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Comparison of Negative Pressure Wound Therapy (NPWT) Using Polyvinyl Alcohol (PVA) Sponge with Advanced Wound Dressings

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Abstract

Objective: The primary purpose of this study is to compare appearance of granulation tissue, rate of wound infection, period of hospital stay and duration for complete wound healing using two different methods of wound dressing at secondary healthcare centres.

Material and Methods: 127 patients between the age group 14-68 years with an average age of 42 years were included in this study. Out of these 127 cases, 1 died due to urosepsis with severe lung infection and 6 cases did not turn up for follow up treatment. The remaining 120 cases were divided into two groups i.e. A and B.

Group A was subjected to modified negative pressure wound therapy (NPWT) using sterilized polyvinyl alcohol sponge as an alternative to standard Granu Foam. A Ryle's tube with additional pores were created and interposed between the PVA sponges. The Ryle's tube was attached to the suction drain and another end of the suction drain connected directly to wall suction which is programmed to produce a pressure of 125 mmHg. At the end of 72 hours, a new cycle was repeated. Group B was subjected to daily dressing with advanced wound dressings (dermacyn and solcoseryl gel).

Results: Statistically better result was obtained in favour of NPWT for wound dressing. The appearance of granulation tissue was more rapid in group A patients. The infection rate of group A patients was very low when compared to group B patients. The mean time (duration) to complete healing was faster in Group A, however the mean length of hospital stay was longer as compared to group B patients.

Conclusion: Healing is more rapid with less infection rate in NPWT group compared to advanced wound dressing group. NPWT using wall suction and PVA sponge can be performed in secondary healthcare centres with low resources as well as for patients who could not have afforded charges of commercially available standard VAC device or advance wound dressings.

Keywords: Negative pressure wound therapy; Polyvinyl alcohol sponge; Wall suction; Secondary healthcare centres

Introduction

Wound maybe caused by trauma, surgical incision, crush injury, gunshot injury, pressure injury, diabetes, venous insufficiency and radiation. These wounds can be broadly categorized as having either an acute or chronic etiology. Delay in wound healing predisposes to infection and grievous morbidity. There are different medical devices available to dress the wound depending on the wound type, level of exudates and the stage of healing. Saline-moisture gauze being the standard method for wound dressing which has been replaced by advanced wound dressings such as hydrocolloid, hydrofibre, hydrogel, foams, silver, and hyperbaric oxygen therapy [1].

Negative pressure wound therapy (NPWT) or vacuum assisted closure (VAC) is a simple wound management technique that exposes wound bed to negative pressure by way of a closed system which reduces contamination and protecting the wound from infection by decreasing bacterial burden [2]. This system controls the moisture content of the wound, maintaining the optimum pH and temperature to encourage healing by promoting granulation formation hence, reconstructs the damaged soft tissues or wounds. The pressure used is sub atmospheric pressure varying between -125 and -75 mmHg in a continuous or intermittent manner. Fleischmann et al. stated that when the wound is exposed to sub atmospheric pressure for an extended period it promotes debridement and healing [3]. NPWT has been shown to be effective in the management of soft tissue loss from infections, vascular insufficiency, radiation-induced soft tissue necrosis, and traumatic disorders [4]. Commercially available VAC using Granu Foam and canister (Figure 1) device clinically being practiced to promote wound healing at tertiary healthcare centres and private hospitals. However, standard VAC device is expensive thus it is not available at secondary healthcare centres which receive less government or private subsidies. A modified or custom made NPWT using simple wall suction and a polyvinyl alcohol (PVA) synthetic sponge (Figure 2) was used by our team for this research study.

Dermasyn is a super-oxidized, water-based disinfectant solution. This solution is helpful in healing of the wounds by reducing microbial load and assisting in creating a moist environment. It is designed to treat wide range of pathogens [5]. Solcoseryl is a deproteinised extract of calf blood. It contains a broad spectrum of low molecular organic and inorganic substance which helps in wound healing by normalizing metabolic disturbances and tissue damage associated with hypoxia [6]. Till today, no data is available about the efficacy of this modified NPWT verses advanced wound dressing. Therefore we endeavor to put forward a prospective randomized study to compare and evaluate the effectiveness of this system using PVA sponge verses advanced wound dressings on healing of both acute and chronic wounds.

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Figure 1: Standard VAC device using Granu Foam dressing.

Figure 2: Modified NPWT.

