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Original Research Article

Assessment of the Outcome of Vacuum Assisted Wound Therapy in Patients with Open Musculoskeletal Injuries: An Observational Study

Sanjay Kumar[1], S.K. Jha[2], P. D.Verma[3], R. K. Ajay[4]

[1]Senior Resident, Department of Plastic Surgery, Nalanda Medical College and Hospital, Patna, Bihar, India

[2]Assistant Professor, Department of Plastic surgery, Nalanda Medical College and Hospital, Patna, Bihar, India

[3]Professor and Head, Department of Plastic surgery, Nalanda Medical College and Hospital, Patna, Bihar, India

[4]Professor and head , Department of General Surgery, Nalanda Medical College and Hospital, Patna, Bihar, India

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Corresponding Author: Dr. Sanjay Kumar

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Abstract:

Aim: The aim of the present study was to evaluate the results of vacuum assisted wound therapy in patients with open musculoskeletal injuries.

Methods: The study was conducted on 50 patients in the Department of Plastic Surgery over a period of 12 months, after obtaining the permission from institutional ethical committee and taking informed and written consents from the patients.

Results: Out of 50 patients, 35 were male and 15 were females. Mean patient age was 39 ± 18 years (range, 18 to 76 years). Road traffic accident was the most common mode of injury (56%), with most of the wounds located over extremities. According to Gustilo Anderson classification, out of 50 patients, 28 patients had grade IIIb injury, 10 had grade IIIc injury, 7 had IIIa injury, and 5 had grade II injury. There was significant decrease in wound size from day zero to day eight in VAC group in comparison to saline-wet-to-moist group. There was significant decrease in the bacterial growth in the VAC group as compared to saline-wet- to-moist group. On histological comparison too, there was a statistical difference between the VAC group and saline-wet-to-moist group, *P* value being less than 0.05 by using Wilcoxon signed rank test between the findings from day zero to day eighth.

Conclusion: Vacuum assisted closure therapy appears to be a viable adjunct for the treatment of open musculoskeletal injuries. Application of sub atmospheric pressure after the initial debridement to the wounds results in an increase in local functional blood perfusion, an accelerated rate of granulation tissue formation, and decrease in tissue bacterial levels.

Keywords: Vacuum Assisted Wound Therapy, Open Musculoskeletal Injuries.

Introduction

Compound fractures are surgical emergencies which require both skeletal stability as well as adequate soft tissue coverage. Debridement of all the dead and necrotic tissue can result in large soft tissue defects precluding healing through delayed primary closures or secondary intention. [1] Various surgical methods have been developed to obtain coverage in these difficult situations like skin grafts, myocutaneous or fasciocutaneous flaps but even skin grafts are contraindicated when bone is exposed. [2] In such situations, a local rotation flap may be required to obtain coverage. [3,4]

Vacuum assisted closure (VAC) therapy is a newer technique designed to promote granulation tissue formation for faster healing in the wounds resulting from compound fractures. Wound healing is a complex and dynamic process that includes an immediate sequence of cell migration leading to repair and closure. In most of the standard treatment includes debridement of necrotic tissue; dressings with enzymatic debridement compounds, hydrocolloid wound gels, infection control, local ulcer care, mechanical offloading, management of blood glucose levels, education on foot care, hyperbaric oxygen therapy. [5] The optimum level of negative pressure appears to be around 125

mmHg below ambient and there is evidence that this is most effective if applied in a cyclical fashion of five minutes on and two minutes off. [6] Despite the significant costs involved, the technique is said to compare favorably in financial terms with conventional treatments in the management of difficult to heal wounds.

The concept of applying sub atmospheric pressure to a wound bed was proposed more recently in 1993 by Fleischmann, who described a technique of porous polyvinyl alcohol foam wrapped around suction drains, which were introduced into a wound sealed with a polyurethane drape and attached to a suction apparatus at 600 mm Hg. [7] Negative pressure wound therapy (NPWT) is a technique for managing an open wound by exposing the wound to either continuous or intermittent sub atmospheric pressure. [8] Vacuum assisted closure has proved its efficacy for wound dressing leading to faster wound healing and shorter hospital stay.

