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Original Research Article

ENHANCING HEALING IN CHRONIC DIABETIC ULCERS: VACUUM ASSISTED CLOSURE VERSUS CONVENTIONAL MANAGEMENT - A CLINICAL TRIAL

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ABSTRACT

Background

Lower extremity diabetic ulcers are a devastating and expensive medical complication. Conventional treatments such as antibiotics, off-loading and debridement among others are often insufficient by themselves to treat chronic ulcers completely. A novel approach to wound treatment called VAC (Vacuum Assisted Closure) therapy creates a vacuum, enhances tissue perfusion, and suctions exudates to hasten the healing process. Recent randomized controlled studies suggest that VAC gives better results than the conventional management strategy. This study aims to evaluate its efficacy in the treatment of diabetic foot ulcers.

Methods

This was a randomized case-control study including 70 patients with DM aged 20 -70 years with stage 2 or 3 DFU, randomized either to group 1 (patients treated with VAC) or group 2 (patients treated with conventional dressings), with an equal number of patients in each group (n = 35). Each group was assessed on their improvement based on the rate of healing,

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as calculated by the percentage decrease in the total surface area of the ulcer at the end of days 3 and 6. Other contributing variables like the presence of neuropathy, distal pulsations, duration of diabetes etc., were also considered and their effect on wound healing was analyzed.

Results

We measured wound healing based on the percentage decrease in the wound surface area at the end of 3rd and 6th days, and we found that the healing was much faster in the cases in which VAC was applied. The VAC group significantly reduced the number of 'In Patient' days, which indirectly decreased treatment expenditure from the patient's perspective. Additionally, the VAC group demonstrated better patient compliance due to its less painful nature. Another significant finding in our study was that VAC therapy did not increase the chance of wound infection, and there was no increase in the bacterial load in either VAC group. Neuropathy and decreased distal vascularity were identified to have a direct effect on the wound healing pattern in both groups, while the presence of neuropathy dampened the healing in both groups. Our study also revealed that ulcers with a larger surface area have better results with VAC therapy. Patient compliance and satisfaction were also higher in the VAC group.

Conclusion

When it comes to treating diabetic patients' foot ulcers, NPWT with VAC is more effective than traditional therapy without raising the risk of infection.

Keywords: Diabetic Foot Ulcers, Moist Saline Wound Dressing, VAC Closure (Vacuum-Assisted Closure), NPWT (Negative Pressure Wound Therapy)

INTRODUCTION

DFU (Diabetic Foot Ulcer) occurs in 25% of all patients with diabetes and precedes 84% of all diabetes-related lower-leg amputations.[1] The management of DFU heavily depends on the degree of infection, the limb's vascularity, and its severity. The conventional approach has been to use gauze that has been wet with saline; however, using these dressings makes it challenging to keep the wound moist all the time. The use of growth factors, enzymatic debridement agents, hyperbaric oxygen therapy, cultured skin substitutes, hydrocolloid wound gels, and other wound remedies has since been promoted. Despite their high cost and limited empirical data to support their effectiveness, certain circumstances still use these treatments. In the field of wound care, negative pressure wound therapy is relatively new, particularly in the context of managing chronic wounds. Few studies have demonstrated significant improvement in wound depth in chronic wounds treated with negative-pressure therapy as compared with wounds treated with saline wet to moist dressings. In addition, treatment with negative pressure results in faster healing times with fewer associated complications.[2] Hence, the present work was carried out to study the change in surface area of ulcers by assessing the rate of healing in patients undergoing negative pressure therapy when compared to conventional management and to assess the duration of hospital stay in both groups as an indicator of the effectiveness of ulcer healing.

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MATERIALS & METHODS

The Department of General Surgery and Department of Plastic Surgery at Government Medical College, Thiruvanathapuram, Kerala, conducted this randomized case-control study to evaluate the effectiveness of VAC and traditional dressings in healing DFU. The study population included patients with DM between the ages of 20 and 70 who had stage 2 or 3 DFU (according to Wagner's classification).

