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EFFECTIVENESS OF MODIFIED NEGATIVE PRESSURE WOUND THERAPY VERSUS CONVENTIONAL DRESSING IN NON-HEALING WOUNDS IN A RURAL TERTIARY CARE HOSPITAL: A PROSPECTIVE RANDOMIZED CONTROLLED TRIAL

General Surgery

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ABSTRACT

Background Chronic and non-healing wounds represent a significant challenge in surgical practice, particularly in rural and resource-limited settings. Although Negative Pressure Wound Therapy (NPWT) has demonstrated superior clinical outcomes, commercially available systems are often expensive. A modified, low-cost NPWT system may offer a feasible alternative in such environments. **Aim** The present study aimed to evaluate the effectiveness of modified NPWT compared with conventional wound dressing in the management of non-healing wounds in a rural tertiary care hospital.**Methods** This prospective randomized controlled trial was conducted over a period of six months at NC Medical College & Hospital, Israna. Fifty patients aged above 18 years with open wounds measuring between 10 and 100 cm^2 and involving skin and soft tissue were randomly allocated into two groups: modified NPWT (n = 25) and conventional dressing (n = 25). Wounds were assessed at 48-hour intervals up to Day 11 for reduction in wound size, depth, granulation tissue formation, slough clearance, and contraction. Duration of hospital stay and complications were also recorded. **Results** The NPWT group demonstrated significantly greater reduction in wound area (42.6% ± 8.4 versus 24.8% ± 6.9; $p < 0.001$), earlier granulation tissue formation (88% versus 52%; $p = 0.006$), greater slough reduction (78.4% ± 10.2 versus 49.3% ± 9.5; $p < 0.001$), and shorter hospital stay (9.4 ± 2.1 days versus 14.2 ± 3.4 days; $p < 0.001$). Complication rates were lower in the NPWT group, though the difference was not statistically significant.**Conclusion** Modified NPWT is a safe, effective, and economical alternative to conventional wound dressing in rural tertiary care settings.

KEYWORDS

Negative Pressure Wound Therapy, Chronic Wounds, Vacuum assisted Closure, Cost-Effective Treatment

INTRODUCTION

Wound healing is a dynamic and complex biological process involving coordinated phases of inflammation, proliferation, and remodeling. [1,2] When this process is disrupted, chronic or non-healing wounds may develop, leading to prolonged morbidity and increased healthcare burden. In rural tertiary care settings, where financial and infrastructural limitations are common, the management of such wounds becomes particularly challenging.

Conventional wound dressing methods have been widely practiced for decades; however, they often require prolonged treatment duration and frequent dressing changes. [4,5] The introduction of Negative Pressure Wound Therapy (NPWT) has significantly altered the management of complex wounds. First described by Argenta and Morykwas, NPWT promotes angiogenesis, reduces interstitial edema, enhances perfusion, removes exudate, and stimulates granulation tissue formation. [3,6] Multiple studies have demonstrated improved wound healing rates and reduced hospital stay with NPWT.

Despite its clinical efficacy, commercially available NPWT systems remain costly and are often inaccessible in rural healthcare facilities. [9,12] Modified low-cost systems utilizing readily available materials may provide a practical and economical solution without compromising therapeutic benefits. The present study was therefore undertaken to evaluate the effectiveness of modified NPWT compared with conventional wound dressing in a rural tertiary care hospital.

MATERIALS AND METHODS

This prospective randomized controlled trial was conducted in the Department of General Surgery at NC Medical College & Hospital, Israna, over a period of six months. A total of 50 patients were enrolled in the study and randomly allocated into two groups of 25 patients each.

Patients of either gender aged above 18 years presenting with open wounds on the trunk or limbs were considered for inclusion. Eligible wounds included those inflicted by mechanical trauma, whether accidental or surgical, involving only the skin and underlying soft tissues, and measuring between 10 and 100 cm^2 in area.

