in short time leading to less overall morbidity with decreased hospital stay.

Keywords: Vacuum Assisted Closure (VAC), Traumatic Wounds, Non Healing Wound

Introduction
Wound healing is a complex, dynamic process and delayed wound healing is significant health problem in India. In addition to pain and suffering, Failure of wound to heal imposes Social & financial burdens. Wound healing includes an immediate sequence of cell migration leading to repair and closure. This sequence begins with removal of debris, angiogenesis, control of infection, deposition of granulation tissue, clearance of inflammation, remodeling of the connective tissue matrix, contraction and maturation. When wound fails to undergo this sequence of events, a chronic open wound without anatomical or functional integrity results [1]. Standard treatment of wound healing includes debridement of necrotic tissue, hydrocolloid wound gels, dressings with enzymatic debridement compounds, local ulcer care, infection control, mechanical off-loading, management of blood glucose levels, hyperbaric oxygen

therapy and education on wound care. When wound fails to undergo this sequence of events, a chronic open wound without anatomical or functional integrity results [2].

Open fractures require both skeletal stability and adequate soft tissue coverage. In such injuries, debridement of all nonviable tissue can produce significant soft-tissue defects precluding healing through primary closures, delayed primary closures, or secondary intention [3]. Clinically, chronic wounds may be associated with pressure sore, trauma, venous insufficiency, diabetes, vascular disease, or prolonged immobilization. The treatment of chronic, open wounds is variable and costly, demanding lengthy hospital stays or specialized home care requiring skilled nursing and costly supplies. Rapid healing of chronic wounds could result in decreased hospitalization and an earlier return of function.

Various type of surgical methods have been developed for wound healing such as skin grafts, local rotation flaps, Advanced Wound Care Therapies (AWCT)/Vacuum-Assisted Closure (VAC) and myo-cutaneous or fascio-cutaneous tissue transfers, Stander dressing therapy etc.

Vacuum assisted closure (VAC) dressing therapy, may also be known as negative pressure wound therapy or Micro deformational wound therapy, which has brought a revolution in wound care since past 20 years. This method was first described by Fleischmann *et al*. in 1993 [4]. VAC dressing therapy is a Non-Invasive therapy. It is a Therapeutic technique using a vacuum dressing to promote healing in Acute or Chronic (non healing wounds, traumatic wounds) and enhance healing of First & Second Degree Burns. It involves controlled application of sub-atmospheric pressure to local wound environment, using a sealed wound dressing connected to a vacuum pump. It uses vacuum assisted drainage to remove blood or serous fluid from operative site. It promotes dry surgical field & control blood flow. It reduces infection rates; increasing localized blood flow. It also supplies wound with oxygen & nutrition to promote healing. Initially developed in the early 1990s, for the management of large, chronically infected wounds that could not be closed in extremely debilitated patients, the use of vacuum-assisted closure (VAC) dressing therapy has been more recently used in the treatment of non-healing and traumatic wounds [5].

Aim

Aim of our study is to evaluate functional outcome of Vacuum-Assisted Closure (VAC) dressing therapy for the management of non-healing wounds and traumatic wounds.

Materials and Methods

Table 1: Distribution of patients according to Age, Sex and Mode of Injury

Number of cases	30
Sex	Male 18(60%)
	Female 12(40%)
Average Age of patients	Male 19 to 58
	Female 20 to 60
Mode of injury	RTA 20(67%)
	Machinery injury 6(20%)
	Fall from Height 4(13%)

Our study was conducted on 30 patients in the Department of Orthopaedic, Kamineni Hospital, LB Nagar Hyderabad from May 2017 to June 2018. Ethical approval was obtained for this study from local ethical committee and taking informed and written consents from the patients. All patients are of above 18 years of age of both sexes. Out of 30 patients 18 male and 12 females, mean age ranging from 19 to 58 for males and 20 to 60 for females. All patients had suffered an acute trauma. In our study, maximum cases were reported Road traffic accident 20 (67%) patients, followed by machinery injury in 6 (20%) patients and 4 (13%) patients had a fall from height.

Vacuum Assisted Closure (VAC) dressing therapy applied for non-healing wounds and traumatic wounds.

Inclusion Criteria

- Wounds with exposed bone and tendons.
- Partial thickness burns.
- Chronic pressure ulcers and non-healing ulcers.
- Traumatic wounds.
- Neuropathic ulcers.

Excluding Criteria

- Ulcers over the extremities with peripheral vascular disease.
- Fistula to organs or body cavities.
- Acute burns.
- Untreated osteomyelitis.
- Wound with exposed blood vessels or organs.
- Presence of necrotic tissue.
- Malignancy in wound.
- Wounds of very large surface area (area more than 10% body surface area, areas like perineum, groin, axilla)
- Patients with hemorrhagic disorders.

