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Negative Pressure Wound Therapy: The Experience of Our Surgery Department

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Abstract

Introduction: The negative pressure wound therapy NPWT is a simple technique using negative pressure which aims to heal different types of wounds in different kinds of surgeries. The purpose of our study is to evaluate the results of this therapy on patients who have had delayed wound healing in cardiac, vascular or thoracic surgery.

Methods: It is a retrospective review, from 2009 to 2021, including 31 patients, hospitalized in the thoracic and cardiovascular surgery department of Abderrahman Mami hospital of Ariana - Tunisia. Data were collected on patient cardiovascular risk factors, primary diagnosis, intervention, site of the wound, duration of the therapy, number of NPWT dressing implemented, the inflammatory assessment, the microorganism found and the evolution after the NPWT.

Results: The mean age was 61 years with a maximum of 78-year-old-patient and minimum of 24 (Range 24 Year Old-78 Year Old)

There were 23 male and 8 female patients with the following risk factors and comorbidities:

Diabetes (70,59%), Smoking (47,06%), Hypertension (41,17%), Dyslipidemia (29,41%).

Five patients presented with mediastinitis after coronary by-pass and five others had an infected scarpa but the bypass was preserved. Ten (10) cases presented with critical limb ischemia and

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have had distal revascularization of the limb by bypass associated to trans metatarsal amputation.

Six patients presented with diabetic foot ulceration. Four of them had limb revascularization.

Four patients had a complex thoracic wound after lung biopsy for tuberculosis (1 case), lobectomy for purulent pleurisy (1 case); resection of a tumor in the chest wall (1 case), pneumonectomy for adenocarcinoma (1 case).

One patient had NPWT on lower limb aponeurotomy wound. The average duration of NPWT was 17 days with a maximum of 30 days and minimum of 5 days (range 5 days-30 days).

The frequency of the dressing change varies from 3 to 5 days with the use of one to six dressings per patient. Wound closure was obtained in 28 patients. Three patients had major amputation for poor vascular supply.

Conclusion: The application of NPWT in multiple surgeries have shown promising results.

It helps rapid wound healing and can reduce morbidity and mortality in patients with severe wound infections. It also lower surgical reinterventions and reduces hospital stay.

Keywords

Negative Pressure Wound Therapy; Cardiac Surgery; Thoracic Surgery; Vascular Wounds

Introduction

The negative pressure wound therapy NPWT is a simple technique using negative pressure which aims to heal different types of wounds in different kinds of surgeries.

The system is made of 4 components: A sponge, a semi-permeable dressing to isolate the wound environment and allow the vacuum system to transmit sub atmospheric pressures to the wound surface, a connecting tube and a vacuum system [1].

It consists of putting a sponge made of open-cell polyurethane ether into the wound. This sponge is linked to a tube which is connected to the vacuum pump. The pressure used varies from 50 to 160 mmhg [2].

This negative pressure helps to remove tissue oedema, improve circulation, stimulate the granulation of tissues and stops bacterial growth [3]. It has been widely used to help the healing of wounds and especially in infected tissues [4].

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Objectives

The purpose of our study is to evaluate the results of this therapy on patients who have had delayed wound healing in cardiac, vascular or thoracic surgery.

Materials and Methods

Our study is a retrospective review, from 2009 to 2021, including 31 patients, hospitalized in the thoracic and cardiovascular surgery department of Abderrahman Mami hospital Ariana - Tunisia.

The inclusion criteria were all patients who have had negative pressure wound therapy.

The exclusion criteria were the contraindications of using the vacuum which are [5]:

- Osteomyelitis not treated with antibiotics
- Presence of exposed vessels and organs
- Malignant wounds
- Presence of black, adherent necrotic tissue

Data were collected on patient cardiovascular risk factors, primary diagnosis, intervention, site of the wound, duration of the therapy, number of NPWT dressing implemented, the inflammatory assessment, the microorganism found and the evolution after the NPWT.

Patients were divided into two groups: Group 1: PRIMARY NPWT, means the wound therapy was used immediately after surgery. Group 2: SECONDARY NPWT, means NPWT was used after a delay in healing. The average time to healing depended on the type of surgery.

The software used to study our patient's population was SPSS version 24.0.

Descriptive Study

It is based on the calculation of simple frequencies and percentages for the qualitative variables, and on the calculation of means, medians, standard and range.

(Extreme values = minimum and maximum) for the quantitative variables.

Application of the NPWT

Before the application of the NPWT device, surgical debridement removed all devitalized necrotic tissues.

The sponge is putted into the wound. We pay attention to fit the sponge in a way that takes the shape of the wound. We put on an adhesive tape to prevent air entry, keeping this way a tight system.