Patients were randomized into two groups: group 1 (VAC-treated patients) and group 2 (conventional dressings), each containing the same number of patients (n = 35). Individuals with co-morbidities related to the cardiovascular, pulmonary, or other systems of the body, as well as those with osteomyelitis of the underlying bone, were excluded from the study. The study also excluded individuals on medications like immunosuppressive agents or chemotherapy, as well as pregnant or nursing mothers. All of the study participants' wounds had initial, sharp surgical debridement to remove necrotic tissue and slough, and later dressing changes. In all aseptic circumstances, study group patients covered their wounds with foam-based coverings afterward debridement. To provide an airtight seal, an adhesive drape was placed over the dressing. We inserted an evacuation tube into the foam, attached a vacuum to it, and continuously delivered sub-atmospheric (negative) pressure within the range of 80 to 125 mmHg for 72 hours. The control group received saline soaked gauze dressing once a day. Ulcers were treated for 6 days in both groups. At the end of day 6 healing was assessed by measuring the new dimensions of the ulcer using a Venier caliper, calculating the area of the ulcer from the dimensions, and calculating the percentage change in the ulcer area, when compared to the initial surface area. Treatment outcome and patient satisfaction were assessed in terms of a decrease in the surface area of the ulcer and wound closure, as well as pain and discomfort during the course of treatment.

Statistical Analysis

Data was entered and analyzed using SPSS 14. Background variables were analyzed by using Pearson’s chi-square and student's independent t-test. The statistics for the ulcer area were assessed on days 1, 3, and 6 by calculating the mean and median of the ulcer area. ANCOVA statistics was used to compare the treatment of ulcers on days 3 and 6. Comparison of ulcer healing based on selected variables was done. Ulcer healing for the neuropathy variable was assessed using the student's t-test, while we used ANOVA statistics to assess the distal pulse variable. Results were expressed as n (%). P-values < 0.05 were considered to be statistically significant.

RESULTS

The patients in the case and control groups had an average age of 43±12.3 and 45.5±10.9 years, respectively. Patients selected for case and control were comparable based on age, as the difference between both groups was insignificant ($p > 0.05$). Males accounted for 60% of cases and 54.3% of controls. Females accounted for 45.7% of the control group and 40% of the cases. Both groups were comparable based on sex ($p = 0.629$). The average duration of ulcers was 2.1 ± 1.5 months in the case group and 2.1 ± 1.3 months in the control group. An independent t-test showed that the difference between the case and control groups was

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insignificant (p = 0.917). There was no difference in the duration of diabetes between the groups (5.4 ± 3.5 years vs. 4.9 ± 3.1 years, p = 0.504). There was no statistically significant difference in the distribution of patients with neuropathy in both groups (p = 0.794), with 31.4% among cases and 28.6% among controls. Chi square analysis showed (p = 0.340) that there was no statistically significant difference in the distribution of patients with respect to peripheral vascularity as assessed by distal pulses.

Descriptive analysis comparing the area of the ulcer prior to treatment, after 3 days of treatment, and at the completion of treatment after 6 days are as shown in Tables 1–3.

	Case	**Control**
Mean ± SD	80.3 ± 37.3	72.8 ± 35.7
Median	75.5	76.4
Minimum	16.0	22.6
Maximum	144.1	153.4

Table 1: Area of Ulcer Prior to Treatment

	Case	**Control**
Mean ± SD	71.3 ± 34.8	67.3 ± 34.3
Median	68.5	71.3
Minimum	14.4	18.2
Maximum	138.7	146.3

Table 2: Area of Ulcer on Day 3

	Case	**Control**
Mean ± SD	65.2 ± 33.1	61.4 ± 32.1
Median	64.2	65.3
Minimum	11.0	16.4
Maximum	130.0	130.7

Table 3: Area of Ulcer on Day 6

The mean ulcer area at the start of the intervention in the case and control groups was 80.3 ± 37.3 and 72.8 ± 35.7, respectively. On day 6, the mean area of ulcers for the case group was 65.2 ± 33.1 and 61.4 ± 32.1 for the control group. The difference in the end point of the descriptive analysis needed further assessment as there was a difference in the initial mean area in both groups. The ANCOVA (Analysis of Co-Variance) study needed to be applied in this case, making the difference at the starting point negligible.

