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Review article

Negative pressure wound therapy in orthopaedic surgery

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ABSTRACT

Negative pressure wound therapy (NPWT) consists in applying subatmospheric pressure to a wound that is sealed off by a specially designed dressing and connected by a tube to a suction pump and drainage collection system. Skin defects are extremely common in orthopaedic and trauma surgery. NPWT is valuable across a range of indications. Proven effects include an increase in blood flow, stimulation of angiogenesis, and a decrease in wound surface area. NPWT can be used to treat post-traumatic and surgical wounds, burns, and chronic wounds such as pressure sores and ulcers. The lower frequency of dressing changes with NPWT lightens the staff workload. The French high authority for health (HAS) has issued good practice guidelines for the use of NPWT in specific and limited indications. NPWT has benefited from the introduction of several technological improvements such as silicone interfaces, foam dressings with various densities and pore sizes, and irrigation systems. The result is greater adaptability to each specific situation. Nevertheless, NPWT is not appropriate in every case and cannot replace a necessary surgical procedure. The goal of this work is to review the principles, practical modalities, and indications of NPWT.

1. Introduction

Negative pressure wound therapy (NPWT), whose most widely used variant is Vacuum Assisted Closure® (VAC)®, was introduced in North America in 1997 by Argenta and Morykwas [1,2]. Subatmospheric pressure is applied to the surface of a wound that is sealed off by a film dressing and connected via a tube to a suction pump and drainage collection system. NPWT is gaining in popularity as a method that diminishes the number of dressing changes, can be applied readily at the bedside, and is generally believed to shorten the duration of wound care.

NPWT is an adjunctive healing method for selected surgical wounds at high risk for complications, acute wounds, and certain chronic wounds after failure of primary intention healing. The negative pressure is applied until granulation tissue develops or the local conditions allow an additional surgical procedure (e.g., skin graft or flap).

Nevertheless, NPWT is not a panacea. Thorough familiarity with the indications, modalities of use, and technological advances is essential. The French high authority for health (HAS) issued recommendations about NPWT in 2011 [3].

2. Definition and mechanisms of action of negative pressure wound therapy (NPWT)

2.1. Current opinion

NPWT accelerates granulation tissue formation via effects related to local subatmospheric pressure and fluid drainage.

2.2. Data from the literature

The principles of NPWT are relatively well established [4–10]:

- open-cell foam is applied to the wound surface so that it conforms to the shape of the wound, ensuring uniformity of the local pressure decrease;
- collapse of the foam cells under the effect of the negative pressure shrinks the wound surface area, thereby approximating the wound margins;
- the negative pressure combined with the open-cell structure results in a 3-fold increase in fibroblast migration and a 2.4-fold decrease in cell death compared to a conventional dressing;

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- connection to a central suction unit allows both continuous control of the negative pressure and collection of the drainage material.

NPWT has been proven to stimulate local angiogenesis, thereby increasing blood flow. The result is enhanced granulation tissue formation, which decreases the surface area of the wound [11]. In contrast, there is no firm evidence that NPWT diminishes the oedema or bacterial load in the wound [12].

NPWT can be used to treat acute and chronic wounds, with the following objectives:

- to drain the wound exudate;
- to enhance the development of high-quality granulation tissue, thus decreasing the severity and/or size of the wound, thereby accelerating controlled spontaneous wound healing or facilitating a surgical wound coverage procedure (skin graft or flap);
- to avoid retraction of the skin margins, particularly after surgical wound dehiscence;
- to provide a temporary dressing until additional surgery can be performed;
- given the sterile conditions of NPWT application, to diminish the bacterial contamination of a surgical site until surgery can be performed.

2.3. In sum

NPWT enhances granulation tissue formation over previously cleansed wounds, by stimulating local angiogenesis, thereby improving the local blood supply. This local increase in vascularity results in an influx of fibroblasts, which diminish the surface area of the wound by approximating its margins.

