

Ideas and Innovations

Timer switch to convert suction apparatus for negative pressure wound therapy application

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ABSTRACT

Background: Negative pressure wound therapy (NPWT) is an established modality in the treatment of chronic wounds, open fractures, and post-operative wound problems. This method has not been widely used due to the high cost of equipment and consumables. This study demonstrates an indigenously developed apparatus which gives comparable results at a fraction of the cost. Readily available materials are used for the air-tight dressing. **Materials and Methods:** Equipment consists of suction apparatus with adjustable pressure valve set to a pressure 125-150 mmHg. An electronic timer switch with a sequential working time of 5 min and a standby time of 3 min provides the required intermittent negative pressure. Readily available materials such as polyvinyl alcohol sponge, suction drains and steridrapes were used to provide an air tight wound cover. **Results:** A total of 90 cases underwent 262 NPWT applications from 2009 to 2014. This series, comprised of 30 open fractures, 21 post-operative and 39 chronic wounds. The wound healing rate in our study was comparable to other published studies using NPWT. **Conclusion:** The addition of electronic timer switch will convert a suction apparatus into NPWT machine, and the results are equally effective compared to more expensive counter parts. The use of indigenous dressing materials reduces the cost significantly.

KEY WORDS

Cost effective dressing materials; negative pressure wound therapy; timer switch; wound healing

INTRODUCTION

Negative pressure wound therapy (NPWT) is an established modality in the treatment of chronic wounds, open fractures, and post-operative wound problems. Widespread use of this method has not been forthcoming due to the high cost of equipment and consumables. This study demonstrates an indigenously

developed apparatus which gives comparable results at a fraction of the cost.

Studies on NPWT have used either continuous or intermittent suction modes. The disadvantages of continuous suction are

1. It is connected to a wall suction unit, thereby blocking hospital bed in Surgical Intensive Care Unit or step down units.
2. A portable suction apparatus will break down if used in continuous mode.

When used in intermittent mode, NPWT resulted in increased granulation tissue and reduction in wound size, more rapidly than continuous mode. The increase in granulation tissue was 63% in continuous mode as

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compared to 103% increases with intermittent negative pressure. Majority of the articles support the intermittent NPWT.^[1-10]

In this article we want to demonstrate that the crucial piece of equipment is a cyclical timer switch, which provides intermittent suction. The circuit diagram for the timer switch is provided and it can be assembled by any biomedical technician. The dressings are improvised using readily available materials.

MATERIALS AND METHODS

From 2009 to 2014, a total of 90 patients were treated with 262 NPWT dressings (average 2.91/patient). The types of wounds were 30 post-traumatic (76 applications, 2.53 average), 21 post-operative (60 applications, 2.85 average) and 39 chronic wounds (126 applications, 3.23 average). The traumatic wounds were with or without under lying fracture. Patients with open fractures were subjected to other methods of treatment such as external fixator application. Wounds with active infection, significant bleeding and peripheral vascular disease were excluded from the study. When debridement was done the application of NPWT dressings was deferred for 24-48 hours until the wound stabilised. The dressings were changed every 48 hours and the following parameters were observed.

1. Exudate collected in the canister was measured and ranged between 3-50 ml depending on the type of wound.
2. Granulation tissue in the bed was observed, the quality of which determined whether the dressing is to be continued. When adequate granulation tissue was formed soft tissue reconstruction was taken up (flap/graft/secondary suturing).
3. Reduction in size of the wound was measured by using wound imprint technique.^[11]

Technical information

The existing literature on NPWT was reviewed and the following factors were found to be optimal for wound healing.^[2-5,12,13]

1. Negative pressure between 125 to 150 mmHg.
2. Intermittent application of suction with 5 min on and 3 min stand by.
3. Air tight wound without leaks.
4. Uniform negative pressure applied to the wound surface.

A suction apparatus with an adjustable pressure gauge was taken (220 V/150 W. Maximum vacuum: 680 mmHg).

