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Low-cost vacuum assisted closure therapy for extensive musculoskeletal trauma and infection: Outcomes, efficacy and limitations

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Abstract

Introduction: High-energy musculoskeletal trauma with extensive soft tissue loss is difficult to treat and underlying fracture makes it more cumbersome. This prolongs hospitalization and regular conventional dressings increase socio-economic burden. Vacuum assisted closure (VAC) was developed to prepare wound for early definitive management. It acts by decreasing edema, exudates, bacterial counts and promotes granulation tissue formation, neovascularization, approximates wound edges.

Aim: To evaluate outcomes, efficacy and limitations of low-cost VAC for management of extensive soft tissue loss and infected wounds.

Materials and Methods: This study was conducted in Dept. Of Orthopedics of a tertiary care hospital from December 2018 to July 2019 on 53 patients, either with extensive soft tissue injury following acute trauma or those with infected-necrotic wound. Forty two patients had acute trauma history while remaining 11 had infected non healing wound. Cultures were sent pre and post VAC application and antibiotic coverage was administered. Low cost VAC was applied after debridement and changed after every 3 – 4 days.

Results: Forty eight cases treated with low-cost VAC were ready for skin graft/flap/secondary suture after 1 to 3 cycles (4 to 12 days) of therapy. Another two cases developed spontaneous re-epithelization. The wound infection was controlled in 70% of the cases. Three patients did not achieve desired result due to limitations of the procedure.

Conclusion: Low-cost VAC has proved to be effective while being substantially cheaper (1/16th of conventional VAC). Its role is limited when the depth of wound is far greater than its length.

Keywords: Low cost VAC, Vacuum assisted closure, wound management, Negative pressure wound therapy, Soft tissue loss, Compound fracture

Introduction

High energy trauma to the musculoskeletal system is invariably associated with extensive skin and soft tissue loss. This in association with underlying fracture becomes a therapeutic challenge and is an economical and psychological burden to the patient as well as the treating surgeon. This situation poses a challenge as daily dressings become cumbersome due to presence of POP casts/splints. Excessive wound discharge and soakage leads to compromised wound hygiene and risk of further infection. This can lead to prolonged hospitalization and frequent dressing changes.

To tackle these conditions 'negative pressure wound therapy' (NPWT) also known as 'vacuum assisted closure' (VAC) was devised. This technique was pioneered by Dr M. Morykwas and Dr. L. Argenta in 1993. It acts by creating a continuous or intermittent negative pressure to remove any wound discharge and local oedema. It helps in decreasing the bacterial count by removing bacteria rich exudate from the wound [5]. It rapidly prepares [6] an extensive wound for definitive procedures like skin grafting, secondary closure or spontaneous re-epithelization in fewer number of dressings [10,12,13,15] and at a significantly lower cost [7,11,12,16]. It decreases the wound oedema, exudate, creates hypoxia to initiate neovascularization and creates aseptic environment and helps formation of healthy granulation tissue. This together approximates the wound edges and decrease area and volume [8] of the wound. It also increases extravascular migration of neutrophils and macrophages which phagocytise bacteria. It also improves the quality of split skin graft (SSG) [14,15].

This is usually achieved by an automated microprocessor controlled unit which can give a continuous or an intermittent negative pressure in a closed circuit. The cost to rent this machine along with other expendable items like canister, open cell reticulated foam, etc. is not within the reach of a vast majority of our patients. This prevents them from getting benefitted by this novel technique.

In our hospital we are trying to provide benefits of this technique to these population group by using a low-cost VAC therapy. This system is also a closed system which uses vacuum lines embedded in the walls of our hospital ward instead of automated vacuum machine.