Materials Required

- Autoclaved sponge foam (double autoclaved at pressure of 20 PSI, 250°F for 30 min) [6]
- Tegaderm /opsite /plastic cover/surgical glove of appropriate size/ Ioban
- Disposable syringes (10 cc, 20 cc, 50 cc), romovac suction drain, mucus suckers, pedal suction apparatus, portable electrical suction machine
- Suction catheter/Ryle's tube/infant feeding tube
- Transparent adhesive tape/micropore
- Plastic sheet

The VAC Procedure

Any dressings from the wound were removed and discarded. A culture swab for microbiology was taken before wound irrigation with normal saline. Necrotic tissues were surgically removed and adequate haemostasis was achieved. Prior to application of the drape, it was essential to prepare the peri-wound skin and ensure that it was dry. Autoclaved Sponge foam which is normally available at hardware stores of 8 mm thickness is taken and is cut in to shape of the wound with slightly larger size than the wound. A suction catheter/Ryle's tube with adequate number of fenestrations made depending upon the wound size is placed in between the two sponge layers and the whole wound area is sealed with tegaderm/opsite [7] /adhesive Ioban drape covering the foam and tubing and at least three to five centimeters of surrounding healthy tissue to ensure a seal and the suction catheter on the other end is connected to vacuum creating device and is charged. The syringe/romovac suction machine is cleared of drainage and recharged with vacuum after each clearance at timely intervals. The negative pressure applied will be from −75 mm Hg to −200 mm Hg depending upon the type of modality used to create the vacuum. VAC Dressings are changed at intervals of 48-72 h depending upon the

amount of exudates drained, leakage from the sealed area due to fluid logging in and also upon the state of the wound and pictures of the wound and measurements are taken. The VAC dressing therapy are done till the granulation tissue of the wound fills till to the skin surface and left to healing by secondary intention or as secondary method of wound closure as secondary suturing, flap repair, split skin grafting.

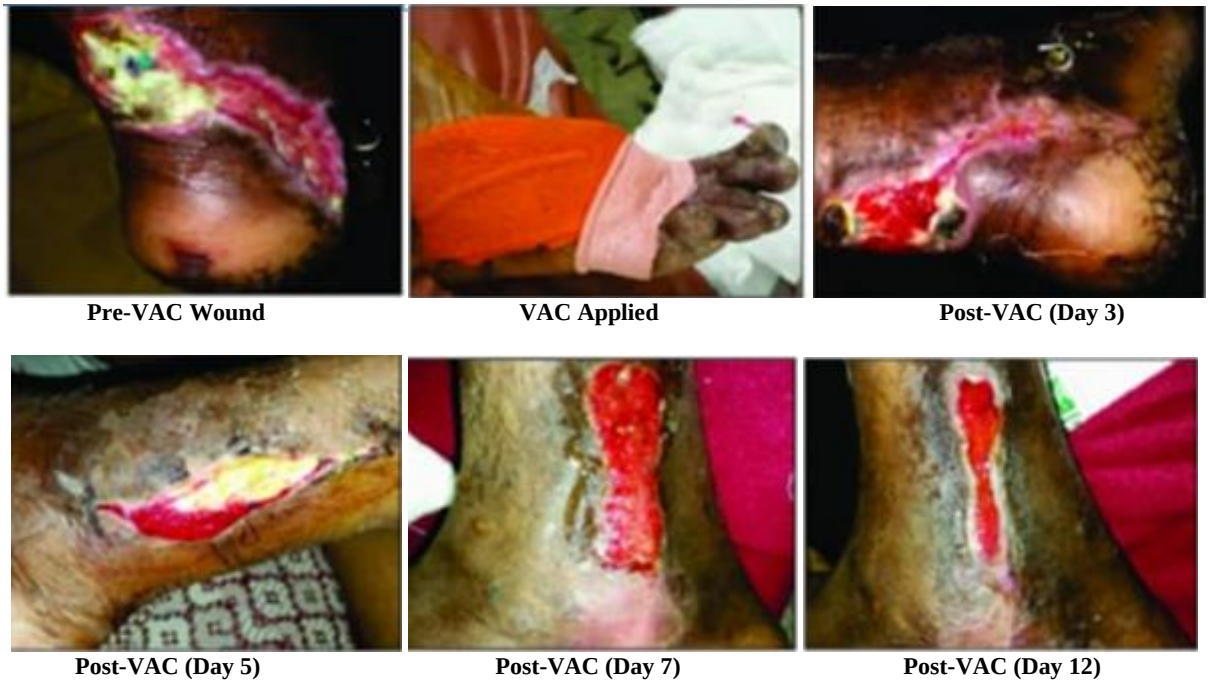

Fig 1: VAC Procedure

Results

Out of 30 wounds taken in the study, 20 wounds reduced in area & were resurfaced with split thickness skin grafting and 5 wounds showed reduction in area & were subjected to secondary closure. In our study, 5 patients were considered as failure (2 patients developed leak in vacuum, 2 patients not improved and changed to other modality of dressing, 1 patients underwent amputation) and these patients were excluded from study population of vacuum dressing. During start of VAC dressing therapy, all wounds were infected. At the end of VAC dressing, all wounds became swab negative during course of VAC dressing therapy, no patient required surgical debridement and there was gradual decrease in size of wound.