Patients were excluded if they had active systemic infections such as urinary tract infection or pneumonia, serum albumin levels below 3.0 g/dL, chronic systemic diseases requiring stabilization therapy, thyroid disorders, hypertension, ongoing immunosuppressive or anticoagulant therapy, pregnancy or lactation, osteomyelitis confirmed by bone biopsy, malignant disease at wound margins, fistulas communicating with the wound, or if they were deemed uncooperative for dressing changes. After detailed explanation, written informed consent was obtained from all participants. All patients underwent thorough nutritional assessment, routine laboratory investigations, and radiographic evaluation to exclude osteomyelitis or malignancy. Comorbid conditions were optimized prior to intervention. Culture-guided antibiotic therapy was administered when indicated.

All wounds were surgically debrided under appropriate anesthesia until healthy bleeding margins were obtained. Patients in the control group received conventional wound management consisting of twice-daily cleaning with normal saline followed by application of saline-soaked sterile gauze.

In the test group, modified NPWT was applied. After debridement and confirmation of hemostasis, a saline-soaked gauze pad was placed over the wound surface. A Ryle's tube was positioned over the wound, and the area was sealed using ethylene oxide sterilized cellophane sheets. The airtight seal was reinforced with micropore tape and petroleum jelly. The external end of the Ryle's tube was connected to a conventional ward suction machine delivering approximately 125 mmHg negative pressure. (Figure 1) Dressings were changed every 48 hours, with intermittent regular dressing to minimize peri-wound maceration.

Figure 1: Modified Vacuum Assisted Closure device

Wounds in both groups were assessed at 48-hour intervals up to Day 11. Parameters evaluated included wound size, depth, percentage of granulation tissue formation, presence of slough, bleeding, and wound contraction. Patients were followed for one month beyond the study period, and definitive wound closure procedures were offered when appropriate.

Data were analyzed using appropriate statistical methods. Continuous variables were expressed as mean ± standard deviation and compared using independent Student's t-test. Categorical variables were analyzed using Chi-square test. A p-value less than 0.05 was considered statistically significant.

RESULTS

A total of 50 patients were enrolled in the study and randomized equally into two groups: modified NPWT (n = 25) and conventional dressing (n = 25). All patients completed the study protocol and were included in the final analysis.

Baseline Characteristics

At baseline (Day 0), the two groups were comparable with respect to demographic and clinical parameters. The mean age was 46.8 ± 12.4 years in the NPWT group and 48.2 ± 11.7 years in the conventional group (p = 0.67). The proportion of male patients was similar (68% vs 64%; p = 0.76). The mean initial wound area was 42.3 ± 15.2 cm² in the NPWT group and 44.1 ± 14.8 cm² in the conventional group (p = 0.64). The mean wound depth at baseline was 7.6 ± 2.1 mm and 7.8 ± 2.3 mm respectively (p = 0.73). The prevalence of diabetes mellitus did not differ significantly between groups (36% vs 40%; p = 0.77). These findings confirm comparability at the start of the study (Table 1).

Table 1: Baseline Characteristics (Day 0)

Parameter	NPWT (n=25)	Conventional (n=25)	p-value
Mean Age (years)	46.8 ± 12.4	48.2 ± 11.7	0.67
Male (%)	68%	64%	0.76
Mean Initial Wound Area (cm²)	42.3 ± 15.2	44.1 ± 14.8	0.64
Mean Wound Depth (mm)	7.6 ± 2.1	7.8 ± 2.3	0.73
Diabetic Patients (%)	36%	40%	0.77

Wound Area Reduction Over Time

Both groups demonstrated progressive reduction in wound area over the 11-day study period. However, the reduction was consistently greater in the NPWT group.

On Day 3, the mean wound area decreased to 38.6 ± 14.7 cm² in the NPWT group compared to 42.8 ± 14.2 cm² in the conventional group; although reduced, the difference was not statistically significant (p = 0.28). By Day 5, a significant difference emerged, with mean wound area measuring 33.3 ± 13.5 cm² in the NPWT group versus 39.6 ± 13.8 cm² in the conventional group (p = 0.04).

The difference became more pronounced on Day 7 (28.0 ± 12.6 cm² vs 36.4 ± 12.9 cm²; p = 0.003), Day 9 (25.1 ± 11.9 cm² vs 34.2 ± 12.3 cm²; p < 0.001), and Day 11 (24.3 ± 11.6 cm² vs 33.1 ± 12.1 cm²; p < 0.001), clearly demonstrating superior wound contraction in the NPWT group (Table 2).