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Materials and methods

The study was conducted in Department Of Orthopaedics of a Tertiary Care Hospital from December 2018 to July 2019 on 53 patients out of which 33 were males and rest 20 were females (Table

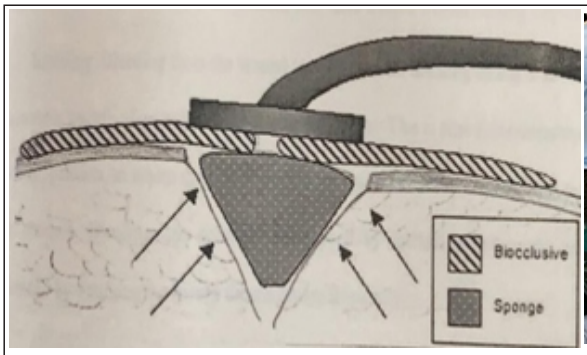

Figure 1

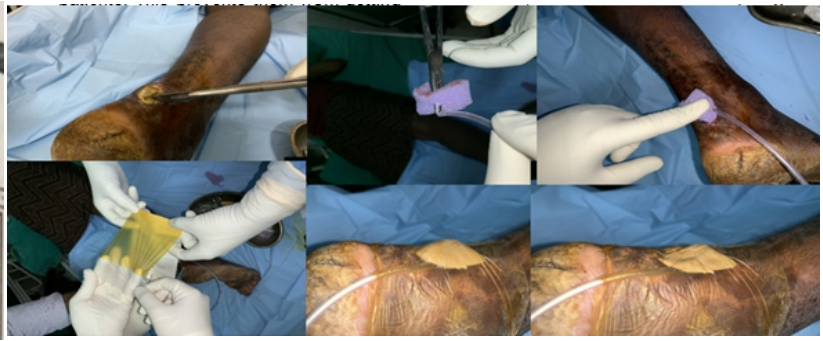

Figure 2

Inclusion criteria for our study were 1) skin and soft tissue defects following trauma that cannot be closed with primary suturing, 2) Infected wounds that were not healing by conventional dressings, 3) Necrotic wounds, 4) Wound with underlying muscle, tendon, exposed.

The exclusion criteria were 1) wound with depth <10mm, 2) wound that can be closed with Primary suturing/Split-thickness Skin Graft (SSG), 3) wound with exposed nerves, large vessels.

The patients getting admitted in our hospital were selected on the basis of inclusion and exclusion criteria. Informed written consent was taken to participate in this study. 42 patients had acute trauma history on presentation (<72 hours) and were also treated for underlying compound fracture/dislocation with either an external fixator/K-wire /splints. Concurrently VAC therapy was administered. 11 patients had infected wound either post trauma/post surgery/Chronic Osteomyelitis who were previously treated with conventional dressings.

Table 1: Patient data

BASIC PATIENT DATA	
Number of patients	53
Age (in years)	Jun-71
M:F ratio	33:20:00
Patients with Co-Morbidities	27
Wound Surface Area Range (in cm^2)	10 - 300
Wound Volume Range (in cm^3)	40 - 900

Table 2: Organisms isolated from wounds and discharge

ORGANISM ISOLATED FROM WOUND / DISCHARGE			
ORGANISM	PRE - VAC	POST - VAC	% CURED
E. coli	9	1	88.9
Staphylococcus Sp.	10	3	70
Pseudomonas Sp.	6	3	50
Klebsiella Sp.	3	2	33.3
Others	5	1	80
No Growth	20	43	Overall 70 %

After patient selection routine blood investigations and wound swabs were sent for bacterial culture and antibiotic sensitivity testing. Wound was washed thoroughly with povidone iodine solution, normal saline and Hydrogen peroxide. Following this under all aseptic conditions surgical debridement was done whose end point was appearance of healthy tissue with pin point bleeding in wound bed and margins. Underlying fracture (if required fixation) was managed at this stage to provide stability. Data like wound diameters (length, breadth and depth), underlying structures (muscle, fat, fascia, tendons), discharge, etc. were recorded in a sterile manner using sterile measuring scale. In our low-cost VAC we used commercially available open cell polyurethane foam whose thickness was depending on wound depth. It was sterilized using ethylene oxide at our hospital's sterile supply department. This foam was cut to appropriate size preferably by putting it over the wound and cutting it accordingly while making sure it does not overlap normal skin. Then the distal fenestrated part of an infant feeding tube (Fg 10) was partially inserted inside the foam by making a tunnel in it by using an artery forceps. This was placed over the wound and an IOBAN (3M) was applied over it making sure it covers at least 2-3 cm of surrounding skin which is dry to provide adequate air tight seal (Fig. 1 and 2). Alternatively, a sterile latex glove can also be used at sites where application of IOBAN is difficult, like distal part of foot where web spaces are also involved. The airtight seal was confirmed by creating a negative pressure with 50 ml Syringe and looking for wrinkling and contraction over the surface of IOBAN. The