After 3 days of intervention, the study group's average measurement of wound ulcers dropped from 80.3 to 71.3, while the control group's assessments were 67We used ANCOVA to determine whether the groups differed in wound healing. The ANCOVA statistics (F = 26.82, p<0.01) show that the wound ulcer (67.7) is much smaller than the control wound ulcer (70.9), even after taking into account the difference in measurements between day 3 and day 1 measurements. Table 4 demonstrates that the study group's intervention was

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significantly more effective than the control group's patients.

Area of Ulcer (in cm^2)		Mean ± SD	DF	F	P-Value
Day 1	Case	80.3 ± 37.3	(1,68)	0.74	0.393
	Control	72.8 ± 35.7			
Day 3	Case	71.3 ± 34.8	(1,68)	0.23	0.636
	Control	67.3 ± 34.3			
Adjusted Areafor Day 3	Case	67.7 ± 0.4	(1,67)	26.82**	0.000
	Control	70.9 ± 0.4			
Table 4: Comparison of Treatment on Day 3					
**: - Significant at 0.01 level					

The ANCOVA statistics (F = 13.13, p<0.01) showed that the wound ulcer (61.9 ± 0.6) is much smaller than the control wound ulcer (64.8 ± 0.6). This was even after taking into account the difference in measurements between day 1 and day 6. Therefore, the study group's intervention significantly outperforms the control group's patients' intervention. (Table 5).

Area of Ulcer (in cm^2)		Mean ± SD	DF	F	P-Value
Day 1	Case	80.3 ± 37.3	(1,68)	0.74	0.393
	Control	72.8 ± 35.7			
Day 6	Case	65.2 ± 33.1	(1,68)	0.23	0.632
	Control	61.4 ± 32.1			
Adjusted Area for Day 6	Case	61.9 ± 0.6	(1,67)	13.13**	0.001
	Control	64.8 ± 0.6			
Table 5: Comparison of Treatment on Day 6					
**: - Significant at 0.01 level					

Table 6 shows a comparison of the percentage change in healing done using an independent t test, and the analysis revealed a significant difference in healing with the case group when compared to the control group (p = 0.015). With this data, it was evidently proven that healing was better in the VAC group.

Group	Mean	SD	N	T	P-Value
Case	20.8	6.6	35	2.49*	0.015
Control	17.2	5.6	35		
Table 6: Comparison of Percentage Change in Healing					
*: - Significant at 0.05 level					

Another background variable analyzed was the number of days of stay in both groups. Independent t-test analysis was done for comparison, and (p = 0.046) was suggestive

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that the minor difference in the mean IP days of case (20.3) and control (23.3) was statistically significant. This study, therefore, concluded that VAC therapy definitely had an upper hand in meeting the end point of the treatment. (Table 7).

Group	Mean	SD	N	T	P-Value
Case	20.3	8.4	35	1.74	0.046
Control	23.3	6.1	35		

Table 7: Comparison of Days of Stay

Another variable analyzed was the presence of wound infection or bacterial load post-intervention in both groups, as it was suggested by the literature review that VAC group was more prone to increased bacterial load post-intervention. However, chi square analysis was done and the result (p = 0.232) indicated that the case group had no statistically significant risk of wound infection compared to the control group. **(**Table 8).

Pus Culture and Sensitivity	Case		Control		χ^2	P-Value
	Count	Percent	Count	Percent		
Negative	26	74.3	30	85.7	1.43	0.232
Positive	9	25.7	5	14.3		

Table 8: Comparison of Pus Culture and Sensitivity

DISCUSSION

Patients with diabetic mellitus are frequently admitted to hospitals due to foot issues, which result in several surgical procedures and extended hospital stays. The degree (grade), vascularity, and presence of infection all play major roles in the management of DFU. For diabetic foot ulcers, one of the most crucial treatments is NPWT (Negative Pressure Wound Therapy).[3] With the use of a VAC device, a more recent non-invasive adjunctive therapy system, controlled negative pressure is applied to open wounds to facilitate the removal of fluid, prepare the wound bed for closure, lessen edema, and encourage the formation and perfusion of granulation tissue. There is a dearth of information on NPWT's function in DFU management. As a result, we conducted research to evaluate the efficacy of VAC versus traditional dressings in DFU healing.

