

Negative pressure wound therapy and conventional wound management at a rural tertiary care center – A comparative study



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ABSTRACT

Background: Wounds are a major source of morbidity and sometimes, mortality and there are several ways to treat them. Negative pressure wound therapy (NPWT) is one way, and this involves the use of a suction device to aspirate and remove fluids, debris, and infectious materials from the wound bed to promote the formation of granulation tissue and wound healing. Another way is with the use of conventional wound dressings.

Aims and Objectives: The aim was to compare NPWT and conventional wound dressings for the poor in a rural setting. **Materials and Methods:** Sixty consecutive cases clinically presenting with wounds between March 2018 and August 2019 were examined and divided into NPWT or conventional wound dressing groups. Outcome was measured by recording wound scores on day 7 or thereafter. Cases and controls were studied from admission until complete healing. Outcome and complications of NPWT and conventional wound dressings were noted. Results were tabulated in MS excel and evaluated using Graphpad Prism 9 software (San Diego, CA, USA). **Results:** Many patients (33.33%) were in the 5th and 6th decades of life and most (77%) were male. Many wounds were located on the foot (40%). Those patients younger than 40 years of age with a wound <10 days old had a better median wound score in both the groups. The majority of wounds (43.33%) were traumatic. Wound healing was better in non-diabetics and non-smokers. There was a considerable reduction in the organism load in the NPWT group ($P=0.0078$). Complications were minor. The NPWT group had a significantly shorter mean hospital stay ($P=0.0001$). **Conclusion:** NPWT enhanced granulation tissue formation leading to earlier wound healing and faster recovery compared to conventional wound dressings.

Key words: Negative pressure wound therapy; Suction device; Wound healing; Granulation tissue

INTRODUCTION

The incidence of chronic non-healing wounds, such as pressure ulcers, diabetic feet, and leg ulcers, is high in our community and is a common cause of prolonged in-hospital admission. The conventional wound dressings take a long time for these wounds to heal effecting a higher loss of man-days and also incurring high expenditure. In this context, the advantages conferred by negative pressure wound therapy (NPWT) to the patients, health-care

professionals, and public health resources are many. It is a useful adjunct in wound management. Despite the advent of numerous new techniques and technologies, NPWT remains a cornerstone to the management of complex wounds.¹ Management of chronic non-healing (vascular, traumatic, and diabetic) wounds differs according to the size of wound, the type of structures exposed and the comorbid condition of the patients and aetiology.² An abundance of publications have demonstrated the use of NPWT to promote wound healing in various complex

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clinical domains, such as for diabetic foot ulcers, pressure ulcerations, chronic wounds, and skin grafts.³ The concept of using controlled sub atmospheric pressure to treat or infected wounds was initially described by Fleischmann et al., in 1993.⁴ In 1996, the first commercially available NPWT system was introduced by Kinetic Concepts, Inc./KCI USA, Inc., San Antonio, TX. The mechanism of NPWT includes mechanotransduction, drainage of fluids, stabilization of the wound environment, and micro deformation. The primary goals of an NPWT dressing are to accelerate wound healing by reducing edema, contraction at wound edges, granulation tissue formation from the base of the wound, and typically reduced frequency of dressing changes and hospital stay.⁵ Absolute contraindications of NPWT include malignancy and exposed vital structures while ischemic, devitalized or infected tissue being relatively contraindicated. NPWT is a universally accepted method for wound management. Complications such as bleeding, pain, sepsis are reported in patients undergoing NPWT.³ Still it has proved its efficacy in complex wound management with faster wound healing and shorter hospital stay. It is cost-effective too.⁶ Hence, the study was undertaken to cater to the poor people of north-east sub-Himalayan region, who come to our rural tertiary care center with this effective, economical, and yet underexplored NPWT system.

Aims and objectives

General objective

The aim of the study was to assess the efficacy of NPWT in wounds and compare it with conventional wound dressings.

Specific objectives

The objectives of the study are as follows:

1. To study the etiological spectrum, clinical profile, associated comorbid conditions, and treatment history in patients with wounds
2. To know the efficacy of NPWT in wounds in terms of number of days required for healing, a wound score system adopted in our study (mentioned below) and control of infection and comparing it to conventional dressings
3. To understand the important factors (e.g., smoker/nonsmoker, diabetic/non-diabetic, traumatic/vascular, and wound area size) which may influence the efficacy of NPWT.