Figure 3: A pressure of -125 mmHg is applied

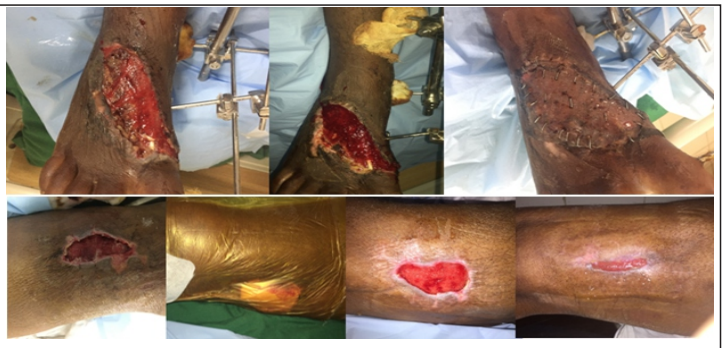

Figure 4

proximal end of feeding tube was then connected to a suction catheter (Fg 12/14) which was connected to Vacuum pressure gauge with the help of sterile rubber tubes. The pressure was set at -125 mmHg [1,2] (Fig. 3) and was applied continuously for next 48 - 96 hours depending upon amount of fluid collected in suction jar and soakage (if present).

During the whole procedure adequate antibiotics with anaerobic coverage were given which were later changed based on culture and sensitivity reports. The wound exudate which was getting collected in vacuum jar was daily examined for its quantity and colour. The dressings were removed after 48 - 96 hours of initial application and wound was re-examined for dimensions, presence of healthy granulation tissue, slough, discharge, etc. and were recorded. Wound swabs were again taken for culture and sensitivity testing. If required more cycles of VAC therapy was given. The end point of VAC dressing were any one of the following 1) depth <10 mm, 2) wound edges can be closed by secondary suturing, 3) wound ready for SSG. To term it as failure of VAC the parameters were 1) wound dimensions increased (even if due to re-debridement), 2) wound infection and discharge worsening over time, 3) wound diameter unchanged after application of 2 VAC cycles 4) infection /necrosis spreads to surrounding area. SSG was also done in our department and signs of graft take up and rejection were recorded.

Results

Mean wound area and depth reduction was 35.4 % and 38.9 % in our study (Table 3, 4). In case of previously infected wounds, sterile cultures were obtained in 70 % (23/33) after completion of therapy (Table 2). Around 86 % (46/53) were ready for definitive procedures after 1-3 cycles (4-12 days) of low-cost VAC. Thirty-one of those underwent SSG while fifteen had secondary suturing.

Table 3: Area of floor covered with Granulation tissue

AREA OF FLOOR COVERED WITH GRANULATION TISSUE			
	< 1/3	> 1/3 to < 2/3	> 2/3
Day 0	53	0	0
Day 4	37	11	5
Day 8	19	10	24
Day 12	3	8	42

Table 4: Mean wound dimensions

MEAN WOUND DIMENSIONS (cm)			
	Length	Breadth	Depth
Pre VAC	15.4	6.9	4.3
Post VAC	10.8	6.1	2.6

Table 5: Final outcomes

FINAL OUTCOME		
Outcome	No. of Patients	Percentage
Split Skin Graft	31	58.4
Secondary Suturing	15	28.3
Spontaneous Epithelisation	4	7.5
Failure	3	5.7
Total	53	100

