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Original Article

Low-cost Negative Pressure Therapy for Wound Healing

T Srinivas[1], M Aparna[2], A Nagaraju[2], K Sreevani[3]

[1]Associate Professor, Department of General Surgery, Government Medical College, Mahabubnagar, Telangana, India, [2]Assistant Professor, Department of General Surgery, Government Medical College, Mahabubnagar, Telangana, India, [3]Senior Resident, Department of General Surgery, Government Medical College, Mahabubnagar, Telangana, India

Abstract

Background and Objective: Wounds are a major source of morbidity, lead to considerable disability, and are associated with increased mortality; therefore, they have a significant impact on public health and the expenditure of healthcare resources. Vacuum-assisted closure (VAC) uses negative pressure to assist wound healing. Negative pressure drains fluid from the wound, thus removing the substrate for growth of microorganisms. Negative pressure may also accelerate granulation tissue formation and promote angiogenesis. The mechanical stimulation of cells by tensile forces may also play a role by increasing cellular proliferation and protein synthesis. Negative pressure wound therapy (NPWT) involves the use of a negative pressure therapy or suction device to aspirate and remove fluids, debris, and infectious materials from the wound bed to promote the formation of granulation tissue.

Methodology: A total of 50 cases clinically presenting as ulcer between January 2019 and December 2019 in Government Medical College, Mahabubnagar, were taken for study. Each case was examined clinically in a systematic manner for the study of all patients presenting with ulcers. VAC dressing was done and outcome was measured by recording wound scores on days 3, 7, and 10.

Results: In our clinical study of 50 cases managed by VAC dressing, 50% of the cases were of traumatic, 36% diabetic, and 14% cases of vascular etiology. Wound healing was better in the non-diabetic group compared to diabetic and in non-smokers compared to smokers. The most common organisms isolated were *Staphylococcus*, *Pseudomonas*, and *Proteus*.

Interpretation and Conclusion: In our study, VAC therapy enhanced granulation tissue formation leading to better wound healing and faster recovery. VAC is thus a promising new technology that can be used in both acute and chronic wounds as an adjuvant therapy to improve the results of various surgical procedures.

Key words: Negative pressure wound therapy, Vacuum-assisted closure, Wound healing

INTRODUCTION

Vacuum-assisted closure (VAC) is a new technique in the challenging field of management of contaminated, acute, and chronic wounds. Negative pressure wound therapy (NPWT) also called vacuum-assisted wound closure and refers to wound dressing systems that continuously or intermittently apply sub-atmospheric pressure to the surface of a wound. The application of controlled levels of negative pressure has been shown to accelerate debridement and promote healing in many different types of wounds. The optimum level of negative pressure appears to be around 125 mmHg below ambient and it is believed that negative pressure assists in the removal of interstitial fluid, decreasing localized edema and increasing blood flow. This, in turn, decreases tissue bacterial levels. Despite the significant costs involved, the technique is said to compare favorably in financial terms with conventional treatments in the management of difficult wounds.[1]

It involves the application of sterile, open-pore foam dressing directly on the wound. The wound is then sealed with an occlusive drape to create a closed, controlled environment. A fenestrated vacuum tube is connected to a vacuum source; fluid is drawn from the wound through the foam into a reservoir for subsequent disposal. Negative pressure is applied at 50–125 mm/Hg, resulting

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Corresponding Author: M Aparna, Department of General Surgery, Government Medical College, Mahabubnagar, Telangana, India.

in a decrease in the local interstitial pressure, and effluent from the wound is drawn out into the collection device. Initially, the vacuum pressure is applied continuously. As the amount of drainage decreases, the vacuum may be applied on an intermittent basis. The vacuum dressing is usually changed at the approximately 48-h interval.[2,3] Wound progress is recorded using parameters in the wound scoring system. The objectivity of assessments used to generate the wound score makes this scoring system ideal for evaluating treatment and outcome of wounds.[4]