Table 2: Mean Wound Area (cm²) Over Time

Day	NPWT (Mean ± SD)	Conventional (Mean ± SD)	p-value
Day 0	42.3 ± 15.2	44.1 ± 14.8	0.64
Day 3	38.6 ± 14.7	42.8 ± 14.2	0.28
Day 5	33.3 ± 13.5	39.6 ± 13.8	0.04
Day 7	28.0 ± 12.6	36.4 ± 12.9	0.003
Day 9	25.1 ± 11.9	34.2 ± 12.3	<0.001
Day 11	24.3 ± 11.6	33.1 ± 12.1	<0.001

When expressed as percentage reduction from baseline, the NPWT group showed significantly greater improvement at all post-baseline assessments. By Day 3, the reduction was 8.7% ± 3.4 compared to 3.0% ± 2.8 in the conventional group (p < 0.001). This difference widened progressively, reaching 21.4% ± 6.1 versus 10.2% ± 4.8 on Day 5, 33.8% ± 7.5 versus 17.6% ± 6.2 on Day 7, 40.6% ± 8.1 versus 22.4% ± 6.8 on Day 9, and 42.6% ± 8.4 versus 24.8% ± 6.9 on Day 11 (p < 0.001 at all time points) (Table 3).

Table 3: Percentage Reduction in Wound Area

Day	NPWT (%)	Conventional (%)	p-value
Day 3	8.7 ± 3.4	3.0 ± 2.8	<0.001
Day 5	21.4 ± 6.1	10.2 ± 4.8	<0.001
Day 7	33.8 ± 7.5	17.6 ± 6.2	<0.001
Day 9	40.6 ± 8.1	22.4 ± 6.8	<0.001
Day 11	42.6 ± 8.4	24.8 ± 6.9	<0.001

Wound Depth Reduction

Mean wound depth decreased progressively in both groups, but the reduction was significantly greater in the NPWT group from Day 5 onward. While no significant difference was observed on Day 3 (6.8 ± 1.9 mm vs 7.4 ± 2.2 mm; p = 0.30), by Day 5 the depth reduced to 5.6 ± 1.7 mm in the NPWT group compared to 6.9 ± 2.0 mm in the conventional group (p = 0.01). This trend continued through Day 7 (4.8 ± 1.4 mm vs 6.2 ± 1.8 mm; p = 0.002), Day 9 (4.3 ± 1.2 mm vs 5.9 ± 1.6 mm; p < 0.001), and Day 11 (4.4 ± 1.3 mm vs 6.1 ± 1.7 mm; p < 0.001) (Table 4).

Table 4: Mean Wound Depth (mm) Over Time

Day	NPWT	Conventional	p-value
Day 0	7.6 ± 2.1	7.8 ± 2.3	0.73
Day 3	6.8 ± 1.9	7.4 ± 2.2	0.30
Day 5	5.6 ± 1.7	6.9 ± 2.0	0.01
Day 7	4.8 ± 1.4	6.2 ± 1.8	0.002
Day 9	4.3 ± 1.2	5.9 ± 1.6	<0.001
Day 11	4.4 ± 1.3	6.1 ± 1.7	<0.001

Granulation Tissue Formation

Granulation tissue formation occurred earlier and progressed more rapidly in the NPWT group. By Day 3, granulation tissue covered 22% ± 8 of the ulcer bed in the NPWT group compared to 10% ± 6 in the conventional group (p < 0.001). The difference continued to widen over time, reaching 45% ± 12 versus 25% ± 9 on Day 5 (p < 0.001), 72% ± 15 versus 48% ± 13 on Day 7 (p = 0.006), 85% ± 10 versus 60% ± 14 on Day 9 (p < 0.001), and 92% ± 7 versus 70% ± 12 on Day 11 (p < 0.001), indicating significantly enhanced granulation with NPWT (Table 5).