MATERIALS AND METHODS

This was a prospective, institution-based, and observational study conducted in the Department of General Surgery (In Patient Department and Surgery Casualty Ward) of a rural tertiary care center of North Bengal, India, for a duration of 1½ years.

Inclusion criteria

Sixty consecutive patients (Nonprobability sampling) patients presenting with wounds with a size >2 cm were included in the study.

Exclusion criteria

Patients with malignant ulcers, active Charcot disease, ulcers resulting from chemical or radiation burns, untreated osteomyelitis, dry gangrene, and surgical site infection with fistula to organ or cavity were excluded from our study.

After obtaining ethical committee clearance (IEC/2017-18/10) and the consent of the patients, patient particulars were noted, detailed history taken, clinically examined and appropriate laboratory tests done. They were allotted into two groups, 30 each after matching for sociodemographic and clinical factors into a case group (NPWT) and a control group (Conventional wound dressing).

Wound swabs were obtained, and the wound irrigated and/or debrided. When adequate hemostasis was achieved, a silver net was placed over the raw wound only. Then a sterile and open-cell foam dressing was gently placed into the wound cavity over the net and sealed with an adhesive drape ensuring that the drapes covered the foam and at least 3–5 cm of surrounding healthy tissue. Then, controlled negative pressure was uniformly applied to all tissues on the inner surface of the wound using commercially available NPWT vacuum pump, which could deliver either continuous or intermittent pressures, ranging from –50 to –125 mm Hg. The foam dressing compressed in response to the negative pressure (Figure 1). The pressure was applied continuously for the first 7 days and changed and again applied for the next 7 days and as required thereafter. All selected cases were studied from admission up to the complete healing of wounds. The control group had conventional dressings using normal saline, povidone iodine, and sterile gauzes. The final outcome of the wound and complications of NPWT dressing, if any, was also noted.

The outcome was measured using a wound scoring system consisting of the area of the wound covered with granulation tissue, its color, and consistency in our study as depicted below.

Wound scoring system used in our study.

Granulation	Score	Day 7
None	0	
^{1/4} Wound area	1	
^{1/2} Wound area	2	
^{3/4} Wound area	3	
Complete	4	

Color	Score	Day 7
Pale	0	
Pink	1	
Bright red	2	

Consistency	Score	Day 7
Spongy	0	
Solid	1	

Results were tabulated in Microsoft excel and appropriate statistical methods were employed using Graphpad Prism 9 software (San Diego, CA, USA). Descriptive statistical analysis included the calculation of means, medians and standard deviations of the data obtained. P<0.05 was considered significant. Categorical data were analyzed using Chi-square test. Continuous data were analyzed using paired t-test results.

RESULTS

A third of the patients presenting with wounds was in the 5th and 6th decades of life (33.33%). The younger patients had a better wound score at Day 7 in both the groups. However, across all ages the NPWT group showed improved wound scores (Table 1). Wounds were more common in males, 46 cases (77%) than in females, 14 cases (23%). Male to female ratio was 3.285:1.

Based on the duration of wounds, cases were grouped into three categories: <10 days, 10–20 days, and >20 days.

Most cases fall in the group 10–20 days, 38 (63.33%), 20 cases (33.33%) in the group <10 days, and two cases (3.33%) in the group >20 days. Those with a lesser wound age fared better. However, across all ages the NPWT group showed improved wound scores (Table 2).

Wounds were most commonly located on the feet 24 (40%) followed by leg 20 (33.33%), forearm 6 (10%), and ankle and sole 4 (6.66%) each. There were two abdominal wounds. Those with wounds on the forearm, sole, and abdomen had the best Day 7 median wound score of 6 taking both groups together (Table 3).

Table 1: Age-wise evaluation of wound healing score at day 7

Age in years	Number		Median wound score at day 7	
	Cases	Controls	Cases	Controls
<40	9	9	6	5
41–50	10	10	5	4
>50	11	11	4	3
Total	30	30	5	4

More than half (53%) of cases were smokers, 28 (47%) were non-smokers. The non-smokers had a better wound score at day 7, but it was statistically insignificant. However, the cases group fared slightly better (Table 4).

Based on the etiology of wounds, which was determined by history and clinical examination, wounds were divided into traumatic, diabetic, and vascular group. A major portion 14 (46.66%) of cases fell into the traumatic group and 13 (43.33%) into the diabetic and 3 (10%) into the vascular group. Diabetics fared poorly overall. The wound scores were better in the NPWT arm (Table 5).