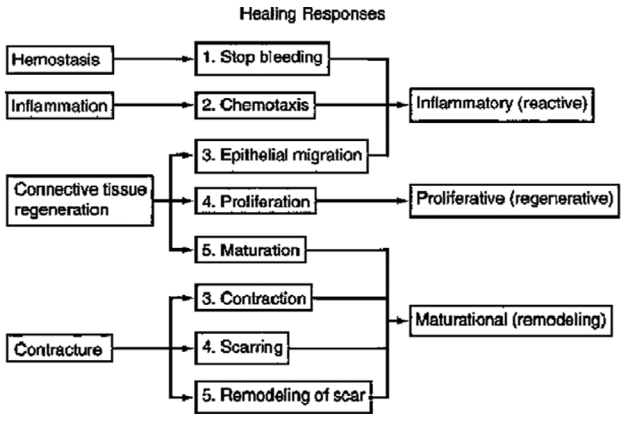
Objectives of the Study

1. To study the outcome of vacuum-assisted closure of wounds.

A wound is defined as a discontinuity of the skin, mucous membrane, or tissue caused by physical, chemical, or biological insult. Surgeon's goal in wound management is to create an environment where the healing process can proceed in an optimal fashion. Wound healing is a fundamental hemostatic process in response to injury. It involves the activation of a basic cellular process of inflammation, cell proliferation, and cell growth as well as regeneration of these processes once the repair is complete. The processes of wound healing take place in an overlapping and sequential manner.

Phases of Wound Healing

1. Hemostasis and inflammatory phase
2. Proliferative phase
3. Maturation and remodeling phase.[5]



Management of Wounds

Wound healing is a highly orchestrated process, which commences with the removal of debris and control of infection. Subsequently, the wound heals through deposition of granulation tissue, wound contraction, and maturation. Factors such as pressure, trauma, venous insufficiency, diabetes mellitus, vascular disease, and prolonged immobilization will influence wound healing.[6]

Standard wound management consists of initial surgical debridement, then either wet-to moist (WM) gauze dressings, which need to be changed at least twice daily, can be used to cover the wound. These dressings are relatively inexpensive, readily available, and easy to apply. Vacuum-assisted closure has been suggested as an alternative that may promote faster wound healing with fewer painful dressing changes.

Vacuum-assisted Closure

Vacuum-assisted closure is a potential alternative for treating of skin wounds. It uses negative pressure to assist wound healing.[7]

Indications and Contraindications for the use of VAC

The principal indications for the use of VAC are:

- Acute and traumatic wounds
- Pressure ulcers
- Chronic open wounds (stasis ulcers and diabetic ulcers)
- Meshed grafts
- Flaps
- Lower extremity diabetic ulcers

Contraindications are:

- Fistulas to organs or body cavities
- Necrotic tissue in eschar
- Osteomyelitis(untreated)
- Malignancy in the wound

MATERIALS AND METHODS

A total of 50 cases clinically presenting as ulcers between January 2019 and December 2019 were included in the study. A clinical examination of each case was done systematically for the study.

Wound Preparation

Any dressings from the wound were removed and discarded. A culture swab for microbiology was taken before wound irrigation with normal saline. Surgical debridement was done and adequate hemostasis achieved.

Method of use of NPWT Dressing

The sterile hydrocolloid sheet of the approximate size of the wound is placed gently into position.

The perforated drain tube is then placed on top of the sheet and a second hydrocolloid sheet placed over the top. The wound, together with the first few inches of the drainage tube and the surrounding area of healthy skin,

is then covered with the adhesive transparent membrane supplied. At this stage, it is important to ensure that the membrane forms a good seal, both with the skin and the drainage tube. The distal end of the drain is connected to the suction device. This was achieved by Romo Vac suction device; suction was applied continuously or intermittently based on the amount of wound discharge.

RESULTS

An interventional study involving 50 cases of wounds was done in the Department of Surgery, Government Medical College, Mahabubnagar between January 2019 and December 2019.

Gender Distribution of Wounds

Wounds were more common in males 38 cases (76%) than in females 12 cases (24%) male to female ratio 3.167: 1.

Duration of Wounds

Based on the duration of wounds, cases were grouped into three categories: <10 days, 10–30 days, and >30 days. Most cases fall in the group 10–30 days 30 (60%), 19 cases (38%) in the group <10 days, and 1 case (2%) in the group > 30 days [Table 1].