According to Gustilo Anderson classification, out of 30 patients, 18 patients had grade IIIb injury, 6 had grade IIIc injury, 4 had IIIa injury, and 2 had grade II injury.

Table 2: Bacterial growth on various days

Bacterial Growth	VAC Patients n=25		
	Day 0	Day 3	Day 7
Present	25(100%)	15(60%)	3(12%)
Absent	0	10(40%)	22(88%)

Discussion

Wound healing is independent process that involves complex interactions between cells, the cellular microenvironment and extracellular matrix molecules that usually results in a functional restoration of the injured tissue [8, 9]. Locally acting growth factors influence healing in the events of migration of neutrophils, proliferation, angiogenesis, formation of extracellular matrix, macrophages, fibroblasts, increasing collagen and protein production thereby enhancing the healing of wound [10, 11]. Disruption of any of these factors may adversely affect the healing process, resulting in a chronic or non-healing wound.

Application of sub atmospheric pressure decreases the bacterial colonization over the wound and increases the blood flow [12]. Increase in oxygenated blood flow to the damaged tissues increases the wound resistance to the infection [13]. Increased oxygenated blood flow to the wound healing promotes the oxidative bursts in neutrophils and there by promoting the killing of microbes and preventing infection [14]. Successful, spontaneous healing and healing following surgical intervention are correlated with tissue bacterial counts of less than 105 organisms per gram of tissue [15].

Our study showed that in VAC dressing therapy after day 3, there were 40% of patients who had no bacterial growth, and on day 7 there were 88% of patients who growth, whereas in saline-wet-to-moist patients only 10% of patients had no bacterial growth on the 8th day. There have been similar studies by Morykwas and Argenta, Banwell *et al*, [16] and Morykwas *et al* [17]. Which showed clearance of bacteria from infected wounds using VAC dressing therapy. Weed *et al*. while quantifying bacterial bio burden during negative pressure wound therapy concluded with serial quantitative cultures that there is no consistent bacterial clearance with the VAC dressing therapy, and the bacterial growth remained in the range of 10^4–10^6. [18].

Thomas first postulated that application of mechanical stress would result in angiogenesis and tissue growth. Unlike sutures or tension devices, the VAC dressing therapy can exert a uniform force at each individual point on the edge of the wound drawing it toward the center of the defect by mechanically stretching the cells when negative pressure is applied [19]. This allows the VAC to move distensible soft tissue, similar to expanders, towards the center of the wound, thereby decreasing the actual size of the wound [20].

Our study showed that VAC dressing therapy increases the vascularity and rate of granulation tissue formation compared to standard wound dressing therapy. Histological, VAC dressing patients showed angiogenesis and healthy tissue

growth. Those treated with stander wound therapy Inflammation had increased and decreased in those patients treated with VAC dressing therapy. The highly significant increase in the rate of granulation tissue formation of sub atmospheric 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 visco-elastic flow and promote granulation tissue formation. Standard wound dressings adhere to devitalized tissue and within four to six hours the gauze can be removed, along with the tissue, as a form of mechanical debridement. This method of wound care has been criticized for removing viable tissue as well as nonviable tissue and being traumatic to granulation tissue and to new epithelial cells [21].

For the treatment with VAC dressing therapy, many factors to be considered in view of goal of treatment, type of dressing, suction pressure application. For different types of wounds, there is different amount pressure protocols and the duration of treatment changes. In acute wounds, it is beneficial to start within 48 h initially with continuous suction followed by intermittent suction therapy. For chronic wounds they benefit more by continuous VAC dressing therapy. Short and intermittent VAC dressing therapy [22] shows improved tissue response than compared to the continuous effect, but it may not be applicable for all types of cases. Intermittent VAC dressing pressure may not be tolerated by some patients due to discomfort. The optimal pressure to be applied for improvement of the wound is not yet currently known, there are different studies with application from −75 mm Hg to −150 mm Hg pressure and achieved good healing responses. Frequent change of vacuum dressings may be required for wounds with increased risk of infection.

Conclusion

VAC dressing therapy provides sterile and controlled environment to large, educating wound surfaces by controlled application of sub-atmospheric pressure. Application of sub atmospheric pressure after the initial debridement to the wounds results an accelerated rate of granulation tissue formation, an increase in local functional blood perfusion, and decrease in tissue bacterial levels. VAC dressing prepares wounds for closure through split skin grafting and secondary closure in short time leading to less overall morbidity with decreased hospital stay. Inour study Vacuum assisted closure (VAC) dressing therapy appears to be beneficial for the treatment of non-healing wounds and traumatic wounds.

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