This open-cell foam in which is embedded an evacuation tube, is connected to a container in the vacuum system.

We apply finally the continuous negative pressure. Usually, the pressure used is between 90 and 120 mmhg. The choice depends on the nature and extent of the wound.

The frequency of dressing change varies from 3 to 6 days depending on the condition of the wound.

Results

Our study included 31 patients from 2009 to 2021. The mean age was 61 years with a maximum of 78-year-old-patient and minimum of 24.

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There were 23 male and eight female patients with the following risk factors and comorbidities: Diabetes (70,59%), Smoking (47,06%), Hypertension (41,17%), Dyslipidemia (29,41%).

Five patients presented with mediastinitis after coronary by-pass;

Five others had an infected scarpa but the bypass was preserved;

10 cases presented with critical limb ischemia and have had distal revascularization of the limb by bypass associated to trans metatarsal amputation;

Six patients presented with diabetic foot ulceration. Four of them had limb revascularization.

Four patients had a complex thoracic wound after lung biopsy for tuberculosis (1 case); lobectomy for purulent pleurisy (1case); resection of a tumor in the chest wall (1 case); pneumonectomy for adenocarcinoma (1 case).

One patient had NPWT on lower limb aponeurotomy wound (Fig. 1).

A cytobacteriological examination was done on 27 patients. The micro-organisms found were *Staphylococcus aureus* in eight patients, *Staphylococcus epidermidis* in six cases, *Klebsiella pneumonia* in five patients, *Enterococcus faecalis* in four, *Proteus mirabilis* in three patients and *Pseudomonas aeruginosa* in one case.

All patients with positive wound culture had an antibiotic therapy in accordance with the antibiogram.

We tried to report the level of C-Reactive Protein (CRP) before and after NPWT. The maximum level of CRP at the initiation of NPWT was 400 mg/l and the minimum was 3,83 mg/l.

We have noticed that the level of CRP dropped after the first use of the therapy with a maximum of 90.

The average duration of NPWT was 17 days with a maximum of 30 days and minimum of 5 days. The frequency of the dressing change varies from 3 to 5 days with the use of one to six dressings per patient.

Wound closure was obtained in 28 patients. Three patients had major amputation for poor vascular supply (Table 1).

Figure 1: Patients who had NPWT.

Patients Number	31
Age (Median)	61
Female (Number)	8
Male (Number)	23
Risk Factors %	
• Diabetes	70.59
• Smoking	47.06
• Hypertension	41.17
• Dyslipidemia	29.41
CRP Levels	
• Maximum before NPWT	400 mg/l
• Maximum after NPWT	90 mg/l
Duration (Median)	17 days
Dressing Change Frequency	3-5 days

Table 1: Table summarizing the main results.

Discussion

The NPWT was first used in debilitated patients with large, infected, chronic wounds [6].

The aim of wound healing is to replace damaged tissue with new one and restore an intact epithelial barrier.

This process needs a good vascular supply, biochemical mediators, extracellular matrix molecules [7]. The importance of the vascular supply is that good circulation increases the tissue resistance to infection [8].

Factors that influence how quickly negative pressure therapy heals wounds are [9]:

- Removal of excessive edema fluid with increase in tissue blood flow. In fact, vacuum-assisted closure allows open drainage that continuously absorbs exudate [10]
- Associated decrease in the amount of bacteria
- Movement and growth of tissue surrounding the wound in response to the mechanical force of suction pressure
- Stimulation of angiogenesis by helping express angiogenic factors [11]

The utility of NPWT has been demonstrated in several surgeries. Through the study of our patients, we have tried to demonstrate the importance and contribution of the therapy in wound healing whether in cardiac, thoracic and vascular surgery.

For our series containing 31 patients, 32% of this study population had the diagnosis of critical ischemia of the limb and had a procedure of revascularization associated with trans metatarsal amputation. The use of VAC was straight away in 3 patients whose prognosis was poor given the highly infected local condition. For the 7 others, the recourse to NPWT was for delayed healing. We admitted that there was a delay in healing for a period of 10 days.

The average duration of NPWT in these patients was 16 days and the number of packs used varies from 3 to 4. The biological control of these infected patients showed a drop in CRP after the first use of the vacuum system. The control of the amputation stump condition noted improvement in limb condition with budding and infection control. Only three patients have an unfavorable evolution because of a poor vascular supply and a major amputation was performed. Two of these three patients were diabetic.

Five (5) patients from the 31 had an infected scarpa after vascular bypass. The NPWT therapy was used within an average of 12 days and after trying local treatments in association to antibiotherapy. The evolution was remarkable with excellent healing.

Some have studied the NPWT in amputations and proved that patients who underwent amputation and who had negative pressure wound therapy had less major amputation than patients with conventional dressing [12].