Objective

The primary purpose of this study is to compare appearance of granulation tissue, rate of wound infection, period of hospital stay and duration for complete wound healing using two different methods of wound dressing at secondary healthcare centres.

Methodology

The period of study was undertaken between April 2012 and November 2015 after the study protocol was approved by Hospital Wound Care Team. 127 patients between the age group 14-68 years with an average age of 42 years were included in this study. Out of these 127 cases, 1 died due to urosepsis with severe lung infection and 6 cases did not turn up for follow up treatment. The remaining 120 cases were divided into two groups i.e. A and B. The group A and group B study population was made up of 88 male subjects and 32 female subjects respectively. Different types of the wounds (Figure 3) and the location (Figure 4) were identified and documented.

Group A was subjected to NPWT using sterilized PVA sponge (Figure 3) as an alternative to standard VAC device using GranuFoam dressing. This NPWT is using a wall suction unit which is available in all hospital wards. A sealed PVA sponge was autoclaved and cut to match the shape of the wound and a Ryle's tube with additional side pores was created and interposed between the PVA sponges and placed over the wound. The entire dressing was covered by an adherent transparent plastic film which forms an effective airtight seal with the skin. The Ryle's tube was attached to the suction drain and another end of the suction drain connected directly to wall suction (Figure 5) which was programmed to produce a pressure of 125 mmHg. Once the wall suction was switched on, the air was sucked out of the PVA sponge causing it to collapse inwards and drawing the edges of the wound. The fluid within the wound is absorbed by PVA sponge and transported into the disposable container. At the end of 72 hours, the vacuum dressing was removed and the sponge was changed to prevent overgrowth of exuberant granulation tissue. A good care was taken when removing adherent transparent plastic film to avoid periwound skin irritation and breakdown. Wound was washed with normal saline, and new cycle of dressing was repeated. The technical problems such as blockage of tubes and leaks of seals were very well taken care during the study.

Group B patients were subjected to daily dermacyn irrigation followed by solcoseryl gel application over the wound. Initially all

Figure 3: PVA sponge.

Figure 4: A wall suction.

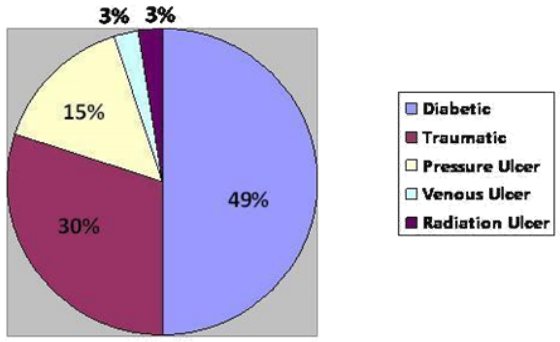

Figure 5: Type of wound selected for the study.

wounds were debrided with thorough surgical excision of devitalized tissues and sent for bacterial cultures and sensitivity test. In some instances, patients required serial bedside debridement. All procedures were done under sterile technique by skilled nurses or doctors (Figure 6).

Inclusion criteria: All patients with wound size ranged from 15 cm^2 to 60 cm^2

Exclusion criteria: Actively bleeding wound, untreated osteomyelitis, malignant ulcers, grossly infected wound, and patients on corticosteroids or anticoagulants.

Data collection: Data was collected utilising a pre-prepared proforma and analysed. Inference has drawn using a computer software SPSS-16. The statistical test performed was the Pearson's Chi-Square test. Every patient's hemoglobin and blood sugar were closely monitored and maintained under normal value throughout this study. Infection was assessed on the basis of clinical signs and symptoms.

Results

The age distribution of patients was varied from 14-68 years with mean age of study group been 41 years. Majority of patients were in the 35-45 age groups. Out of 120 patients 73.3% (n = 88) were males while 26.7% (n = 32) were females (Table 1). Main outcome measures were frequency of granulation tissue formation, rate of wound infection, period of hospital stay and time to complete healing or 100% wound closure with re-epithelialization. After 1 week of NPWT application, wounds started showing significant improvement. The appearance of granulation tissue was more rapid in group A with mean 8.76 days compared to group B with mean 13.16 days which was also found to be statistically significant with Pearson's Chi-Square value 25.947 and P-value < 0.001. The wound bed in 75% group A patients filled with granulation in less than 2 weeks as compare to 31% patients in group B for the same duration (Figure 7). We observed bacterial growth occurred in 5 cases in group A and 20 cases in group B at the end of fourth week of treatment (Figure 8). *Staphylococcus aureus* was found to be more prominent in patients of group A whereas culture from group B mostly showed *E coli* and pseudomonas with significant p-value < 0.001. The repeated swab culture of these patients after one week of intravenous antibiotics were negative for microorganisms. Mean length of hospital stay was 31.33 days in group A and 19.68 days in group B with Chi-Square value 7.960 and P-value < 0.005. Complete healing of the wound by 9 weeks seen in 52 patients in group A and 17 patients in group B. Wound of 25 patients in NPWT group were closed by split skin graft (SSG) whereas 12 patients in advanced dressing group were posted for SSG. The rest of the wound in both groups were healed by secondary intention (Table 2).

