Negative-Pressure Wound Therapy in Abdominal Surgery

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1 Introduction

Surgical site infection (SSI) is a common wound complication. It is defined as infection related to a surgical procedure that occurs at or near the incision site within 30 days after the procedure or in the subsequent 90 days in the case of material implantation during the surgery [1].

Different factors such as an increase in the mean age of the patients undergoing surgery, high rates of obesity, and immunosuppression secondary to oncological treatments have led to an increase in its incidence. SSI may lead to increased healthcare costs due to delayed recovery and prolonged hospital stay, repeat surgery, and need for increased wound follow-up.

Negative-pressure wound therapy (NPWT), also known as vacuum-assisted wound closure therapy, refers to wound dressing devices that apply continuous or intermittent subatmospheric pressure to the surface of the wound. The positive clinical effects of negative-pressure wound therapy (NPWT) on open and complicated wounds are well known. Recently, the application of this technique has been extended to the treatment of closed, clean wounds. A growing body of evidence has reported the positive effects of NPWT over closed wounds, particularly in patients with comorbidities which make them prone to develop surgical site infections.

2 Technique

2.1 Mechanism of Action

There are systemic and local factors that can contribute to a delay in the normal process of wound healing. Systemic factors (malnutrition, wound ischemia) should be identified and corrected as early as possible. Local factors include desiccation, tissue edema, excessive exudate, SSI, and poor tissue apposition (for example, in flap situations). NPWT will act on all these local factors, thus accelerating healing and reducing wound closure time.

2.2 Reduction of Tissue Edema

Interstitial fluid accumulation generates an extrinsic compression of the microvascular network decreasing the oxygen supply to the tissue and alters the venous and lymphatic drainage perpetuating the edema. Moreover, wound exudate is rich in matrix-degrading proteases and poor in epithelial growth factors.

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Thus NPWT contributes to wound healing by removing fluid and reducing the formation of hematomas and seromas and by improving the wound microenvironment by removing excess of proteases [2, 3].

2.3 Increase of Granulation Tissue

NPWT has been shown to increase the organization of collagen and the expression of vascular endothelial growth factor (VEGF) and fibroblast growth factor 8, thus promoting faster and more effective wound healing [4–6].

2.4 Holding Incision Edges Together

In deep open wounds, the sponge's open porous structure imparts the negative pressure homogeneously to the wound surface, reaching all its edges. The wound will deform to join its edges and to firmly adhere any skin flaps present. In closed wounds, NPWT maintains the cohesion of the incision edges, facilitates contraction of the epithelial edges, and helps reduce tensile forces [2, 3, 7–12].

2.5 Physical Barrier to Microorganisms

With NPWT, there is less need for dressing changes with respect to conventional techniques, with less possibility of colonization of the wound.

3 Devices Used in Negative-Pressure Therapy

3.1 Assisted Vacuum Locking System (Renasys®) and V.A.C. Unit®

These devices create a subatmospheric pressure at the wound site through the placement of a polyurethane sponge inside the edges of the wound which is covered tightly with a self-adhering plastic. A small incision is made in the plastic over the sponge and a suction tube is attached which is connected to an empty container (canister), which in turn is connected to an automatically controlled mechanical pump, which generates continuous or intermittent negative pressures up to −125 mmHg. Applying the suction creates an airtight seal that protects the wound, drains fluids through the pores of the sponge, and approximates the edges of the wound, accelerating the healing process. The size of the sponge is reduced slightly in each of the dressing changes, which must be performed every 3 days, such that the edges of the wound gradually approach one another. Transparent self-adhesive film allows monitoring of the status of the wound edges without removing the dressing.

3.2 PICO®/Prevena® System

These single-use pocket devices stand out for being disposable, portable, and of immediate application. The device consists of a sponge with a microperforated dressing covered with an adhesive sheet. A suction drain is connected to the sponge and a vacuum applied, with a small tank for collecting fluids. When the system is activated, a negative pressure of 80 mmHg (PICO® device) or 125 mmHg (Prevena® device) is applied to the wound, excessive fluid is extracted if present, and the incision is completely isolated from external contamination. The battery has a duration of 7 days. Light signals inform of its correct operation, or situations of leakage or low battery.

The microperforated dressing is composed of different layers: a silicon adhesive layer which is in direct contact with the wound, an air layer to homogenize the negative pressure, an absorption layer, and a surface layer of water-resistant polyurethane, which allows evaporation but avoids the entry of air with the consequent loss of vacuum. The exudate enters the air layer and is quickly transferred to the absorption layer, where it is stored forming a gel, which will progressively evaporate through the polyurethane layer to prevent the dressing from becoming heavy with the storage of liquid.

4 Discussion

4.1 NPWT Versus Conventional Systems

Conventional systems used in wound care consist of dressings that have to be changed up to three times daily, which is usually associated with pain with each dressing replacement. NPWT uses dressings that can be changed every 2–3 days and up to weekly. This, in addition to reducing episodes of pain, is associated with fewer manipulations and therefore less risk of SSI. NPWT significantly reduces wound-healing time improving patient quality life and decreasing inpatient stay.

