Negative Pressure Wound Therapy: An Algorithm

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KEYWORDS

• Complications • Clinical evidence • Negative pressure wound therapy • NPWT
• Subatmospheric pressure • Wound healing

KEY POINTS

- Evidence shows negative pressure wound therapy (NPWT) to be effective in reducing wound exudates and increasing granulation tissue formation.
- NPWT derives its beneficial effects on wound healing from multiple interactions with changes effected both on a microscopic as well as a macroscopic level.
- NPWT has specifically proved to be an effective modality for wound therapy in several areas, most notably diabetic foot ulcers, open fractures, mediastinal wounds, and skin grafts.
- The benefits of NPWT are based on principles relevant to wound care and healing in general; NPWT does not ameliorate deleterious effects of local infection, hypoxia, trauma, foreign bodies, or systemic problems such as diabetes, malnutrition, or immunodeficiency, which are most frequently responsible for wound healing delay and chronic wound formation.

INTRODUCTION

The concept of treating wounds with negative or subatmospheric pressure was first described by Fleishmann (**Tables 1–6**).[1] At that time, the wound treatment modality consisted of applying a negative pressure wound dressing consisting of a semiocclusive dressing and a suction device over an open fracture. Negative pressure wound therapy (NPWT) on open fractures resulted in improved granulation tissue formation. Fleishmann and colleagues[2–5] subsequent work described the usefulness in traumatic, acute, and chronic wounds.

Argenta and Morykwas[6] and Morykwas and colleagues[7] reported findings from animal as well as human clinical trials showing the usefulness of NPWT on 300 acute, subacute, and chronic wounds, including a 4-fold increase in blood flow levels when 125 mm Hg subatmospheric pressure was applied. A significantly increased rate of granulation tissue formation ($P \leq .05$) was reported with continuous (63.3% $\pm$ 26.1%) and intermittent (103% $\pm$ 35.3%) application of NPWT and tissue bacterial counts were also significantly decreased ($P \leq .05$) after 4 days of application.

Since that time, NPWT has overwhelmed the wound-healing world. The use of subatmospheric pressure on wounds has increased exponentially, as has the number of capable devices available. NPWT can be and has been applied to nearly every region of the body: scalp, face, trunk, and extremities. Certain types of wounds such as open sternal wounds and diabetic foot ulcers have occurred frequently enough for them to provide a large body of evidence. This evidence varies in quality

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Table 1
Descriptors of evidence levels

Evidence Level	Description
I	High-quality meta-analysis, systematic reviews of randomized controlled trials (RCTs), high-quality RCTs
II	High-quality systemic reviews of case control or cohort studies, high-quality case control or cohort studies
III	Nonanalytical studies (eg, case reports, case series, or in vivo or in vitro studies)
IV	Expert opinion

from observational case reports and series to randomized controlled trials (RCTs).

We have developed an algorithm after careful evaluation and analysis of the scientific literature supporting the use of these devices.

MECHANISM OF ACTION OF NEGATIVE PRESSURE WOUND HEALING

Since antiquity, wound dressings have been used to facilitate and accelerate wound healing. Two concepts that are critical to dressing selection are:

1. Occlusion
2. Absorption.

Wounds treated with occlusive dressings have been shown to re-epithelialize more quickly than wounds left exposed and allowed to dry.[8] Excessive exudates tend to macerate the skin around wound edges and also encourage bacterial overgrowth, resulting in impaired wound healing, hence the need for absorptive dressings.[9] NPWT fulfills both these basic tenets and provides additional benefits to the healing wound.

NPWT derives its beneficial effects on wound healing from multiple interactions, with changes effected both on a microscopic as well as a macroscopic level.

Table 2
Evidence-based recommendations for NPWT in venous ulcers

Author	Year	Evidence Level	Evidentiary Bullet
Vuerstaek et al[19]	2006	I	The use of NPWT reduced skin graft preparation time by 58% and also reduced time to overall complete healing by 35%
Korber et al[20]	2008	II	Skin graft take with NPWT 92% vs skin graft alone 67%

Tissue Strain

One theory suggests that the subatmospheric pressure induces microdeformations or strain on tissue of between 5% and 20%. This level of strain has been shown to promote cellular proliferation and division, elaboration of growth factors, and angiogenesis.[10] Tissue expansion to expand soft tissue and Ilizarovian distraction osteogenesis to lengthen bones use the same principles of strain.[11,12]

Inflammation Reduction

Second, inflammation generally leads to increased capillary permeability that causes an increase in interstitial fluid: edema. Edema inhibits wound healing by decreasing oxygen and nutrient transport across tissue. Edema also increases the distance between capillaries and healing cells, thereby increasing the likelihood of tissue necrosis. NPWT actively reduces the amount of edema fluid, proteolytic enzymes, acute phase proteins, metalloproteases, proinflammatory mediators and cytokines and increases the blood flow in tissue.[7]

Bacterial Load Reduction

Wounds are often further complicated by bacterial overgrowth and infection, leading to further tissue necrosis and cell death. Infection has also been shown to prolong the inflammatory phase of wound healing, thereby delaying wound repair. The effect of NPWT on infection has been shown by the ability to reduce bacterial load in a wound, decrease interstitial fluid, and improve local blood flow, the combined effect of which is an improvement in the rate at which wound healing occurs.

NPWT ALGORITHM

NPWT has become a mainstay of treatment of acute and chronic wounds. The evidence for use of NPWT is variable. Most clinicians have developed a personal algorithm for application of NPWT, and there have been attempts at creating a consensus statement or guidelines for use of NPWT.[13]