All patients in this study were in patients. An integrated circuit [IC] based timer switch was used to provide intermittent negative pressure. This switches the unit ON for 5 min turns it OFF for 3 min. These features gave the system optimal time and pressure settings.

Commercially available medium density polyvinyl alcohol (PVA) sponge used for wound dressing. PVA sponge is a synthetic polymer derived from polyvinyl acetate. It is used as biomaterial due to its bio-compatible, non-carcinogenic, non-toxic properties.^[14] The pore size ranged between 300-600 microns and is an open cell type of a sponge. This pore size allows best ingrowth of granulation tissue. It is autoclavable and has requisite softness at the applied negative pressure of about 150 mmHg. Prior to autoclaving the sponge was cleansed to remove hazardous inclusions. The sponge was wrapped in theatre linen and autoclaved with indicator tapes (signal-log). A perforated tube (16 F) supplied with Romovac suction drain is passed through this sponge so that it lies in the middle. In order to get best results, the tube should not come in contact with the wound or the drape. The wound is sealed carefully with adhesive steridrape, ensuring that the drape extends at least five cm beyond the wound in all directions [Figure 1]. The area where the tubing exits the drape is prone to leaks. Hence special care must be taken to seal that area properly. Change of dressing was done once in 48 hours irrespective of the wound condition. If skin edges were macerated, saline dressing were done for 24 hours and NPWT resumed. The dressing was applied to the wound based on the guidelines suggested by Mendez-Eastman^[15] and Bollero *et al.*^[16] The most common problem in dressing was an air leak which was taken care by resealing the edge of the wound.

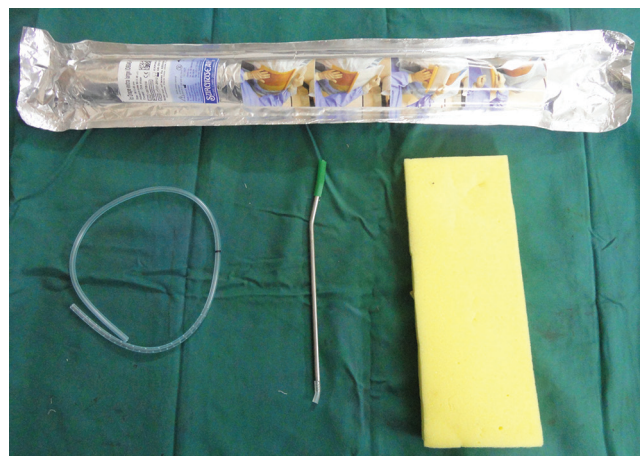


Figure 1: Materials used for dressing

RESULTS

A total of 90 patients were treated between 2009-14 comprising of 82% of male and 18% female patients. The etiological factors are shown in [Table 1], all the patients who underwent NPWT dressings were admitted because they needed supervision of the wound. Chronic wounds comprised of the largest number in our study.

Age of patients ranged from 7 to 80 years (average: 44.8 years). Number of NPWT dressings 262 (average 2.91), minimum one and maximum seven. Mean duration of NPWT dressing was 6 days (minimum 2 days to maximum 14 days).

In our study, average wound area 68 cm² (minimum 6 cm² to maximum 300 cm²) reduced to 42.6 cm² (38%). Mean duration of hospital stay 15-49 days (average 31 days). The dressings were discontinued once the wound was suitable for secondary procedure such as suturing, skin grafting or flap cover [Chart 1, Figures 2-5].

Cost of NPWT dressing components [Table 2].

Therefore, the cost of one dressing is about Rs 300 per dressings compared to the Rs 7500 for commercially available dressings of similar nature.

DISCUSSION

The aim of this study is to compartmentalize various components of NPWT and indigenously devise methods or equipment to make it affordable, efficient and safe to the patient.