Wounds were most commonly located in the foot 20 (40%) followed by the leg 16 (32%) and the ankle and sole 4 (8%) each. One case of wound in the abdomen was included in the study. [Chart 2 and Table 2].

Smokers and Non-smokers

Twenty-seven (54%) of cases were smokers, 23 (46%) were non-smokers [Table 3].

Table 1: Duration of wound – evaluation of wound healing score on day 7

Duration in years	*n*	Day 7		
		Mean	SD	Median
<10 days	16	4.94	0.85	5
>10 days	25	4.84	1.21	5
Total	41	4.88	1.08	5

Mann–Whitney test, *P*=0.7

Table 2: Location of wound – evaluation of wound healing score on day 7

Location	Wound score					
	3.00	4.00	5.00	6.00	7.00	Total
Forearm	0	2	3	0	0	5
Abdomen	0	0	0	0	1	1
Leg	1	2	7	4	0	14
Ankle	1	0	1	1	0	3
Foot	2	5	2	5	1	15
Sole	1	0	2	0	0	3
Total	5	9	15	10	2	41

P – 0.024. Significant difference in wound healing depending on the location of the wound.

Table 3: Smoking – evaluation of wound healing score on day 7

Smoking	*n*	Day 7		
		Mean (18)	SD	Median
Yes	24	4.50	0.89	5
No	17	5.41	1.12	6
Total	41	4.88	1.08	5

Mann–Whitney test, *P*=0.006

Table 4: Etiology – evaluation of wound healing score on day 7

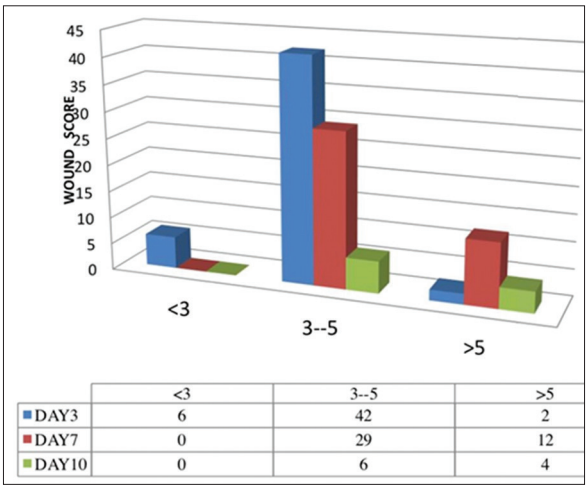
Location	*n*	Day 3		
		Mean	SD	Median
Traumatic	20	5.25	0.78	5
Diabetic	16	4.44	1.21	4
Vascular	05	4.80	1.30	5
Total	41	4.88	1.08	5

Kruskal–Wallis test, *P*=0.08 Mann–Whitney test. Traumatic versus diabetic – 0.03

Table 5: Age-wise evaluation of wound healing score on day 7

Age in years	*n*	Day 7		
		Mean	SD	Median
<40	11	5.09	0.94	5
41–50	15	4.73	1.22	5
>50	15	4.87	1.06	5
Total	41	4.88	1.08	5