Wound area has an impact on wound healing. The smaller the wound area, the better the wound healing was when compared to larger wound area, more so in the NPWT group (Table 6).

The organism most commonly isolated was *Staphylococcus aureus*, followed by *Pseudomonas* and *Proteus*, with a considerable reduction in the organism load in the NPWT group (P=0.0078) (Table 7).

Table 2: Age of wound – evaluation of wound score at day 7

Age of wound in days	Number		Median wound score at day 7	
	Cases	Controls	Cases	Controls
<10	10	10	5.5	5
10–20	19	19	5	4.5
>20	1	1	3	2.5
Total	30	30	5	4

Table 3: Location of wound and wound score at day 7

Location	Wound score at day 7			
	N	Mean	SD	Median
Forearm	6	6	1	6
Abdomen	2	6	-	6
Leg	20	4.6	0.96	4.5
Ankle	4	5	1.41	5
Foot	24	5.08	1.56	5
Sole	4	6	0	6
Total	60	5.1	1.26	5

Table 4: Smoking – evaluation of wound healing score at day 7

Smoking	Number		Median wound score at day 7	
	Cases	Controls	Cases	Controls
Yes	16	16	4.5	4
No	14	14	6	4.5
Total	30	30	5	4

Table 5: Aetiology – evaluation of wound healing score at day 7

Etiology	Number		Median wound score at day 7	
	Cases	Controls	Cases	Controls
Diabetes	13	13	4	3.5
Traumatic	14	14	6	5.5
Vascular	3	3	6	4.5
Total	30	30	5	4

Table 6: Wound area – evaluation of wound healing score on day 7

Wound area	Number		Median wound score at day 7	
	Cases	Controls	Cases	Controls
<20 sq cm	20	20	6	5
21–40 sq cm	6	6	4.5	4
>40 sq cm	4	4	4	2.5
Total	30	30	5	3

Table 7: Growth of organism in the two groups

Group	No. of patients having growth		P-value
	Pre	Post	
Cases	25	3	0.0078
Controls	22	15	

However, the sterile wounds remained sterile in both wound groups.

Cases

Pre-NPWT – growth – 25, sterile – 5
 Post-NPWT – growth – 3, sterile – 27.

Controls

Pre-dressing – growth – 22, sterile – 8
 Post-dressing – growth – 15, sterile – 15.

The NPWT group had a mean hospital stay of about 21 days whereas the control group had a mean stay of about 28 days, which was significant with P=0.0001 (Table 8).

Complications of the NPWT

Out of 30 patients, 7 (23%) complained of a tingling sensation and local site itching while the suction was applied. Only 2 (6.7%) patients had skin reaction in the form of rashes under the bandaged site which subsided subsequently. No patient reported any serious complications of NPWT dressing.

Final outcome of the NPWT

NPWT had a better overall effect on the final outcome of wounds. Wounds which seemingly needed a flap surgery in the first impression, with successive application of

Table 8: Hospital stay in the two groups

Group	n	Hospital stay		P-value
		Mean	SD	
Case	30	20.56	2.12	0.0001
Control	30	28.12	3.24	



Figure 1: NPWT application method

NPWT dressing cycles, could be covered with a simple split thickness skin graft (Figure 2). The majority of patients healed by epithelialization/secondary suturing or underwent split thickness skin grafting post NPWT. In a single case with exposed bony areas in limbs, bone drilling was done to granulate the wound followed by a flap surgery to cover the defect. The results however were not statistically significant between the two groups in our study (Table 9).

DISCUSSION

NPWT has been proposed as a novel method of manipulating the chronic wound environment to assist and accelerate wound healing. Although initial clinical results are promising, the gap between available scientific evidence and everyday, clinical practice does not give a balanced view of the appropriate use of NPWT.⁷

Various modalities of dressings and local applicants are routinely used for augmentation of wound healing. Despite all these, different ulcers often become chronic and chronic wounds are a major cause of morbidity, leading to considerable disability, and are often associated with increased mortality.^{8,9}

NPWT is an expensive treatment modality, and, because the costs are high, a recent consensus report suggests that use as a first-line therapy is inappropriate. However, others suggest that it has the potential for saving money if it is

Table 9: End of treatment in both the groups

Group	Split skin graft	End of treatment			P-value
		Healing by epithelialization/secondary suture	Regional flap	Amputation	
Cases	10	18	1	1	0.256
Controls	12	12	1	5	



Figure 2: Effect of NPWT therapy (a and b) A 35 year old female with a venous ulcer, before NPWT and 1 week after NPWT. (c-e) A 50 year old male with a diabetic ulcer, before NPWT, 1 and 2 weeks post NPWT

used on the “right patient, the right wound, at the right time” minimizing skin graft rejection.