Discussion

NPWT is a therapeutic technique using sub atmospheric pressure to promote healing in acute or chronic wounds using a sealed wound dressing connected to wall suction which is acting as a vacuum pump. Even though various surgical methods like skin grafts, local rotational flaps, myocutaneous or fascio cutaneous transfers been practiced to obtain adequate soft tissue coverage, NPWT device converts the open wound to controlled closed wound until appropriate soft tissue reconstruction has performed [7]. The mechanism of action of NPWT is not clear but there are 3 major mechanisms proposed-increased local blood flow, decreased local oedema, and mechanical stretch on the cytoskeleton leading to the release of cytokines associated with granulation tissue formation subsequently wound contracture [8]. We noted that the group A patients had an early appearance of granulation tissue as compare to patients in Group B. By the end of 6 weeks, we achieved 90% and 65% granulation in group A and group B patients respectively, which was statistically significant (p value < 0.04). In our study, the median time to achieve 90% granulation tissue for group A patients was 40 days whereas it was 78 days for group B patients. This result is comparable to randomized controlled trials conducted by Armstrong et.al who achieved the median time to 76%-100% granulation tissue formation for patients receiving vacuum therapy was 42 days whereas it was delayed up to 84 days in the control group [9]. Application of negative pressure over wound bed allows the arterioles to dilate, so increasing the effectiveness of local circulation, promoting angiogenesis which assisting in the proliferation of granulation tissue [9]. NPWT in combination with surgical debridement resulted in improved wound healing by reducing the bacterial load in the wound. We observed that patients of group A showed rapid clearence of bacteria compare to group B patients at the end of 4th week of treatment, with wound infection occurred in 5 cases and 20 cases respectively. Infection was assessed on the basis of clinical signs and

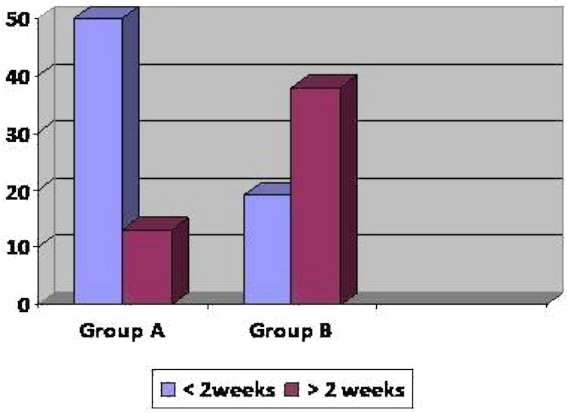

Figure 6: Location of wound selected for the study.

Type of group	Male	Female	Total
Group A (NPWT)	44	18	62
Group B (Advanced Dressing)	44	14	58

Table 1: Gender distribution of patients.

No.	Duration in weeks	Group A, n = 62	Group B, n = 58	p-value (%)
1	Up to 4 weeks	41 (70.68%)	10 (16.13%)	P < 0.001
2	Up to 9 weeks	52 (83.87%)	17 (29.32%)	P < 0.001

Table 2: The duration of complete healing of wound.

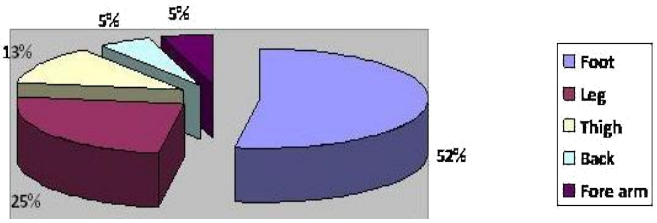

Figure 7: Appearance of granulation tissue.

