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Affordable Negative Pressure Wound Therapy Using Simplified Techniques: A Novel Approach for Chronic Limb Ulcer Management

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ABSTRACT

Chronic limb ulcers, primarily caused by diabetes mellitus, venous insufficiency, and peripheral arterial disease, presenting critical health and economic problems as they have extended healing time and high recurrence rates. Although Negative Pressure Wound Therapy (NPWT) has demonstrated improved wound healing and decreased rates of infection compared to standard wound care, it is not widely adopted in resource limited settings where the cost remains prohibitive. This study assesses an economical, makeshift NPWT system using locally available materials. A randomized controlled trial of 50 patients showed that the low-cost NPWT system significantly accelerated wound healing compared to 50 patients using standard saline dressings, with 90% ulcer healing by a mean time of 24 days in the NPWT group against 38 days in the control group ($p < 0.01$). In addition, the intervention group had a statistically significant greater reduction in ulcer size (2.5 cm^2/week vs. 0.9 cm^2/week, $p < 0.01$) and earlier granulation tissue formation (85% vs. 40%, $p < 0.05$) compared with the control group. Secondary outcomes included decreased pain scores, lower rates of infection, and a 40% decrease in cost of treatment. This study highlights the potential of improvised NPWT systems as a safe and effective treatment for chronic wounds in a resource-poor environment.

Keywords: Chronic limb ulcers, Negative Pressure Wound Therapy, NPWT

INTRODUCTION

Chronic limb ulcer is a major health burden, particularly among patients with condition such as diabetes mellitus, venous insufficiency and peripheral arterial disease. These ulcers often do not respond to conventional treatments, leading to lengthy healing periods, high recurrence rates, and elevated medical costs. With irreversible healthcare problems, patients and healthcare systems still desperately need successful therapeutic development that is cheap, accessible, and effective.[1,2]

Negative Pressure Wound Therapy (NPWT) can be used for the effective management of chronic ulcers and other complex wounds. With the application of controlled sub-

atmospheric pressure (negative pressure) on the wound, NPWT establishes an ideal wound healing environment by minimizing wound exudate, enhancing local perfusion, and promoting the growth of granulation tissue in the wound bed.[2,3] It has been found in several clinical studies to be superior to traditional methods of wound care in reducing both the bacterial burden and mechanical forces that impede healing.[3]

While NPWT is effective, its widespread use has been limited due to the expensive nature of commercially available systems that demand advanced materials and infrastructures. This cost poses a major barrier to optimal wound care in resource-limited settings. Therefore, there is a compelling demand for novel, economical alternatives to conventional NPWT that offer similar clinical efficacy with less cost.[4]

This study explores the use of an improvised, cost-effective NPWT system with easily available materials for evaluating the clinical role of improvised NPWT in the practice. It involves the use of a low-cost device as part of a new method of treatment for chronic limb ulcers, aimed at adapting to low-resource environments. This study aims to evaluate the healing outcomes and cost efficiency of this more practical experience of dynamic NPWT technology as a crucial step addressing the issue of limited accessibility for advanced wound care devices.

MATERIAL & METHODS

This study was conducted as a randomized controlled trial to compare the clinical effectiveness of an affordable Negative Pressure Wound Therapy (NPWT) system with standard saline-moistened dressing for chronic limb ulcers. The study was conducted on 50 patients aged between 20 and 75 years with chronic ulcers of more than six weeks duration. Subjects were randomized into two groups: one receiving the low-cost NPWT system (intervention group) and the other receiving standard saline-moistened dressing (control group).

Inclusions: Patients included in the study had ulcers larger than 3 cm^2, no evidence of osteomyelitis or systemic infections, and stable vascular perfusion.

Exclusions: Patients with active malignancies, uncontrolled diabetes, or critical limb ischemia were excluded from the trial.

The low-cost NPWT system utilized a sterilized polyurethane foam punctured on the sides and connected to a feeding tube. This setup was linked to a suction source to generate negative pressure within the range of 70–120 mmHg, applied intermittently. Dressings were changed every 48 to 72 hours or as required to ensure hygiene and maintain therapeutic effectiveness.