The pump is a suction machine with an adjustable pressure guage capable of delivering 100-125 mm Hg negative pressure. A machine that works with a diaphragm is silent and does not disturb the patient.

The timer switch is a standalone device, which looks like an extension box [Figures 7 and 8]. The working voltage of the circuit is 12 volts, which does not pose an electric hazard to the patient. Only one component in this circuit generated heat (regulated IC7812) and this is taken care by using a heat sink.

The circuit diagram and components required are provided [Figure 6 and Table 3]. Separation of timer from the suction pump has the advantage of allowing the components to function independently of each other in case of break down. This circuit is sturdy and can function without breakdown for long periods. It has continuously worked up to 7-8 days without interruption, except to change dressing.

Dressing materials were procured from readily available source to bring further down cost of consumables. The PVA sponge was rendered medical grade by repeated washes with water until 50cc of the wash water upon vigorous shaking did not produce a foam that maintained itself longer than 10 seconds. This indicates that any inclusions in the sponge, which could leach out and have adverse effects, have been effectively removed.^[17] Sponge is then autoclaved before use.

The trackpad is a patented design of KCI (Kinetic Concepts Inc, San Antonio, Tx) and it provides uniform suction over the wound. A similar effect is attained by the perforated tube, which has a large area over which negative pressure is developed. It also traverses a longer distance in the sponge than the track pad.

A similar study was done in 2008 by Shalom *et al.*^[18] who devised a homemade vacuum assisted closure system. However draw backs of this system are continuous pressure from wall suction device and lack of intermittent sub atmospheric pressure. Hence the dressing can be applied

Table 1: Classification of wound type

Wound location	Type of wounds	Number of wounds	Average number of NPWT per wound	Average number of NPWT treatment days	Mean duration hospital stay
Upper limb	Open fractures	3	2.5	6	24
	Postoperative wounds	2	2.85	8	28
	Chronic wounds	0	0	0	0
Lower limb	Open fractures	21	2.53	6	26
	Postoperative wounds	17	2.85	8	30
	Chronic wounds	39	3.23	10	24
Spine	Postoperative wounds	8	3.4	10	26

NPWT: Negative pressure wound therapy

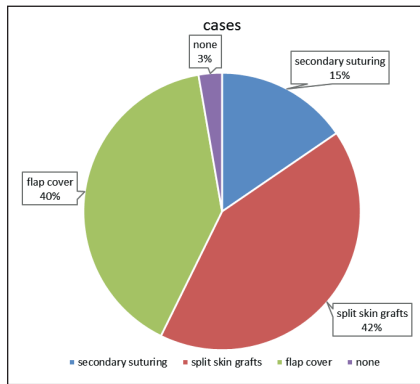


Chart 1: Definitive wound management



Figure 2: Open fracture grade IIIB, lateral condyle tibia fracture site exposed



Figure 3: 10 days after starting NPWT

Table 2: Cost of dressing

Component	Cost for single dressing
Suction tube from romovac (can be used for two dressings)	Rs. 85
Sponge (10 cm × 10 cm)	Rs. 20
Steridrape (medium)	Rs. 150-200

only in areas where wall suction is available. This method severely limits the mobility of the patient and blocks precious hospital beds since wall suction is available only in intensive care units and step down settings. Another major drawback of this method is a lack of the timer switch.



