Introducing a new portable negative pressure wound therapy (NPWT) system

This article looks at the changes to negative pressure wound therapy (NPWT) since its introduction from larger units that were used mainly in wound care clinics with inpatients to the more recent, portable units that can be used in patients' homes. It briefly explores the evidence base for NPWT, and the ways in which it works. Despite the benefits of NPWT, there is still limited use in the community setting which, may relate to patients having difficulty in dealing with systems. A new small ultra-lightweight model for NPWT — PICO® (Smith & Nephew) — has been designed, which is suited for use in the community and also for skin grafts and closed surgical incisions.

KEY WORDS

Negative pressure wound therapy (NPWT)
PICO
Closed surgical wounds
Exudate

The development of negative pressure wound therapy (NPWT) has in many ways revolutionised wound management. Many of the benefits of negative pressure relate not simply to actual wound healing, but to wound management and the overall care of the patient.

When NPWT systems were first developed, they were cumbersome, sometimes noisy and often not ideal for use in the community setting. As technology advanced, smaller systems were developed, which increased the use of systems in the community and allowed patients to be more mobile.

The growth in the number of devices coincided with the introduction of gauze as a wound filler. Traditionally, reticulated polyurethane foam was used as the filler material (Argenta 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 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.

The increase in use of smaller more portable NPWT devices has also allowed more patients to be transferred to the community with NPWT in situ (Dowsett et al, 2011). With increasing numbers of patients receiving NPWT in the community, there is the potential to free up bed space in the acute sector. It has been suggested that NPWT is not as commonly used in the community as it is in the acute sector, and Ousey and Milne (2009) describe some of the barriers to use in the community including lack of expertise, failure to attain funding, lack of communication between acute and primary care sectors and the lack of available training for both staff and patients.

NPWT allows for excellent exudate management, and helps wound contraction and development of granulation tissue (Argenta and Morykwas, 1997). The decision to use negative pressure is often based on the dimensions of the wound. Larger wounds can be managed due to the flexibility of the system, and it is also suitable for use on undermining wounds.

WHAT IS NPWT AND WHAT IS ITS IMPACT ON WOUND CARE?

NPWT is described by Argenta and Morykwas (1997) as 'a technique for managing an open wound by exposing the wound to either continuous or intermittant sub-atmospheric pressure'. Argenta and

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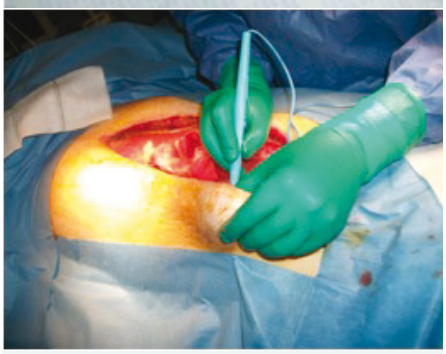

Figure 2: Case report. The patient's wound following use of the abdominal dressing.

Figure 3: Preparing the wound for primary closure.

Morykwas (1997) describe negative pressure as the transfer of gas molecules away from a wound using a suction pump. Ubbink et al (2008), in a Cochrane review of topical negative pressure, define the concept as the application of negative pressure across a wound to aid healing.

Although negative pressure has been applied to the body throughout history using techniques such as cupping, literature relating to current techniques began to appear in 1989. Chariker and Jeter (1989) trialled the use of suction with drains and gauze in a group of surgical patients with enterocutaneous fistulae and abdominal ventral hernias. Their experience highlighted improved healing, fast formation of granulation tissue and improved wound contraction.

Fleischman et al (1993) studied negative pressure in a group of orthopaedic trauma patients with open fractures using foam as the wound filler. The authors recorded efficient cleansing of the wound, lack of bone infection and overall improved healing. The study 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.

Argenta and Morykwas (1997) studied the use of negative pressure on porcine models. They discovered the key ways in which negative pressure affects wound healing, which have provided the five main recognised modes of action of today's NPWT devices. These modes of action were described as:

- Removal of wound exudate
- Promotion of perfusion surrounding the wound
- Promotion of granulation tissue
- Mechanical stimulation of cells
- Reduction in the bioburden.

Today's NPWT equipment generally consist of a device that creates subatmospheric pressure within the wound, a filler material, drapes to create a seal and a canister to hold the exudate.