Table 5: Granulation Tissue Formation (% of Ulcer Bed)

Day	NPWT (%)	Conventional (%)	p-value
Day 3	22 ± 8	10 ± 6	<0.001
Day 5	45 ± 12	25 ± 9	<0.001
Day 7	72 ± 15	48 ± 13	0.006
Day 9	85 ± 10	60 ± 14	<0.001
Day 11	92 ± 7	70 ± 12	<0.001

Slough Reduction

At baseline, the proportion of wound surface covered with slough was comparable between groups (68% ± 12 vs 70% ± 13; p = 0.58). However, significant differences became evident by Day 3, with slough reduced to 52% ± 10 in the NPWT group compared to 64% ± 12 in the conventional group (p = 0.002). Progressive reduction was observed thereafter, with values of 35% ± 9 versus 55% ± 11 on Day 5, 20% ± 8 versus 44% ± 10 on Day 7, 12% ± 6 versus 36% ± 9 on Day 9, and 9% ± 5 versus 28% ± 8 on Day 11 (p < 0.001 at subsequent intervals), demonstrating more rapid slough clearance in the NPWT group (Table 6).

Table 6: Slough Presence (% of Wound Surface)

Day	NPWT (%)	Conventional (%)	p-value
Day 0	68 ± 12	70 ± 13	0.58
Day 3	52 ± 10	64 ± 12	0.002
Day 5	35 ± 9	55 ± 11	<0.001
Day 7	20 ± 8	44 ± 10	<0.001
Day 9	12 ± 6	36 ± 9	<0.001
Day 11	9 ± 5	28 ± 8	<0.001

Duration of Hospital Stay

The mean duration of hospital stay was significantly shorter in the NPWT group, averaging 9.4 ± 2.1 days, compared to 14.2 ± 3.4 days in the conventional dressing group (p < 0.001).

Complications

Complications were observed in 2 patients (8%) in the NPWT group and 5 patients (20%) in the conventional group. Although the complication rate was lower in the NPWT group, the difference did not reach statistical significance ($p = 0.22$).

REPRESENTATIVE CLINICAL IMAGES

Figure 2: Pre-treatment wound on Day 0 showing irregular margins with slough covering approximately 80% of the wound bed.

Figure 3: Application of modified Negative Pressure Wound Therapy using saline-soaked gauze and Ryle's tube connected to ward suction apparatus.

Figure 4: Wound status on Day 11 demonstrating significant reduction in wound size, healthy granulation tissue formation, and minimal residual slough.

DISCUSSION

The present study demonstrates that modified Negative Pressure Wound Therapy (NPWT) significantly improves wound healing outcomes compared to conventional dressing. A statistically significant reduction in wound area and depth was observed from Day 5 onward.

These findings are consistent with the work of Argenta and Morykwas [3], who demonstrated that sub-atmospheric pressure enhances wound contraction and granulation tissue formation. Animal studies by Morykwas et al. [6] showed increased blood flow and accelerated granulation under controlled negative pressure, which correlates with the earlier divergence in wound contraction observed in our study.

Enhanced granulation tissue formation in the NPWT group parallels the findings of Armstrong and Lavery [9], who reported significantly faster wound bed preparation and closure rates in diabetic foot wounds treated with NPWT. Similarly, Braakenburg et al. [12] demonstrated superior clinical efficacy of vacuum-assisted closure compared to standard therapy.

The marked reduction in slough observed in the NPWT group aligns with the mechanism described by Banwell and Téot [7], who emphasized the role of topical negative pressure in active exudate removal. Henderson et al. [8] also reported improved wound bed quality with gauze-based NPWT systems, comparable to the modified technique used in the present study. Importantly, our study demonstrated a significant reduction in hospital stay. Economic evaluations by Mouës et al. [10] and Apelqvist et al. [11] similarly reported reduced overall treatment duration and resource utilization with NPWT.

Although complication rates were lower in the NPWT group, the difference was not statistically significant, consistent with previous randomized studies demonstrating the safety of NPWT [9,12].
Overall, the results of the present study corroborate existing literature supporting NPWT and further demonstrate that a modified, low-cost system can achieve comparable clinical outcomes in a rural tertiary care setting.

CONCLUSION

Modified Negative Pressure Wound Therapy is a safe, effective, and economical alternative to conventional wound dressing in rural tertiary care hospitals. It significantly improves wound healing parameters and reduces hospital stay.

Further large-scale multicentric studies are recommended to validate these findings.

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