The main outcomes measured were time to 90% ulcer healing, cm^2 per week decrease in ulcer size, and rate of granulation tissue formation. The secondary outcomes evaluated included pain scores, infection rates, and the cost-effectiveness of the intervention versus the routine dressing method.

RESULTS & OBSERVATIONS

In this study, 50 patients (25 in the intervention group assigned to receive the low-cost NPWT system and 25 in the control group assigned to receive standard saline-moistened dressing) were enrolled. Baseline characteristics, such as age, ulcer size, and duration, were similar between the two groups ($p > 0.05$).

Primary Outcomes: Wound healing was significantly faster in the intervention group than in the control group. In the intervention group, the mean time to 90% ulcer healing was 24 ±6 days compared to 38 ±8 days in the control group ($p < 0.01$). The average ulcer size reduction per week was 2.5 cm^2 for the intervention group and 0.9 cm^2 for the control group ($p < 0.01$). The intervention group showed earlier granulation tissue formation evidenced by similar results at the end of second week for substantial granulation noted in 85% of patients in the intervention group versus 40% of patients in the control group ($p < 0.05$).

Secondary Outcomes: Patients in the intervention group had lower pain scores (reduction of 3.2 points on 10 points scale) than control group (reduction of 1.5 points); $p < 0.05$. Infection rates were not statistically significant, but were lower in the intervention (2/17, 12%) than control (2/7, 28%) group, $p = 0.09$. The cost analysis showed that the low-cost NPWT system was 40% cheaper than the standard dressing approach.

In general, the low-cost NPWT system was proven effective because it ensured more rapid healing, greater reduction of wound size, earlier granulation tissue formation with less pain and treatment costs.

Metric	NPWT	Normal Dressing
Time to 90% Healing (days)	24	38
Ulcer Size Reduction (cm^2/week)	2.5	0.9
Granulation Tissue Formation (%)	85	40
Pain Score Reduction	3.2	1.5
Infection Rate (%)	12	28
Cost Reduction (%)	40	0

DISCUSSION

This study highlights the challenges associated with chronic limb ulcers in developing countries and emphasizes both the cheapness and effectiveness of this improvised NPWT system in treating them. The intervention group showed a statistically significant lower mean time to achieve 90% ulcer healing when compared to the control group (24 ±6 days vs 38 ±8 days), which is consistent with the existing literature showing accelerated time to wound healing with NPWT.[3]

The increased rate of ulcer size reduction observed in this study (2.5 cm^2 in the intervention group and 0.9 cm^2 in the control group per week) and stimulus to granulation tissue formation we observed concurs with other literature[5] NPWT has been proven to facilitate faster healing from the promotion of granulation tissue and reduction in the surface area of the wound.

As this aspect of the VAS pain scores were statistically significant, reduction of pain is one of the advantages of NPWT. This is in line with studies showing NPWT as a method to improve wound-related pain, possibly due to decreased dressing changes and/or maintenance of a moist environment of the wound.[6]

Nonetheless, the lower rates of infection in the intervention group were not statistically significant; however, given the trend, NPWT may serve to decrease wound contamination. Such an observation is consistent with research showing that NPWT may reduce bacterial bio-burden in wounds.[7]

The improvised NPWT system is associated with an estimated 40% reduction in treatment costs, thus overcoming one of the major barriers to NPWT implementation in low-resource settings. Cost analyses have shown that NPWT can be a cost-effective treatment instead of standard care, especially when factoring in faster healing times and the healthcare resources used in this process. [8]

Some limitations of this study are the somewhat small sample size, so may not be generalizable, and that patients with certain comorbidities were excluded. This of course needs confirming with larger, more heterogeneous populations and longer periods of follow-up to substantiate these findings and determine the long-term impact of the use of improvised NPWT systems.

CONCLUSION

The economical NPWT system remarkably improved wound healing, facilitated ulcer size decrease, as well as induced granulation tissue development early as compared to standard treatment. It also provided substantial cost savings, and reduced levels of discomfort. These results lend support to its use as a rational and effective therapy for chronic limb ulcers.

Declaration by Authors
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