Kruskal–Wallis test, *P*=0.8



	<3	3--5	>5
DAY3	6	42	2
DAY7	0	29	12
DAY10	0	6	4

Chart 1: Wound scores on days 3, 7, and 10

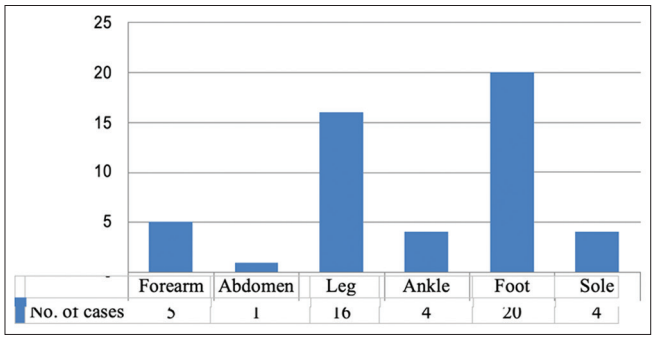


Chart 2: Distribution of location of wounds

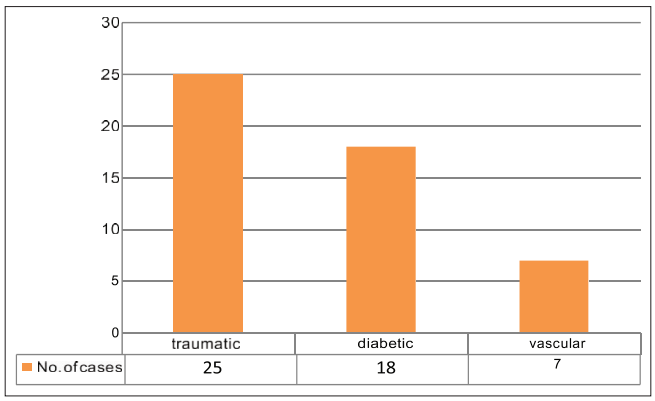


Chart 3: Etiology of wounds

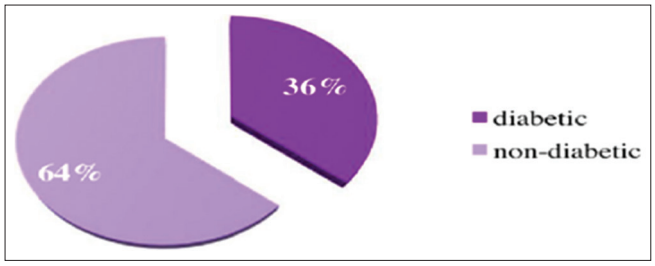


Chart 4: Diabetic and non-diabetic wounds

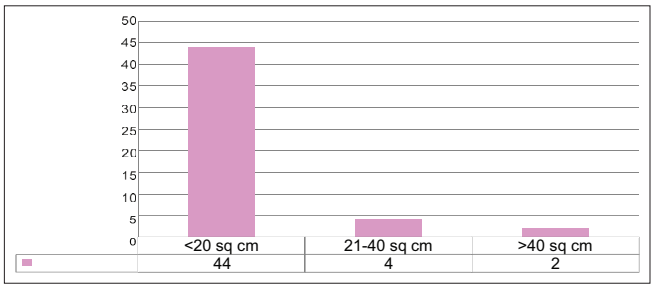


Chart 5: Wound area in square CM

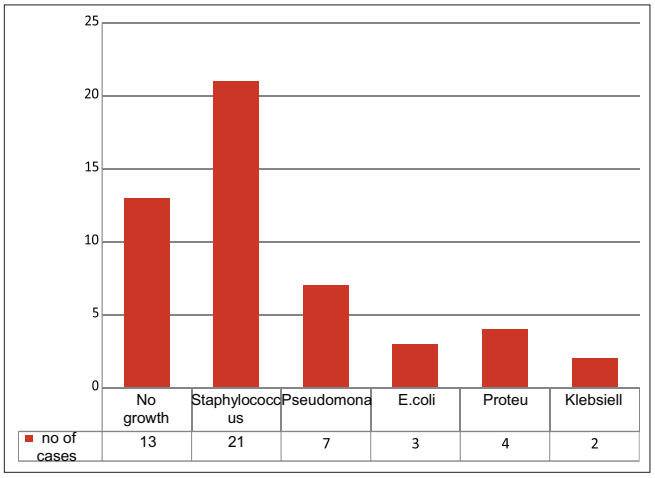


Chart 6: Organisms cultured from wound

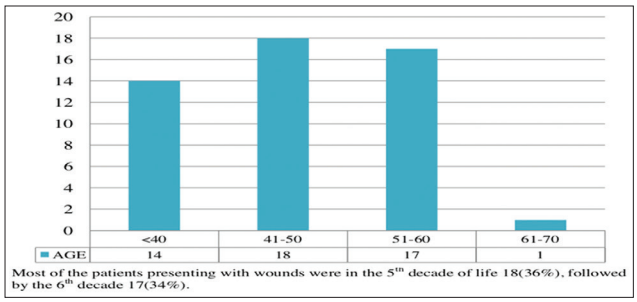


Chart 7: Age distribution of wounds

Based on etiology of wounds, which were determined by history and clinical examination, wounds were divided into traumatic, diabetic and vascular [Chart 3]. A major portion 25 (50%) of cases fell into traumatic group and 18 (36%) into diabetic and 7 (14%) into vascular group [Chart 4 Table 4].