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. A method that improves the healing process could greatly decrease the risk of infection, amputation, and length of hospital stay and result in an estimated potential annual savings of billions of rupees of healthcare cost. [9] 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) has been more recently used in the treatment of traumatic wounds. [10]

The aim of the present study was to evaluate the results of vacuum assisted wound therapy in patients with open musculoskeletal injuries.

Materials and Methods

The study was conducted on 50 patients in the Department of Plastic Surgery, Nalanda Medical College and Hospital, Patna, Bihar, India over a period of 12 months (January 2019 to December 2019), after obtaining the permission from institutional ethical committee and taking informed and written consents from the patients.

All patients above 18 years of age with open musculoskeletal injuries in extremities that required coverage procedures were included in the study. However, patients with preexisting osteomyelitis in the wounds, neurovascular deficit in the injured limb, diabetics, malignancy, and peripheral vascular disease were excluded from the study.

The patients were prospectively randomized into one of the two treatment groups receiving either the vacuum assisted closure therapy or standard saline-wet-to-moist wound care. Files were marked with red (vacuum assisted closure therapy) or yellow (saline-wet-to-moist dressings) labels on the inside panel and were randomly organized. A file was randomly picked for each wound with the treatment determined by the label colour.

Participation in the study did not deviate from the standard care of the acute wound. All patients for wound management were subjected to

(1) Standard radiological assessment of the injured wound,

(2) Routine haematological investigation, for example, complete blood count, ESR, blood sugar, HIV and HbsAg, gram stain and culture,

(3) All patients were supplemented with standard nutritional supplements, including zinc and multivitamin daily.

Vacuum Assisted Wound Therapy Procedure

Wound Preparation. Any dressings from the wound were removed and discarded. A culture swab for micro- biology was taken before wound irrigation with normal saline. Necrotic tissues were surgically removed (surgical debridement), 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.

Placement of Foam: Sterile, open-pore foam (35 ppi density and 33 mm thick) dressing was gently placed into the wound cavity. Open-pore foams are polyurethane with 400– 600 microns size having hydrophobic open cell structured network. Such sizes of pores are most effective at transmitting mechanical forces across the wound and provide an even distribution of negative pressure over the entire wound bed to aid in wound healing.

Sealing with Drapes: The site was then sealed with an adhesive drape covering the foam and tubing and at least three to five centimetres of surrounding healthy tissue to ensure a seal.

The Application of Negative Pressure: Controlled pressure was uniformly applied to all tissues on the inner surface of the wound. The device delivered an intermittent negative pressure of −125 mmHg. The cycle was of seven minutes in which pump was on for five minutes and off for two minutes. The dressings were changed on the fourth day.

Saline-Wet-to-Moist Group Procedure: Wound preparation—any dressings from the wound was removed and discarded. A culture swab for

microbiology was taken before wound irrigation with normal saline. Surface slough or necrotic tissue was surgically removed (surgical debridement), and adequate haemostasis was achieved.

Daily dressings by conventional methods, that is, cleaning with hydrogen peroxide and normal saline and dressing the wound with povidone iodine (5%) and saline-soaked gauze was done and wound examined daily.

Resident who had measured the wounds was not involved in the daily care of the study patients. It was not mentioned to which treatment group the patient was assigned. This blinding arrangement ensured that the person evaluating the wound and collecting data initially at day zero and whenever dressings were subsequently changed had seen the wound only after all dressings, supplies, and equipment were removed from the patient and the room. He took photographs and measured the wound.

The resident doctor also clinically assessed the wounds for signs of infection and obtained 4–6 mm punch biopsy samples for histology and culture. Biopsies were obtained from the four corners and the most "healthy" portion of the wound bed. Samples were taken on day zero, day four, and day eight. The presence of drainage, edema, erythema, exposed bone, or exposed tendon was documented. Any complications associated with vacuum assisted closure therapy were also documented. Such measurements and findings were recorded on day zero, day four, and day eight in both the groups. The wounds were also evaluated by plastic surgeon on day one and on day eight to assess the nature of surgical procedure to be adopted to cover the wound. The pathologist noted and quantified the presence of inflammatory cells, bacteria, arterioles, proliferative fibroblasts, excessive collagen formation, and fibrosis in the biopsy samples.