On the other hand, the main complaint of NPWT patients is the discomfort of transporting the pressure pump. Moreover, NPWT devices are more expensive than traditional dressings. However, in recent years, several studies have reported NPWT to be cost effective when compared with traditional dressings due to the lower frequency of dressing changes, shorter duration of treatment, and no need for skilled wound care. Nevertheless, these studies should be interpreted with caution since they have small sample size or are based on the experience in a single center and lack of randomization.

4.2 NPWT for Management of Closed Incisions

NPWT has become an important tool in wound management. Since the first studies in pigs by Morykwas and Argenta in 1997, its widespread use has been implemented for the management of the open abdomen and for wounds associated with trauma or major complexity. In recent years, it has been proposed for the treatment of closed surgical wounds despite the fact that its effects in patients undergoing surgery with primary wound closure have been poorly investigated [13–15].

SSI is one of the main postoperative complications in abdominal surgery. It decreases the quality of life of the patient and implies a longer hospital stay and greater economic costs for the healthcare system. In developed countries the incidence is 5%, reaching 50% in high-risk patients. The prevention of SSI has been a focus of surgeons' efforts in recent years. Surgeons of different disciplines have incorporated the use of NPWT into the current standards of prevention of SSI (preoperative systemic antibiotic protocols, preoperative shower, surgical surface washing with antiseptic, and sterile surgical technique). In theory, NPWT promotes wound healing by reducing lateral tension on the wound edges, reducing seroma or hematoma formation and thus the risk of infection, and improving lymphatic drainage by decreasing tissue edema. Despite being shown to increase tissue perfusion in open abdominal wounds, an experimental study has shown that its effect on perfusion is minimal in incisional wounds.

Based on this theory, various studies have been conducted in different surgical disciplines to evaluate the benefits of this therapy related to wound infection [16–18]. Some of the first studies used existing NPWT devices designed for open wounds. Currently, small portable devices developed specifically for the treatment of closed incisions are marketed.

In clean surgeries such as cardiac or orthopedic surgery, NPWT has been shown to play an important role in the prevention of SSI. In these disciplines, asepsis marks the success of surgery, so proper wound management is essential to avoid contamination. Colli and Camara published a pilot study in ten patients in which a portable NWPT device was used over sternotomies with no reported complications of SSI [19]. Further trials such as those by Grauhan et al. demonstrated a lower incidence of SSI associated with NPWT use in median sternotomies in obese patients [20].

In the field of general surgery, regarding clean procedures, Olona et al. [21] pointed out a reduction of postoperative drain requirements to an average of 4 days and an absence of postoperative complications after large incisional hernia repairs managed with NPWT. NPWT has also been studied in colorectal surgery. Colorectal procedures are among the surgical interventions with the highest infection rates, especially if performed emergently, or when fecal spillage or manipulation of the bowel occurs. Chadi et al. [22] evaluated the incidence of SSI in perineal wounds (after abdominoperineal resection) in a retrospective study. They reported fewer SSIs of perineal wounds associated with NPWT. Bonds and colleagues retrospectively reviewed the risk factors for SSI in colorectal surgery and determined that NPWT significantly reduced SSI in their series [23]. They used a cut strip of V.A.C. GranuFoam Dressing (KCI) attached to a wound vacuum pump, set at 75 mmHg continuous suction, over open colectomy incisions. The use of this device significantly reduced SSI.

Stoma creation and closure, following the same principles, are also at high risk of infection and could therefore benefit from this type of therapy. Regarding ileostomy reversal, Cantero and colleagues observed a lower rate of SSI associated with NPWT in a pilot study [24].

4.3 Contraindications to NPWT

NPWT is contraindicated in the presence of malignant disease because it may stimulate the proliferation of malignant cell [25]. Nor should it be used in the presence of non-enteric or unexplored fistulae. NPWT should also be avoided in the presence of untreated osteomyelitis [26, 27]. Devitalized tissue in the wound bed impairs wound healing and increases the risk of infection and therefore contraindicates the use of NPWT. All necrotic tissue should be debrided prior to NPWT.

Special caution should be taken in cases of friable or exposed blood vessels since direct negative pressure may cause trauma and bleeding [28]. Negative pressure can cause avulsion of the skin at the margins of the wound in patients with fragile skin (due to use of corticosteroids, age, or disorders of collagen formation). Patients with high risk of bleeding (patients who have received anticoagulants or platelet aggregation inhibitors) should be monitored. If fresh red blood is detected in the tube, NPWT should be discontinued and bleeding control is mandatory.

Conclusions

NPWT reduces SSI. The current knowledge shows that there is no indication of systematic use of negative-pressure wound therapy to all abdominal surgery incisions because of its high costs in comparison with that of standard dressings. It is indicated to prevent SSI in high-risk patients.

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