It has been shown to be effective in complex diabetic ulcers, chronic ulcers, and pressure sores.¹⁰ NPWT is said to increase local blood flow and reduce edema and bacterial colonization rates. It is thought to promote closure of the wound by promoting the rapid formation of granulation tissue as well as by mechanical effects on the wound. It concurrently provides a moist wound environment and removes excess wound exudates thus aiding in the creation of the “ideal wound healing environment.”¹¹ Since the wound is occluded from the surrounding environment, it is also called “limited access dressing.”¹² The NPWT pump can be set to any pressure, but pressures commonly used clinically range from -80 to -125 mmHg.¹³ It is believed that negative pressure assists with removal of interstitial fluid, decreasing localized edema and increased blood flow. This, in turn, decreases tissue bacterial loads. In addition, mechanical deformation of cells is thought to result in protein and matrix molecule synthesis which increases the rate of cell proliferation.

Presenting age group in our study is mainly under 50 years, which is concordant with Patra et al.¹⁴

Wound score is better in NPWT than conventional management in our study concordant with the above study.

Foot followed by leg are the common wound sites similar to the above findings.

Of all those with wounds, 38.46% were among diabetic patients, and 50% of cases were among smokers, and showed scores ≥ 5 on day 7 of NPWT therapy. Thus, slower healing was noted in diabetics and smokers in spite of NPWT dressings but compared to conventional management, it is better. These data suggest that delayed healing in diabetes is associated with altered leukocyte infiltration and wound fluid IL-6 levels during the late inflammatory phase of wound healing as seen by Fahey et al. Age, obesity, malnutrition, microvascular, and macrovascular disease may contribute to wound infection and delayed wound healing especially in Type II diabetic patients.¹⁵

The documented effects of the toxic constituents of cigarette smoke, particularly nicotine, carbon monoxide, and hydrogen cyanide suggest potential mechanisms by which smoking may undermine expeditious wound repair as documented by Silverstein.¹⁶

Traumatic wounds also included cases of iatrogenic wounds. These showed better healing compared to other categories of wounds. There was a case of abdominal wall wound which showed good healing following NPWT. There were three cases of vascular wounds which included venous ulcers and ulcers associated with peripheral

arterial disease. Venous ulcers showed better outcome when NPWT was combined with other modalities of management like limb elevation. This is concordant with the study of Rashid et al.¹

Maintaining negative pressure in NPWT dressing and the contact of the foam to the wound surface, wound debridement, and control of infection are the factors to be taken care of mainly in diabetic wounds, wherein we can delay NPWT therapy until infection is controlled.

Microbial load decreased significantly ($P=0.0078$) in the NPWT group which is concordant with the study of Mary et al.⁶

Hospital stay was also reduced in our study significantly ($P=0.0001$) in the NPWT group much like the above study.

Complications in our study were not that significant and the final outcome shows more split skin grafting thereby avoiding unnecessary amputation/excision. NPWT had a significant effect on the final outcome of wounds. Wounds which seemingly needed a flap surgery in the first impression, with successive application of NPWT dressing cycles, could be covered with a simple split thickness skin graft. This is in tune with the study of Venturi et al.¹⁷

Limitations of the study

The sample size was modest. The statistical association can be improved using a randomised controlled trial.

CONCLUSION

NPWT is an effective and necessary tool in the armamentarium of surgeons serving in the rural areas who are burdened by the huge load of wounds in surgery wards. Although it entails an initial investment, the reduction of the repeated dressings and reduced hospital stay is economical finally. It does not require much expertise and can be replicated anywhere. However, a larger study sample could have improved the statistical analysis.

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Authors' Contributions:

DS- Definition of intellectual content, literature survey, implementation of study protocol, data collection, data analysis, and final manuscript preparation;

MRA- Prepared first draft of manuscript, preparation of clinical photographs, implementation of study protocol, data collection, and data analysis; and


JBS- Design, manuscript preparation, interpretation, editing, manuscript review and revision, coordination, and manuscript submission.


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