3. Technical modalities of negative pressure wound therapy (NPWT)

3.1. Current opinion

Most orthopaedic surgeons use a single type of foam and a constant level of negative pressure regardless of the type of wound.

3.2. Data from the literature

Several NPWT devices are commercially available in France. A collection canister is a consistent feature (Table 1). The kit may or may not contain an interface. Other differences involve the size and type of the foam dressing, whether the negative pressure settings can be modified, the cost, and other factors. Devices with no canister exist (e.g., PICO®, Smith and Nephew) but must be reserved for wounds with little or no exudate. No prospective clinical studies comparing various marketed devices have been published to date [3].

Table 1
Main devices for topical negative pressure wound therapy. Only devices with a canister are listed.

Device	Manufacturer	Included	Silicone interface included
Vac® Terapy	KCI Medical	Yes	No
Vista®	Smith & Nephew	No	Yes
Avance®	Mölnycke	No	Yes
Venturi®	TAlley Medical	No	No
Engenex®	Boehringer Wound System	No	No
Wound Assist®	HNE Medical	No	No
041 Wound®	Wound Atmos Medical France	No	No
Vivano®	HArtmann	No	Yes

3.2.1. Type of foam

Most manufacturers provide a single type of foam. Foams fall into three categories:

- VAC® GranuFoam® is the classical black foam with large open cells that stimulate granulation tissue formation;
- VAC® WhiteFoam® is white and has smaller cells that protect fragile tissues (painful superficial wounds, shallow undermining, and tunnels);
- VAC® GranuFoamSilver® is a grey foam bonded to silver, intended for use on infected wounds.

When applied to healthy skin, the foams cause irritation and skin breaks. Therefore, the healthy skin around the wound should be protected with strips of ultra-fine hydrocolloid dressing or, if allowed by the condition of the skin, strips of adhesive drape.

The foam should never be placed in direct contact with tissues such as bone, tendons, blood vessels, or vital organs, which must be separated from the foam by a non-greasy interface. Alternatively, WhiteFoam® can be used alone.

3.2.2. With or without an interface

An interface can be placed between the wound and the foam. A silicone interface is commonly used. Presence of the interface may result in less pain upon removal of the NPWT device. Furthermore, the interface protects the fragile tissues (blood vessels and nerves) exposed in the wound. It prevents foam from becoming embedded within the wound when left in place for prolonged periods. Another advantage is protection of fragile granulation tissue buds that might otherwise bleed when the device is removed. Thus, the use of an interface protects the tissue while allowing the device to function effectively. A single interface layer should be used, as two layers might obstruct each other's mesh spaces, thereby preventing the foam from acting on the budding granulation tissue.

3.2.3. Tips for preventing leaks

When an external fixator is used, the pins may make complete sealing of the wound difficult to achieve, and leaks may therefore occur in the suction system. The double-sided adhesive hydrogel strip (VAC® Gel®) can be applied to limit air leaks. Bone wax has also been used successfully [13].

3.2.4. Continuous versus intermittent suction

NPWT can be used with either continuous or intermittent suction.

Continuous suction may be more effective during the phase of wound detersion. When a complete seal is difficult to achieve, continuous suction limits the risk of leakage. When using NPWT to maintain a skin graft, continuous suction is mandatory as otherwise the graft would become detached at each return to atmospheric pressure.

Intermittent suction (for periods of 5 minutes separated by 2-minute intervals) may be associated with greater stimulation of granulation tissue formation [1]. Intermittent suction is particularly useful after the detersion phase (except in the event of pain or leaks).

3.2.5. Setting the suction pressure

The standard suction pressure is 125 mmHg. If the application of suction causes pain, a stepwise pressure increase in recommended. Lower suction pressure levels may be appropriate for bleeding wounds, when a pressure of 125 mmHg causes pain, or after skin grafting.

The suction pressure should be increased to 175 mmHg when using high-density foams such as WhiteFoam®.

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