While another 7.5 % (4/53) patients of low-cost VAC had drastic reduction of wound depth after three cycles of VAC and subsequently their wound developed re-epithelisation without any need of SSG (Table 5). Minor complications like pain during dressing change and mild skin rash were seen in 56.6 % (30) and 13.2 % (7) patients respectively. One (1.9 %) patient developed latex allergy and unhealthy surrounding skin due to use of latex glove in first cycle. This was corrected after use of IOBAN in next cycle. One (1.9 %) patient had favourable results of VAC and was treated with SSG but developed graft rejection signs on POD 5 and re-grafting was done which healed uneventfully. One(1.9%) patient whose wound depth was far greater compared to length developed foam adherence and pocket of pus which needed re-debridement and therapy was abandoned. One (1.9 %) patient did not show any reduction in wound diameters after two cycles of VAC. One patient (1.9 %) with injury over anteromedial aspect of thigh developed significant bleeding after application of VAC and later the procedure was abandoned. Overall, favorable results were obtained in fifty patients i.e. 94.3 % while three patients i.e. 5.7 % showed unfavorable results.

Discussion

Our study contained patients who either had extensive soft tissue loss with compound fractures following trauma or had an infected wound following conventional wound dressings. Most of the acute trauma patients were males in their third and fourth decades due to their more active lifestyle hence, exposure to Motor Vehicle Accidents. While people in their sixth and seventh decade were more common in infected wound category mostly due to co-morbidities like Diabetes Mellitus.

Morykwas et al. [1,2] extensively studied negative pressure wound therapy and concluded that at pressures of negative 125 mmHg the microvascular blood flow increases to four times of its baseline value and it was inhibited at pressure levels equal to or greater than negative 400 mmHg.

In a randomised study by Egington et al. [17] change of wound depth and volume were studied with application of negative pressure wound therapy for two weeks and were compared with conventional moist dressings. In NPWT group the decrease in wound depth was 49 % and volume decrease was of 59 %. Isago et al. [18] conducted a study conducted a similar study and took variables like wound surface area and depth into consideration and his results were 55.1 % and 61.2 % respectively.

Another study by Herscovici et al [9] in 21 patients of high – energy trauma wounds treated with VAC concluded that lesser number of dressings and a decreased hospital stay was required as opposed to conventional dressings. He also concluded that there was a decreased requirement of Flap coverage when VAC was applied initially.

In our study we acquired similar results as the above studies with significant decrease in wound dimensions, number of dressings and overall cost. Only two patients (3.8 %) patients required flap coverage. The other benefits were control of exudate, wound infection and odour. In 1995 the US Food and Drug Administration approved the use of Vacuum assisted closure for non-healing ulcer management. Now, the spectrum for application

of VAC is wide and includes but is not limited to chronic, acute, traumatic and subacute wounds, grafts and flaps. The contra indication for application of VAC are high output wounds, underlying osteomyelitis, fistulas, exposed neuro-vascular structures, malignant wounds and dry gangrene.

Conclusion

Vacuum assisted closure can be used after debridement as an initial dressing and it provides excellent improvement in wound quality and hygiene. The wound can later be managed by SSG or secondary suture or can also be left for re-epithelisation to occur. A low-cost VAC which costs around Rs 495 per cycle [3M IOBAN- Rs 1180 (4 cycles), Foam- Rs 100, Infant feeding tube- Rs 46, Suction Catheter- Rs 49] is 1/16 th of the cost of Conventional VAC. Therefore, we can conclude that in resource limited settings a low-cost VAC can be used safely and effectively for management of extensive musculo-skeletal trauma and infected wounds. We also found that minor complications like pain and skin rash can occur near the site. Our VAC failed to give desired results when used in infected wounds with smaller opening compared to its depth due to foam adherence to the tissue therefore, we recommend use of High-density foam which does not tear and adhere easily. In patients with latex allergy surrounding skin maceration was observed when a latex glove was used therefore, we recommend using IOBAN wherever possible and using gloves only if necessary. To reduce pain during dressing we advise use of paraffin gauze beneath the foam while applying it and using abundant normal saline while removing the dressing.

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