INCISION MANAGEMENT WITH NEGATIVE PRESSURE WOUND THERAPY: A NEW MODE OF ACTION?

Negative pressure wound therapy (NPWT) has been traditionally associated with large, open chronic and acute wounds. As technology has progressed, these systems have become smaller, portable and more useful in other indications. The use of NPWT in closed incisions has been pioneered in orthopaedic wounds, however, more recently, incisional NPWT has been used in Caesarean (C)-section patients to help reduce the risk of surgical site infection (SSI) in individuals with a high body mass index. This article discusses the possible modes of action of NPWT for incisional wounds, and the impact of using such a device in an NHS Trust to help reduce the risk of SSI in C-section patients.

"Early clinical studies have shown that NPWT has a positive effect on the wound due to the unique modes of action of the therapy."

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Negative pressure wound therapy (NPWT) is the treatment of wounds using a device that applies subatmospheric pressure to a wound to help the healing process (Malmsjö et al, 2012). Traditionally, negative pressure was used for the treatment of open wounds. However, there is growing evidence of use to treat surgical incisions to help reduce wound complications, such as surgical site infections (SSIs).

Traditional negative pressure techniques involve using a foam or gauze filler material, sealed with a drape, and then applying suction via a drain or a soft port connector. This is then connected to a suction device that removes fluid from the wound and directs it into a canister. This makes NPWT the ideal therapy for the management of large, heavily exuding wounds. Smaller, more portable devices are now employed for use on surgical incisions.

Early clinical studies have shown that NPWT has a positive effect on the wound due to the unique modes of action of the therapy. Clinically, negative pressure has been primarily used in the management of open wounds, such as pressure ulcers, dehisced wounds and diabetic foot ulcers (European Wound Management Association [EWMA], 2007). More recently, NPWT has been used to assist in the management of the open abdomen and in the management of wounds where fistulae have become a problematic complication of open abdominal techniques.

Fleischmann et al (1993) studied negative pressure in a group of orthopaedic trauma patients with open fractures using foam as the wound filler. The author recorded efficient cleansing of the wound, lack of bone infection and overall improved healing. The case studies highlighted in this article used wall suction or surgical vacuum bottles to achieve negative pressure. Despite the small patient numbers involved (*n*=15), this study highlighted the usefulness of NPWT in wound healing.

The work of Morykwas et al (1997) set out to understand the modes of action of negative pressure by conducting animal studies. They were initially carried out to determine the potential benefits of the therapy and were quickly followed up with human studies (Morykwas et al, 1997)

The growth in the range of devices coincided with the introduction of gauze as a wound filler. Traditionally, reticulated polyurethane foam was used as the filler material (Morykwas et al, 1997); however, gauze had been used as the filler in other NPWT systems in studies as early as 1989 (Chariker et al, 1989).

The increase in the number of devices and the introduction of gauze appeared to help reduce the financial cost of using NPWT, perhaps as a direct result of competition within the marketplace. The increase in availability and affordability of NPWT has possibly led to a greater number of patients being treated.

With the increase in development of smaller, more portable systems, there has been an expansion of the types of wounds that can be treated, in particular, high-risk surgical wounds (Stannard et al, 2012)

Negative pressure wound therapy: what are the modes of action?

Increase in local blood flow

Morykwas et al (1997) discovered an increase in local blood flow in wounds created on pigs. This study, carried out using laser Doppler flow sensors, detected a fourfold increase in blood flow in the wounds where negative pressure was applied. The greatest increase in blood flow was noted to be at -125 mmHg. Pressures above -400 mmHg were noted to have an inhibitory effect on blood flow. Malmsjö and Ingemansson (2011) studied blood flow in pigs using both foam and gauze, demonstrating a similar increase in blood flow around the wound margins, with no significant difference in results between gauze and foam.

Increased rate of granulation tissue

Morykwas et al (1997) also examined the rate of granulation tissue formation within the wounds and found a significant increase compared with the control wounds that were treated with saline-soaked gauze. Differences were also noted in the rate of granulation tissue formation when using intermittent negative pressure, compared with using continuous therapy. Increased rates of granulation were noted when intermittent NPWT was used; this is believed to be due to the inactivation of tissue auto-regulation and allowing tissues to rest between cycles, therefore producing key components needed for tissue growth (Malmsjö et al, 2012).

Microdeformation

Morykwas et al (1997) found that application of continuous suction to wounds in pigs resulted in a 60% increase in granulation tissue compared with controls, with 100% difference compared with controls when using intermittent suction. Intermittent therapy is often associated with increased pain and discomfort for the patient and is not as commonly used as continuous suction; however, using variable pressure therapy creates a smooth transition between two levels of negative pressure, which relieves the pain associated with intermittent therapy, while retaining the accelerated healing effects (Malmsjö et al, 2012).

Saxena et al (2004) studied the effect of negative pressure using computer modelling and histological samples of tissue that had been treated with NPWT. The microscopic examination revealed that the strain created by the negative pressure led to cell stretching and division in the treated tissue. This reaction to strain on the tissues leads to what is known as microdeformation, which is witnessed in the wound when the dressing or filler has been removed. This cell stretching is, in part, responsible for the increase in cellular proliferation and angiogenesis that occurs when using NPWT (Malmsjö et al, 2012).

Reduction in bacterial burden

The early work of Morykwas (1997) identified a reduction in the bacterial load of wounds that had undergone NPWT from 105 to 103 colony-forming units per gram of tissue. This would be an additional benefit of NPWT to patients. However, there is debate within the literature as to the reproducibility of these results in human subjects.

