ANALYSIS OF TREATMENT OF WOUNDS IN PATIENTS WITH GRADE IIIB COMPOUND FRACTURE WITH VACUUM-ASSISTED WOUND MANAGEMENT

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ABSTRACT

BACKGROUND

Delayed wound healing is a significant health problem, particularly in patients with compound fractures. It still remains a challenging task in orthopaedic surgery, which in addition to the pain and suffering, failure of the wound to heal, also imposes social and financial burdens.

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

MATERIALS AND METHODS

30 patients of open musculoskeletal injuries underwent randomised trial of vacuum-assisted closure therapy versus standard wound therapy around the upper limb and lower limb. Mean patient age was 39 ± 18 years necrotic tissues were debrided before applying VAC therapy. Dressings were changed every 3 or 4 days. For standard wound therapy, debridement followed by daily dressings was done.

Data Management and Statistical Analysis- The results obtained were subjected to statistical analysis.

RESULTS

Granulation tissue status and skin healing is better in patients undergoing VAC therapy. Hospital stay of patients undergoing VAC therapy was also less.

CONCLUSION

Vacuum-assisted wound therapy was better method of wound management.

KEYWORDS

VAC, Compound Fracture.

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BACKGROUND

Delayed wound healing is a significant health problem particularly in patients with compound fractures. It still remains a challenging task in orthopaedic surgery, which in addition to the pain and suffering, failure of the wound to heal also imposes social and financial burdens.

Wound healing is a complex and dynamic process that includes an immediate sequence of cell migration leading to repair and closure. This sequence begins with removal of debris, control of infection, clearance of inflammation, angiogenesis, deposition of granulation tissue, contraction, remodelling of the connective tissue matrix and maturation. When wound fails to undergo this sequence of events, a chronic open wound without anatomical or functional integrity results.[1]

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.[2]

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 maybe contraindicated when exposed bone, cartilage, tendons or surgical implants exist.[3] Although, nonoperative modalities such as hyperbaric oxygen have been used to enhance wound coverage. These devices may not be available to all patients and may not be adequate for use in patients presenting with high-energy injuries due to oedema, retraction of the skin and soft tissue, wound size or loss of available local coverage.[4] Attempts

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have been made to identify an alternative treatment of wound management in these patients.

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.[1]

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.[5]

The purpose of this study is to provide local data on the results of vacuum-assisted closure therapy and standard wound therapy for the management of patients presenting with open musculoskeletal injuries in a tertiary care centre.

MATERIALS AND METHODS

This prospective study was conducted on 32 patients in the Department of Orthopaedics, BYL Nair Charitable Hospital over a period of 18 months from June 2014 to December 2015 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 of grade IIIB according to Gustilo-Anderson classification that required coverage procedures were included in the study. However, patients with preexisting osteomyelitis in the wounds, neurovascular deficit in the injured limb, fistulas to organs/body cavities, exposed blood vessels/nerves, patients undergoing anticoagulant therapy, diabetics, malignancy and peripheral vascular disease were excluded from the study.

The patients were prospectively randomised into one of the two treatment groups each having 16 members receiving either the vacuum-assisted closure therapy or standard saline wet-to-moist wound care.

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, HCV 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 microbiology 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 is essential to prepare the periwound 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 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 (Figure 1).

Figure 1. Foam was Cut According to Wound Size

Sealing with drapes

The site was then sealed with an adhesive drape covering the foam and tubing and at least 3 to 5 centimetres of surrounding healthy tissue to ensure a seal (Figures 2 and 3).

Figure 2. Sterile Drape was Applied Covering the Foam and 2-3 cm of the Surrounding Skin

Figure 3. The Connecting Tube was Applied After Making a Small Opening (3-4 mm) on the Drape

The application of negative pressure

Controlled pressure was uniformly applied to all tissues on the inner surface of the wound. The pump delivered an intermittent negative pressure of -125 mmHg. The cycle was of 7 minutes in which pump was on for 5 minutes on and off for 2 minutes (Figure 4).

Figure 4. The Connecting Tube was Connected to the Negative Pressure Wound Therapy

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.

An independent resident doctor 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. He took photographs and measured the wound by Vernier.

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 every fourth day. The presence of drainage, oedema, erythema, exposed bone or exposed tendon was documented. Any complications associated with vacuum-assisted closure therapy were also documented.

The wounds were also evaluated by plastic surgeon weekly to assess the nature of surgical procedure to be adopted to cover the wound.

Patients were followed up on OPD basis until their wounds completely healed.

The pathologist noted and quantified the presence of inflammatory cells, bacteria, arterioles, proliferative fibroblasts, excessive collagen formation and fibrosis in the biopsy samples.

The parameters studied were-

1. Status of granulation tissue.
2. Status of skin graft acceptance.
3. Duration of stay.
4. Healing with skin covering the wound.

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 T square and Wilcoxon signed-ranks test.

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

RESULTS

In the present study, the mean age of study population was 43.19 ± 10.30 years with most of the patients were between 31-40 years of age (37.5%) followed by 41-50 years (28.12%). Male predominance was observed in study subjects with prevalence of male-to-female as approx. 1.46:1.