In the current investigation, the mean age of the patients chosen for the case and control groups was 43±12.3 and 45.5±10.9 years, respectively. The mean number of days that patients in group A (n = 60) receiving vacuum assisted closure therapy wound up being 55.45 with a standard deviation of 6.279, while patients in group B (n = 60) receiving conventional dressings for wound closure wound up being 55.23 with a standard deviation of ±6.220. These results were not statistically significant. This was the conclusion drawn from a randomized control trial by Aslam R. et al.[4] In our study, 60% of males were cases and 54.3% were controls. In Aslam R. et al.[4] study females formed 40% of cases and 63.3% were males. In group B (conventional dressing for wound closure), 71.7% were males and 28.3% were females. In a prospective time-bound comparison analysis, Singh B. et al.

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discovered that the average mean age was 54.4 years (37–74 years old). There were twenty-two (73.3%) male patients.[5]

Our study found that the VAC group had a greater reduction in ulcer size, with a 20.8% decrease in surface area as compared to the control group of 17.2%, with a p-value of 0.015. Similarly, Mc Callon et al.[6] found that with VAC therapy, the mean decrease in the size of the ulcer at the end of three weeks was greater than that in the moist dressing group (28.4% vs. 9.5%), which corroborated our observation. Although we did not evaluate complete regeneration in the present study, the rate of wound healing showed similar results.

In a research by Kilic et al.,[7] a substantial decrease in the wound area ($p < 0.05$) was seen over 16 days. Additional research by Dzieciuchowicz et al.,[8] Sepulveda et al.[9] and Ubbink et al.[10] discovered that NPWT outperforms traditional gauze dressings in terms of reducing wound dimensions, completing wound healing, preparing the wound bed more quickly, and reducing the risk of re-amputations. In the 112-day active treatment phase, NPWT (43.2%) resulted in complete ulcer closure in a higher percentage of foot ulcers than AMWT (28.9%), according to an RCT by Blume et al. (2008) ($p = 0.007$).[11]

The creation of macrodes, stabilization of the wound environment and reduction of edema, microdeformation resulting in increased cellular proliferation and angiogenesis, and decreased bacterial load are all thought to contribute to faster healing in NPWT and improved granulation cover. At the contact point between the wound and the foam, NPWT produces mechanical strain that deforms the cytoskeleton and triggers cascades that result in angiogenesis and cell proliferation.[12] The acceleration of granulation tissue production in NPWT is associated with increased levels of fibroblast growth factor, transforming growth factor β, fibroblast proliferation, α smooth muscle actin, interleukin 8, and vascular endothelial growth factor.[13,14] Additionally, VAC therapy establishes a favorable environment by reducing bacterial load and edema, which would otherwise hinder granulation.

Lesions larger than 10 cm were found to have a greater reduction in ulcer area than those smaller than 10 cm, which were deeper and therefore more responsive to the NPWT's macrodeformation impact. According to Liu et al.'s recent systematic review and meta-analysis, NPWT considerably lowers DFUs when compared to regular dressing.[15] In their research, McCallon et al. found that those DFUs receiving NPWT had a decrease of 28.4%, 16.4%, and 23.6%.[6] An Indian study by Nain et al. found similar findings to the current study, showing mean ulcer area reductions of 16.14 cm2 and 5.98 cm2 for DFUs treated with NPWT and traditional dressing, respectively.[16]

A literature review of various articles suggested that VAC therapy significantly reduced hospital stay and thus indirectly hospital expenditure. Independent t test analysis was done for comparison, and ($p = 0.046$) was suggestive that the minor difference in the mean IP days of case (20.3) and control (23.3) was statistically significant. This study, therefore, concluded that VAC therapy definitely had an upper hand in meeting the end point of the treatment. In the NPWT group, the duration of hospitalization until the wound was completely granulated and prepared for skin grafting was 22.87 ± 7.62 days, while in the traditional group it was 32.53 ± 10.17 days. The average length of hospital stay differs significantly from vacuum dressing (P-value = 0.02) and is highly statistically significant.

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These findings support the efficacy of NPWT, which has been reported by several writers in the literature.[17] Clinics frequently use NPWT nowadays to treat a variety of acute, chronic, and specialty wounds with positive therapeutic outcomes.[18]

CONCLUSION

When it comes to treating diabetic patients' foot ulcers, NPWT with VAC is more effective than traditional therapy without raising the risk of infection. Hospitals should consider the VAC therapy set an essential tool for managing diabetic foot wounds.

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