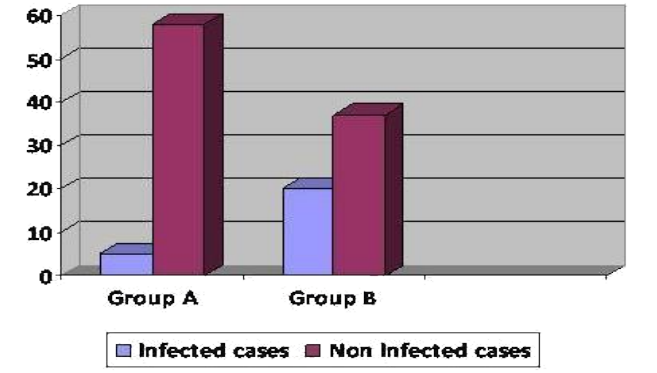

Figure 8: Number of infected cases at 4th week of treatment.

symptoms that included increasing sero purulent or pus discharge, increasing pain and erythema. Antibiotic regimes administered during the study would have decreased the bacterial load, hence influenced the bias in this study.

The vacuum therapy significantly affected the healing process by reducing the bacterial burden and septic complications [10].

The period of hospital stay was significantly longer among group A patients. Mean length of hospital stay was 31.33 days in group A and 19.68 days in group B. Group A patients stayed longer at ward for continuation of negative pressure therapy until more than 80% granulation noted. This is because NPWT using in our study is not a portable system as compare to commercially available VAC device. The integrated VAC therapy system uses a portable generator, canister and GranuFoam whereas our NPWT device typically uses a wall suction and PVA sponge. So, patients in Group A need to be warded until completion of the negative therapy. This is one of the limitations with our study. The median time for complete healing was 30.7 days in group A and 51.8 days in group B respectively. On statistical analysis, this difference was found to be significant with p-value < 0.005. Vuertaek JD from Netherland conducted a prospective, randomized, clinical study comparing vacuum therapy versus advanced wound dressings in the treatment of chronic leg ulcers. His study included 60 patients. The median time to complete healing was 29 days in vacuum therapy group compared with 45 days in controlled group [11].

In another study, Blume et al. [11] showed a greater proportion of foot ulcers achieved complete ulcer closure with NPWT (73 of 169, 43.2%) than with advanced moist wound therapy (48 of 166, 28.9%) within the 112-day active treatment phase (P = 0.007). NPWT provides a moist environment to prevent eschar formation, which allows for a smoother pathway to re-epithelialize the wound surface. Stimulation of angiogenesis improves tissue oxygenation, tissue reconstruction and subsequently wound contracture. Majority of wounds in our patients were closed by split skin graft (SSG) in both groups once the wounds have fully granulated and the repeated swab culture showed negative for microorganisms. The wound of 25 patients in group A and 12 patients in group B were closed by SSG. The rest of the wounds in both groups were healed by secondary intention.

PVA sponge is a synthetic sponge obtained from super cool product [12,13]. It is hydrophilic with porosities from 55% to 95% and has many of the same properties and qualities of a natural sea sponge. It possesses impressive retention, because of capillary caused by micro open pores connecting in all directions and it also has a three dimensional open cell structure similar to that of natural sea sponges. It has pore size variable between 60-1500 microns allows exudates to be removed and enables the dressing to conform to the wound bed. When negative pressure is applied to the wound bed through the PVA sponge, mechanical forces stretch cells as pulled into the open pores of the dressing. The stretching stimulates cellular proliferation, which results in granulation tissue formation [14,15].

Both VAC GranuFoam and PVA sponge can be used for NPWT but the latter is cheaper and readily available at all grocery stores. The cost of standard VAC therapy is not insignificant. In addition to the purchase cost or hire charges of generator machine itself, it is necessary to purchase disposable GranuFoam and drainage tubes.

Conclusion

Results obtained from this study allowed us to conclude that the frequency of granulation tissue formation and time to complete healing is more rapid with less infection rate in our NPWT group compared to advanced wound dressings group. Sterilized PVA sponge is a good alternative to standard GranuFoam as it has many of the same properties and qualities of a natural sea sponge. The modified NPWT using PVA sponge is a suitable treatment modality and more efficacious in the management of various types of wounds. This technique is a simple, safe, reliable and an economical alternative to standard VAC and other available costly wound dressings. It can be performed at secondary healthcare centres with low resources and patient with lower socioeconomic status.

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