Further studies in both human and animal models have failed to show this reduction in bioburden. Despite this, most studies reporting no change or an increase in bioburden do highlight the positive effect of negative pressure on wound healing, even in the presence of significant bacterial load. It could, therefore, be concluded that wounds with bacteria present will continue to heal under negative pressure, but this is not due in any way to a reduction in the bacterial load caused by the therapy (Mouës et al, 2004).

What are the differences between the interfaces?

As the knowledge base in negative pressure grows, studies are revealing important differences in the clinical outcomes related to the different types of negative pressure fillers available. It is essential for clinicians to bear in mind that individual patients will differ immensely and that having a choice of NPWT filler and/or drains available will let the clinician make a more informed choice based on accurate patient and wound assessment.

The most commonly used NPWT filler material is reticulated polyurethane foam, referred to as

Figure 1. ***PICO® device*** **in situ.**

black foam, for instance GranuFoam™ (KCI). This foam was used in much of the research that has been carried out into the effectiveness of NPWT, including the microdeformation study by Saxena et al (2004). Foam is often associated with fast formation of granulation tissue due to the cell stretching that occurs when it is used. In some cases, tissue can grow into the foam dressing, which is sometimes associated with increased pain for the patient (Fraccalvieri et al, 2011).

Fraccalvieri et al (2011) studied the impact of negative pressure filler choice on patients' pain levels and concluded that gauze-based negative pressure results in decreased pain levels compared with the use of foam dressings, because of the heightened adhesive properties of the foam interface and the potential for tissue in-growth. In addition, gauze-based wound fillers are easier to apply due the lack of need to cut the gauze.

For deep wounds with undermining and uneven wound beds, it may be simpler and more beneficial to use gauze-based NPWT (Jeffery, 2009). Gauze can also be used with silicone drains, which can help to target negative pressure into deep wounds to improve removal of exudate and wound debris.

Fraccalvieri et al (2011) studied a group of patients using gauze- and foam-based fillers to prepare the wound bed for skin grafting and found that patients who had gauze-based therapy had thinner scarring than those patients having foam-based therapy. This finding may have implications for patients receiving skin grafting over mobile areas, such as joints.

Management of surgical incisions

NPWT is most commonly used on open wounds, such as dehiscences, pressure ulcers and diabetic foot ulcers. A relatively new indication for the use of negative pressure is for the treatment of surgical incisions. Studies in orthopaedic trauma, cardiothoracic, Caesarean (C-)section, hip and knee revision patients have demonstrated reduced wound complications in high-risk patients when using NPWT to manage the incisions.

Studies by Stannard et al (2006) and Atkins et al (2009) highlighted benefits of the therapy in relation to wound closure. Stannard et al (2012) suggested that the exact modes of action of NPWT for the management of incisions are not yet known, and proposed that NPWT can help to remove some of the fluid and debris that builds up in the wound. Grauhan et al (2013) hypothesised that people with high BMI scores who are undergoing cardiac surgery experience infections due to the tension on the sutures, allowing some skin flora to travel into the wound, and that NPWT has the potential to keep bacteria on the skin from entering the wound.

PICO®

PICO® (Smith & Nephew) is a small, lightweight, ultra-portable, negative pressure system that consists of a dressing, supplied with a small negative pressure pump powered by two AA batteries. The pump is disposable after 7 days. The PICO system produces negative pressure at -80 mmHg continuously, and therapy can be started or paused using the single orange button (*Figure 1*).

This system is designed to be used for high-risk incision patients and wounds that do not have the high levels of exudate that require the larger NPWT systems. The exudate is managed through a breathable film within the dressing and, therefore, negates the need for a canister (Malmsjö et al, 2014).

The portability of the system makes it an ideal dressing for patients who are being discharged to the community. PICO can also be used with a filler material, such as gauze or foam, to treat patients with slightly deeper wounds. The pump connects to the dressing via a port that is anchored on the dressing.

Reducing wound complications in Caesarean section patients

In 2013, the Health Protection Agency carried out a study to assess rates of wound infection in patients after C-section. The overall infection rate was 9.6%, which was more than would be expected for clean surgery (Wloch et al, 2013). The rates of infection for patients with a high BMI (>30) was 19.2%. In Wigan, Wrightington and Leigh NHS Trust, the clinicians witnessed a trend of patient readmissions with wound infection and dehiscence related to high BMI following C-section.

Approximately three patients were readmitted per month. A programme of wound care education and a change in wound dressing practice was implemented. All patients with BMI >35 were treated with PICO negative pressure therapy dressings for 1 week after they underwent C-section. Fifty patients fitted the criteria for PICO and, during this evaluation, there were zero wound infections. The overall wound infection rate for the trust dropped by half, to 6%. PICO is now standard treatment for all patients with a BMI of >35 who have undergone C-section (Bullough et al, 2014).

Conclusion

NPWT has proven to be a beneficial therapy when managing and treating patients with both acute and chronic wounds. The unique modes of action of this therapy provide an ideal wound healing environment and can help stimulate static wounds. The use of NPWT purely in open wounds has now been significantly challenged, and the advances in incision management in recent years would suggest this therapy has a major role to play in reducing SSIs, which will be of huge benefit to patients and could potentially generate significant cost savings for the National Health Service, through reducing length of hospital stays and preventing readmissions. WE

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