Data Management and Statistical Analysis: The results obtained were subjected to statistical analysis which was done by using statistical software SPSS-version 19. Normality of data was checked by Kolmogorov-Smirnov test for unpaired t-test. Quantitative data was expressed in terms of mean ± SD. Categorical data was analysed by Chi-square and Wilcoxon signed ranks test.

For Wilcoxon signed ranks test, the evaluation of histo- logical parameters (Inflammatory cells, proliferative fibroblasts, collagen formation, and fibrosis) was ranked as absent— 0, mild—1, moderate—2, and severe—3.

Results

Table 1: Patient characteristics

Gender	**N%**
Male	35 (70)
Female	15 (30)
Mode of injury	
Road traffic accidents	28 (56)
Fall form height	12 (24)
Others	10 (20)
Gustilo Anderson classification	
II	5 (10)
IIIa	7 (14)
IIIb	28 (56)
IIIc	10 (20)

Out of 50 patients, 35 were male and 15 were females. Mean patient age was 39 ± 18 years (range, 18 to 76 years). Road traffic accident was the most common mode of injury (56%), with most of the wounds located over extremities. According to Gustilo Anderson classification, out of 50 patients, 28 patients had grade IIIb injury, 10 had grade IIIc injury, 7 had IIIa injury, and 5 had grade II injury.

Table 2: Decrease in wound size from day 0 to day 8

Measurements (mm)	VAC (n = 25)	Saline wet to moist (n = 25)
1–4.9	7	23
5–9.9	2	0
10–14.9	7	2
15–19.9	4	0
20–24.9	2	0
>25	3	0

Table 3: Mean wound size difference between VAC and saline wet to moist on day 8

	VAC (n = 25)	Saline wet to moist (n = 25)	P value	95% CI
Mean difference (mm)	12.26 ± 8.42	3.05 ± 2.88	0.0001	12.048 to 16.324

There was significant decrease in wound size from day zero to day eight in VAC group in comparison to saline-wet-to-moist group.

Table 4: Bacterial growth

Bacterial growth	Day 0	VAC patients (n = 1=25) Day 4	Day 8	Day 0	Saline wet to moist (n = 15) Day 4	Day 8
Present	25	22	8	25	25	21
Absent	0	3	17	0	0	4

There was significant decrease in the bacterial growth in the VAC group as compared to saline-wet- to-moist group.

Table 5: Comparison of histological parameters from day 0 to day 8 by Wilcoxon signed ranks test

Stages of wound healing	Positive	Saline wet Negative	to moist Equal	*P* value	Positive	VAC Negative	Equal	*P* value
Inflammatory cells	2	18	5	0.001	2	20	3	0.007
Proliferative fibroblasts	21	0	4	0.001	25	0	0	0.001
Collagen formation	23	0	2	0.001	25	0	0	0.001
Fibrosis	10	0	15	0.07	25	0	0	0.001

On histological comparison too, there was a statistical difference between the VAC group and saline-wet-to-moist group, *P* value being less than 0.05 by using Wilcoxon signed rank test between the findings from day zero to day eighth.

Discussion

High-energy 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. [11] Various surgical methods have been developed to obtain coverage in these difficult situations. These include skin grafts, local rotation flaps, and myocutaneous or fasciocutaneous tissue transfers. Although skin grafts are readily obtainable, they are dependent on the vascularity of its recipient bed and may be contraindicated when exposed bone, cartilage, tendons, or surgical implants exist. [12] In such situation, a local rotation flap may be needed. When the soft tissue defect prevents local coverage [13], free tissue transfers are usually required, but the transfer may produce donor site morbidity and require late revisions due to the size of the muscle flap. [14]