Figure 4: Follow-up 1-year, after split skin grafting

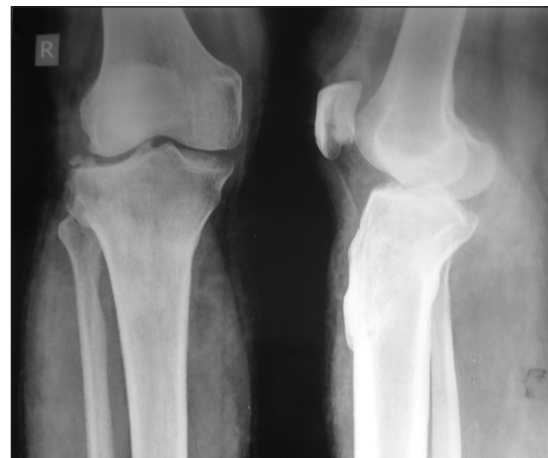


Figure 5: Follow-up 1-year showing fracture union

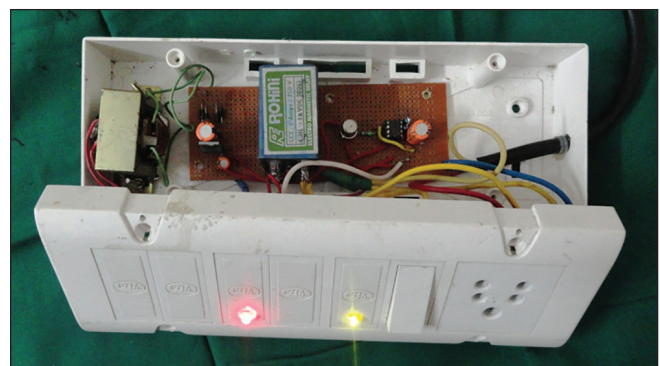


Figure 6: Open timer switch showing circuit

In our study clear steridrapes were used to seal the wound, whereas other authors made use of povidine iodine impregnated drapes. They claim that these drapes could achieve prolonged control of bacterial growth compared to conventional drapes.^[19]

There are certain limitations to this kind of studies, since an exact control group does not exist. There is an element



Figure 7: Timer switch at bedside

Table 3: Components for electronic timer switch

Component name and value	Quantity
On/Off switch 5 Amp	1
Step Down Transformer 12-0-12V 500 ma	1
D1, D2, D3, D4 Diode in 4007	5
Regulated IC 7812	1
Electrolitic Capacitor 35 V 470 MF	2
Transistor SL 100	1
Relay CC2 12 V 200 Ω 8 Pins	1
Timer IC 555	1
Ceramic Capacitor 104 PF/25 V	3
LED Red and Green	1+1
MFR Resistor 330 Ω 1/4 W	2
MFR Resistor 4.6K Ω	1
MFR Resistor 270K Ω	1
MFR Resistor 720K Ω	1
ElectroliticCapaciter 25 V/100 MF	1
AC Female 3 Pin Socket 5A	1
Plastic Box W 8.5 cm \times L 25 cm \times H 3.5 cm	1
AC Male 3 Pin Plug	1
3 Core Power Cable 2 mf	1

of subjectivity in deciding which wound required NPWT and those that could be treated with saline dressing. In open fractures variables such as fracture morphology, contamination and duration from time of injury to NPWT application have not been taken into account. Hence, most of our data has been compared with historically matched controls.

CONCLUSION

In conclusion, we would like to state that the sequential timer switch is the most important component of NPWT machine. We have separated the timer switch from the suction apparatus. This facilitates service in case of break downs where in the faulty component can be repaired without compromising dressing. The consumables used in the study are the most economical compared to all the other studies in the literature while giving comparable results. These innovations bring the equipment within reach of all surgeons (plastic, orthopedic and general surgeons) and consumables no longer a financial burden to the patient.

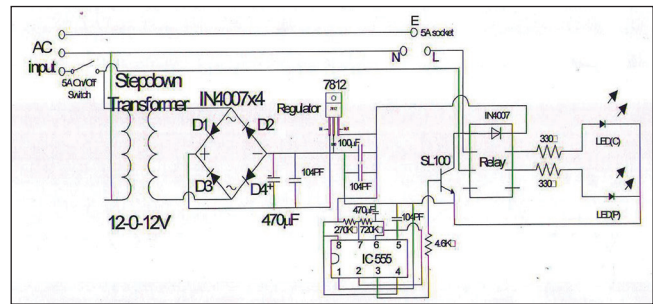


Figure 8: Circuit diagram

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