However, Mendonca et al., has reported that patients with severe peripheral vascular disease should be treated by other methods because of high failure rate [13]. Which was the case of three of our patients who underwent another amputation.

Same for Clare et al., who suggested to treat those with severe peripheral vascular disease with other modalities explaining it by the fact that the overall rate of wound healing is limited by the available vascular supply [10,14].

Another use of NPWT was in diabetic foot ulcers. We had 6 patients with this diagnosis, 4 of them had limb revascularization. The healing was good even in patients who did not have a vascular operation. They had an average use of 4 packs of vacuum system for an average total period of use of 20 days. Long-term follow-up did not show recourse to amputation in these patients. In fact, the fear of diabetic foot ulcers is the evolution towards amputation because it is known that diabetic foot ulcers leads in 12% of cases to amputation [15]. Studies have proven a reduction in amputation for patients with foot ulcers receiving VAC therapy [16].

We have also used negative pressure wound therapy in sternal wound infection in 5 patients. Indeed, deep sternal wound infection is the most feared complication after cardiac surgery. The mortality rate is twice as high in patients suffering from mediastinitis [17].

The management strategy involves surgical revision, closed irrigation, reconstruction. The use of the vac was made after having initiated the antibiotic therapy and after having tried local treatments. After 6 days, on average, of no improvement in the local condition, we used VAC therapy. The median VAC therapy time was 23 days with a maximum of 30 days. After 8 days of the initiation of the vacuum therapy, we noticed a decline in the CRP levels of more than 40%.

A recent study has shown that vacuum-assisted closure therapy is a reliable option in post sternotomy mediastinitis with excellent long-term survival and very low failure rate [18].

Studies has also proven superior efficiency of VAC compared to conventional therapies [19]. In addition, it decreases the reinfection rate [20].

In fact, freedom from mediastinal microbiological cultures was achieved earlier, C-reactive protein levels declined more rapidly, in-hospital stay was shorter [21].

Another use of the negative pressure treatment is in thoracic surgery.

The incidence of wound healing complications after thoracic surgery varies from 2 to 15% [22].

In our series, negative pressure wound therapy has been used on patients after pneumonectomy, lobectomy, lung biopsy and after removal of a chest mass.

For these patients, the use of negative pressure was in second intention after a delay of healing. For the pneumonectomy patient, it was used 15 days after surgery. For the lobectomy, after 12 days and for the lung biopsy/ removal of a chest mass, after 10 days. The process of Healing was accelerated by the NPWT and the patients left hospital after an average of 7 to 9 days of NPWT.

Groetzner et al., have used NPWT after lobectomy, pneumonectomy, empyema and pancoast resection. They found that it accelerates wound healing with good results and less stay in hospital [22].

The removal of this system in our work was for an average of 17 days after surgery. Other studies in literature found at mean a removal 64 days after surgery [22].

For Acosta et al., the median NPWT time was 20 days [21].

The dressing was changed every 3 to 6 days in our patients. In the results found by Giovani were a changing every 3 to 4 days with an average of 8 treatment sessions [22].

Concerning the bacterial pathogens found in our patients, it was *Staph aureus*, *Staph epidermidis*, *Pseudomonas*, *Proteus mirabilis*, *Enterococcus* and *Klebsiella pneumonia*.

Before the culture results, the patients have had a probabilistic antibiotic therapy which was replaced by antibiotic therapy adapted to the antibiogram thereafter. In a study conducted by Lo Torto, it was demonstrated that NPWT increase the antibiotic concentration in damaged and infected tissues [22].

For Holzer et al., it's *Staph aureus* (39%), methicillin-resistant *S. aureus* (23%), *Streptococcus* (7,7%). For Acosta et al., the micro-organisms found were *Pseudomonas aeruginosa* (33,33%), *Enterococcus Faecalis* (11%), *Enterococcus faecium* (11%), *Staphylococcus aureus* (11%) [21].

Conclusion

The NPWT has been widely used in wound therapies. It can be used in different surgical wounds and in unhealed ones. The application of NPWT in multiple surgeries have shown promising results. The mechanism of action of this negative pressure tends to: improve blood circulation, decrease bacterial formation, stimulate neoangiogenesis.

The remarkable effects of this therapy were the improvement of healing, the reduction of reoperations and in particular for some patients reduction of major amputations. Indeed, it helps rapid wound healing and can reduces morbidity and mortality in patients with severe wounds infections.

Another advantage for the patient and for the socio-economic cost is the reduction in the length of hospitalization stay. Admittedly NPWT is a very effective means in the treatment of wounds but other factors must be taken into consideration such as the balance of diabetes and a good nutritional status.

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