Out of 50 patients, 35 were male and 15 were females. Mean patient age was 39 ± 18 years (range, 18 to 76 years). Road traffic accident was the most common mode of injury (56%), with most of the wounds located over extremities. According to Gustilo Anderson classification, out of 50 patients, 28 patients had grade IIIb injury, 10 had grade IIIc injury, 7 had IIIa injury, and 5 had grade II injury. There was significant decrease in wound size from day zero to day eight in VAC group in comparison to saline-wet-to-moist group. Blood flow increases and bacterial colonization of wound tissues decreases following the application of sub atmospheric pressure to wounds. [10] Any increase in circulation and oxygenation to compromised or damaged tissue enhances the resistance to infection. [15] Successful, spontaneous healing and healing following surgical intervention are correlated with tissue bacterial counts of less than 105 organisms per gram of tissue. [16] Higher levels uniformly interfere in wound healing. Increase in local tissue oxygen levels reduce or eliminate the growth of anaerobic organisms, which have been correlated to decreased healing rates. [17,18] Additionally, the increased flow should make greater amounts of oxy- gen available to neutrophils for the oxidative bursts that kill bacteria. [19]

There was significant decrease in the bacterial growth in the VAC group as compared to saline-wet- to-moist group. On histological comparison too, there was a statistical difference between the VAC group and saline-wet-to-moist group, *P* value being less than 0.05 by using Wilcoxon signed rank test between the findings from day zero to day eighth. There have been similar studies by Morykwas and Argenta [10] and Banwell et al [20] which showed clearance of bacteria from infected wounds using VAC therapy. On the other hand, Weed et al [21] while quantifying bacterial bioburden during negative pressure wound therapy

concluded with serial quantitative cultures that there is no consistent bacterial clearance with the VAC therapy, and the bacterial growth remained in the range of 104–106. Thomas first postulated that application of mechanical stress would result in angiogenesis and tissue growth. Unlike sutures or tension devices, the VAC can exert a uniform force at each individual point on the edge of the wound drawing it toward the centre of the defect by mechanically stretching the cells when negative pressure is applied. [22] This allows the VAC to move distensible soft tissue, similar to expanders, towards the centre of the wound, thereby decreasing the actual size of the wound. [23]

The careful handling of soft tissues with radical debridement of all necrotic tissues, the early coverage of soft tissue defects and the osseous stabilization by minimal invasive implants contribute to the avoidance of infections. [24] Chronic infections with septic non-union are three times more frequently found in open fractures and correlated to the severity of soft tissue damage.[24] The high prevalence of microbial contamination of the open wounds predisposes to the development of infection which is related to the severity of the damage to the soft tissue. [25] In recent years the development of packing wound caves with sponges and evacuation of interstitial tissue fluids and bacteria by continuous drainage (vacuum assisted wound closure =VAC systems) gave remarkable results. [24]

VAC therapy can be regarded as a method that combines the benefit of both open and closed treatment and adheres to DeBakey's principles of being short, safe, and simple. It has been shown to work and be beneficial to wound healing. VAC therapy is not the answer for all wounds; however, it can make a significant difference in many cases. VAC is most useful in difficult cavity or highly exudative wounds. VAC is a useful tool in moving a wound to a point where more traditional dressings or more simple surgical reconstructive methods can be used. As such it is a well-deserved, although at present pragmatic addition to the wound healing armamentarium and the reconstructive ladder. [26]

Conclusion

Vacuum assisted closure therapy appears to be a viable adjunct for the treatment of open musculoskeletal injuries. Application of sub atmospheric pressure after the initial debridement to the wounds results in an increase in local functional blood perfusion, an accelerated rate of granulation tissue formation, and decrease in tissue bacterial levels. Although traditional soft tissue reconstruction may still be required to obtain adequate coverage, the use of this device appears to decrease their need overall.