Wounds of area <20 cm^2 constitute maximum number of cases – 44 (88%) [Chart 5].

The most common organism cultured from the wounds was *Staphylococcus aureus* 21 (42%) [Chart 6]

CONCLUSION

VAC therapy is a recent modality of treatment of wounds. Its introduction has changed the course of

management of wounds. Based on the data from the present study and other studies available, VAC does appear to result in better healing, with few serious complications, and thus looks to be a promising alternative for the management of various wounds. The application of VAC is simple but requires training to ensure appropriate and competent use.

In patients treated with negative pressure wound therapy (NPWT), the following was noted:

Earlier appearance of granulation and epithelialization
Rapid decrease in wound size
Shorter duration of hospitalization
Early achievement complete wound score.

On correlating the wound outcome variables, we also noticed that presence of diabetes mellitus increased the duration of formation of granulation tissue and epithelialization.[8] This study confirms that negative pressure wound therapy is safe, has a faster response in wound healing, and gives better efficacy as compared to conventional wound therapy in the management of lower limb ulcers. Hence, it is a better choice for the management of lower limb ulcers.

SUMMARY

The negative pressure wound therapy (NPWT) is a feasible and excellent option for the management of different types of wounds. At present, NPWT has become an established method in wound management.

The application of sub-atmospheric pressure decreases the bacterial colonization over the wound and increases blood flow.[9] Increased oxygenated blood flow to the wound healing promotes the oxidative bursts in neutrophils and thereby promoting the killing of microbes and preventing infection.

Most of the commercially available NPWT devices are foam-based systems. In our study, we used our own NPWT by using a Romo Vac suction drain which is cost-effective for reproducing the same results and for the benefit of patients, as the majority of our patients are from rural area.

- The present interventional study involved 50 cases of wounds.
- Patients affected were most commonly in the 5th (36%) decade followed by 6th decade (34%) [Chart 1 Table 5].
- There was a male preponderance with male:female ratio of 3.2:1.
- Most of the patients in the study presented early, presenting between 10 and 30 days of onset.
- VAC dressing was done in wounds occurring in a variety of locations such as foot 20 (40%), leg 16 (32%), forearm 5 (10%), ankle and sole 4 (8%), and abdomen 1 (2%). Twenty-seven (54%) of patients were smokers.
- Trauma was the most common etiology 25 (50%) followed by diabetes 18 (36%) and vascular causes 7 (14%).
- Wound area was recorded before treatment and grouped into <20 cm^2 (44 cases [88%]), 21–40 sq cm (4 cases [8%]) and > 40 sq cm (4 cases [8%]).
- *Staphylococcus aureus* was the most common organism cultured 21 (42%) followed by *Pseudomonas aeruginosa* 7 (14%). No growth was observed in 13 cases.
- Wound scores were recorded on days 3, 7, and 10 of VAC therapy. The scoring system used was based on the area of granulation tissue, its color, and consistency [Chart 7].
- Of 18 diabetic wounds, wound scores of 5 and above were observed in nine cases following VAC therapy. VAC dressing of longer duration is required for diabetic wounds for a good outcome.
- There was a significantly better outcome in non-smokers compared to smokers, with 75% of non-smokers and 58% of smokers showing wound scores >5 on day 7 of VAC therapy.[10]

Thus, the outcome of VAC therapy depends on various factors such as age, etiology of wounds, and existence of comorbid conditions such as diabetes and factors like smoking. The candidates for VAC therapy should be chosen after considering these factors with care.

From our study, it can be concluded that VAC is a promising new technology in the field of wound healing with multiple applications in a variety of wounds.

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