Granulation		**Standard Wound Therapy**	**VAC**	**Total**
Absent	Count	7	0	**16**
	% within treated with	43.75%	0%	**50%**
Present	Count	9	16	**16**
	% within treated with	56.25%	100%	**50%**
Total	**Count**	**16**	**16**	**32**
	% within treated with	**100%**	**100%**	**100%**

Table 1. Status of Granulation Tissue

P value - <0.05.

As seen in the above table, granulation was significantly observed in VAC group as compared to standard wound therapy.

Skin Grafting		**Standard Wound Therapy**	**VAC**	**Total**
100% accepted	Count	0	2	2
	% within treated with	0%	12.5%	6.3%
50% accepted	Count	1	0	1
	% within treated with	6.3%	0%	3.1%
70% accepted	Count	3	0	3
	% within treated with	18.8%	0%	9.4%

75% accepted	Count	2	0	2
	% within treated with	12.5%	0%	6.3%
80% accepted	Count	9	0	9
	% within treated with	56.3%	0%	28.1%
85% accepted	Count	1	0	1
	% within treated with	6.3%	0%	3.1%
90% accepted	Count	0	2	2
	% within treated with	0%	12.5%	6.3%
95% accepted	Count	0	12	12
	% within treated with	0%	75%	37.5%
Total	**Count**	**16**	**16**	**32**
	% within treated with	**100%**	**100%**	**100%**

Table 2. Skin Grafting Status Amongst Different Study Population

P value - <0.05.

As seen in the above table, skin grafting acceptability was significantly higher in VAC group as compared to standard wound therapy.

Skin Healing		**Standard Wound Therapy**	**VAC**	**Total**
Good	Count	0	16	**16**
	% within treated with	0%	100%	**50%**
Poor	Count	16	0	**16**
	% within treated with	100%	0.0%	**50%**
Total	**Count**	**16**	**16**	**32**
	% within treated with	**100%**	**100%**	**100%**

Table 3. Skin Healing Status Amongst Different Study Population

P value - <0.05.

As seen in the above table, skin healing was good in significant number of patients in VAC group as compared to standard wound therapy.

Total Duration of Hospital Stay		**Standard Wound Therapy**	**VAC**	**Total**
1 Month	Count	0	15	15
	% within treated with	0%	93.8%	46.9%
2 Months	Count	16	1	17
	% within treated with	100%	6.3%	53.1%
Total	**Count**	**16**	**16**	**32**
	% within treated with	**100%**	**100%**	**100%**

Table 4. Total Duration of Hospital Stay Status Amongst Different Study Population

P value - <0.05.

As seen in the above table, total duration of hospital stay was significantly lesser in VAC group as compared to standard wound therapy.

DISCUSSION

In the present study, granulation and skin healing was significantly better in VAC group as compared to standard wound therapy. In the study conducted by Luca Dalla Paola et al, 2010,[6] patients who presented with deep wounds from dehiscence of minor amputations or open amputations with exposure of both bones and tendons, the use of VAC reduced healing time by promoting good granulation tissue, a more rapid control over infections and a reduction in surgical reinterventions.

Our study showed that VAC increases the vascularity and the increase in rate of granulation tissue formation compared to standard wound dressing. The highly significant increase in the rate of granulation tissue formation of subatmospheric 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 viscoelastic low and promote granulation tissue formation.

In the present study, skin grafting acceptability was significantly higher in VAC group as compared to standard wound therapy. In the study conducted by Luca Dalla Paola et al 2010,[6] patients who were undergoing skin grafting at the lower limb level, 80% patients had skin grafting acceptability as compared to controls.

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.[7] 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.[8]

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.[9]

Standard wound dressings adhere to devitalised 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 criticised for removing viable tissue as well as nonviable tissue and being traumatic to granulation tissue and to new epithelial cells.[10]

Total duration of hospital stay was significantly lesser in VAC group as compared to standard wound therapy similarly in the study by Suresh Padya et al, 2015.[11] There was decrease in the hospital stay in VAC group.

There is very little literature available especially on compound injuries using VAC. Open musculoskeletal injuries have very high incidences of nonunion and infection.[12] They require urgent irrigation and debridement. As wounds are frequently let open and require repeated debridement resulting in large soft tissue defects, early coverage of exposed bone, tendons and neurovascular structures is crucial. This is to decrease the risk of infection, nonunion and further tissue loss. We believe that VAC therapy can be effective to overcome all mentioned problems.

Complications like infection, bleeding and skin irritation were not seen in our study. VAC therapy not only reduces requirement of extensive plastic surgery, but also reduces hospital stay, pain, humiliation and depression associated with wound.

CONCLUSION

Vacuum-assisted closure therapy appears to be a viable adjunct for the treatment of open musculoskeletal injuries. Application of subatmospheric 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. The cost of treating wounds with vacuum-assisted closure therapy is comparable to the cost of conventional wound treatment. This method is cost effective in treating categories of wounds for which the evidence indicates a shortened length of stay and reduced mortality. Regarding other wound categories, further clinical studies are required to show whether or not vacuum-assisted wound closure therapy is cost effective.

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