References

1. Yaremchuk MJ, Burgess AR, Brumback RJ. Concepts in soft tissue management in lower extremity salvage and reconstruction. Orthop and Plastic Surg Management. Elsevier Science, New York, NY, USA, 1989. p. 95–10 6.
2. Haller JA, Billingham RE. Studies of the origin of the vasculature in free skin grafts. Ann Plast Surg.1967;166(6):896–901.
3. Geishauser M, Staudenmaier RW, Biemer E. Donor site morbidity of the segmental rectus abdominis muscle flap. British J Plast Surg.1998;51(8):603–7.
4. Kelly MB, Searle A. Improving the donor site cosmesis of the latissimus dorsi flap. Ann Plast Surg. 1998;41(6):629–32.
5. Raffel AB. The use of negative pressure under skin flaps after radical mastectomy. Ann Surg. 1952; 136:1048.
6. Silvis RS, Potter LE, Robinson DW, Hughes WF. The use of continuous suction negative pressure instead of pressure dressing. Ann Surg. 1955;142(2):252-6.
7. Fleischmann W, Strecker W, Bombelli M, Kinzl L. Vacuum sealing as treatment of soft tissue damage in open fractures. Unfallchirurg. 1993;96(9):488-92.
8. Morykwas MJ, Argenta LC. Nonsurgical modalities to enhance healing and care of soft tissue injuries. J Southern Orthopaedic Association. 1997; 6:279-88.
9. Joseph E. A prospective randomized trial of vacuum-assisted closure versus standard therapy of chronic non-healing wounds. Wounds A Compendium of Clinical Research and Practice. 2000; 12:60-7.
10. Morykwas MJ, Argenta LC, Shelton-Brown EI, McGuirt W. Vacuum-assisted closure: a new method for wound control and treatment: animal studies and basic foundation. Annals of plastic surgery. 1997 Jun 1;38(6):553-62.
11. Yaremchuk MJ, Burgess AR, Brumback RJ. Lower extremity salvage and reconstruction: Orthopedic and Plastic Surgical Management. (No Title). 1989.
12. Haller Jr JA, Billingham RE. Studies of the origin of the vasculature in free skin grafts. Annals of surgery. 1967 Dec;166(6):896.
13. Geishauser M, Staudenmaier RW, Biemer E. Donor-site morbidity of the segmental rectus abdominis muscle flap. British journal of plastic surgery. 1998 Dec 1;51(8):603-7.
14. Kelly MB, Searle A. Improving the donor site cosmesis of the latissimus dorsi flap. Annals of plastic surgery. 1998 Dec 1;41(6):629-32.
15. Hunt TK. The physiology of wound healing. Annals of Emergency Medicine. 1988 Dec 1; 17(12):1265-73.
16. KUCAN JO, ROBSON MC, HEGGERS JP, KO F. Comparison of silver sulfadiazine, pov-

idone-iodine and physiologic saline in the treatment of chronic pressure ulcers. Journal of the American Geriatrics Society. 1981 May; 29(5):232-5.
17. Seiler WO, HB S, Sonnabend W. Einfluss Aerober Und Anaerober Keine Auf Den Heilungsverlauf Von Deku Bitalulzera.
18. Daltrey DC, Rhodes B, Chattwood JG. Investigation into the microbial flora of healing and non-healing decubitus ulcers. Journal of Clinical Pathology. 1981 Jul;34(7) :701.
19. Ryan TJ. Microcirculation in psoriasis: blood vessels, lymphatics and tissue fluid. Pharmacology & therapeutics. 1980 Jan 1;10 (1):27-64.
20. Banwell P, Withey S, Holten I. The use of negative pressure to promote healing. British journal of plastic surgery. 1998 Jan;51(1):79.
21. Weed T, Ratliff C, Drake DB. Quantifying bacterial bioburden during negative pressure wound therapy: does the wound VAC enhance bacterial clearance? Annals of plastic surgery. 2004 Mar 1;52(3):276-9.
22. Thoma R. Ueber die histomechanik des gefasssystems und die pathogenese der angioskleroose. Virchows Archiv F Path Anal. 1911; 204:1-74.
23. Philbeck Jr TE, Whittington KT, Millsap MH, Briones RB, Wight DG, Schroeder WJ. The clinical and cost effectiveness of externally applied negative pressure wound therapy in the treatment of wounds in home healthcare Medicare patients. Ostomy/wound managem ent . 1999 Nov 1;45(11):41-50.
24. Neubauer T, Bayer GS, Wagner M. Open fractures and infection. Acta chirurgiae orthopaedicae et traumatologiae Cechoslovaca. 2006 Oct 1;73(5):301.
25. Giannoudis PV, Papakostidis C, Roberts C. A review of the management of open fractures of the tibia and femur. The Journal of Bone & Joint Surgery British Volume. 2006 Mar 1;88 (3):281-9.
26. Jones SM, Banwell PE, Shakespeare PG. Advances in wound healing: topical negative pressure therapy. Postgraduate medical journal .2005 Jun;81(956):353-7.