CREATING A PRESSURE GRADIENT FOR REMOVAL OF WOUND EXUDATE

One of the key modes of action of NPWT is the removal of excess wound exudate and local tissue oedema, which is a direct result of suction on the wound. Wound exudate, particularly in chronic wounds, can contain proteases and inflammatory mediators, which can have a negative impact on the wound-healing process. By removing the excess fluid and reducing the tissue oedema, the wound is more likely to heal in a timely fashion (Molnar, 2004).

IMPROVING PERFUSION IN THE PERIWOUND AREA

The work of Argenta et al (1997) concluded that local blood flow in wounds treated

Figure 1. The PICO single-use NPWT system.

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KEY POINTS

- Negative pressure wound therapy (NPWT) has undoubted benefits for patients and can improve the quality and cost-effectiveness of care for patients.
- Standard negative pressure systems may not be ideal for all patients, particularly in community settings, due to the size of the systems and potential issues of concordance.
- The introduction of a small, portable and lightweight system could help more patients in the community to have the benefits of negative pressure therapy without the need to use a large system.
- PICO is designed for less acute wounds that clinicians feel would benefit from NPWT.

with negative pressure was higher than that in controls. This principle has been studied further by Malmsjo et al (2009), who used laser Doppler flow assessment while NPWT was being applied to identify an area of hypoperfusion in the wound bed and areas of hyperperfusion in the tissue surrounding the wound to a distance of 2.5cm. This decrease in perfusion in the wound bed is due to the pressure of the filler material on the local tissue. This creates oxygen tension in the wound bed, which is known to stimulate wound healing and, more specifically, angiogenesis (Malmsjo et al, 2009).

PROMOTION OF GRANULATION TISSUE

The formation of new capillaries within the wound is a key step in allowing the host to fill in the defect or wound. In promoting granulation tissue and angiogenesis, the key cells and collagen required to form new capillary beds are laid down in the wound. This process has been shown to be more rapid under NPWT than in wounds not treated with NPWT (Saxena et al, 2004).

The development of granulation tissue is a key benefit of NPWT. A recent study using porcine models has indicated that the morphology of the granulation tissue formed under negative pressure varies according to the type of wound filler used (Malmsjo and Ingemansson, 2011). This study demonstrated that granulation tissue in wounds treated with foam was thicker but more fragile, whereas gauze created thinner granulation tissue that was denser and more stable (Malmsjo and Ingemansson, 2011). This finding supports anecdotal evidence from clinicians.

MECHANICAL STRETCHING OF CELLS AND WOUND CONTRACTION

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 with controls when using intermittent suction.

When placed under stress, bone is likely to grow stronger and this principle also applies to soft tissue (Milgrom et al, 2000). Tissue placed under negative pressure has been shown to respond by promoting cell stretching and increased cell mitosis (Chen et al, 1999). Saxena et al (2004) demonstrated the impact of negative pressure on tissue in relation to tissue stretch and concluded that this micro-deformation was more prolific when the tissue came into contact with the wound filler. The clinical presentation of this increased tissue growth is normally visible in the rapid production of granulation tissue and wound contraction.

REDUCTION IN BACTERIAL BURDEN

The early work of Argenta and Morykwas (1997) identified a reduction in the bacterial load of the wounds that had undergone NPWT from 105 to 103 colony-forming units (CFUs) 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 (Boone et al, 2010). Despite this, most studies reporting no change or an increase in bioburden do report on the positive effect of negative pressure on wound healing, despite the presence of significant bacterial load. It could, therefore, be concluded that wounds with bacteria present will continue to heal under negative pressure, but that this is not due in any way to a reduction in the bacterial load caused by the therapy (Boone et al, 2010).

BENEFITS OF NPWT

The benefits of negative pressure for patients include excellent symptom management, reducing the frequency of dressing changes and improvement of the wound status. It is also important to recognise that NPWT can provide a cost-effective alternative to traditional wound therapies due to faster healing times, reduced frequency of dressing changes leading to a reduction in overall treatment costs (Searle and Milne, 2010).

Another benefit is that NPWT provides a sealed dressing, where exudate is contained and removed to a canister,

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reducing the risk of contamination to both the patient and environment.

A NEW NPWT SYSTEM

Until recently, most NPWT systems have consisted of a pump, canister and dressing. The systems are no longer as large as they once were, and many are more lightweight, allowing patients greater freedom and mobility (*Figure 1*). It is important to note that in elderly patients even a small traditional NPWT system can have an impact on their mobility, particularly if they have a Zimmer frame. However, such systems may not be ideal for patients who are confused and/or at risk of tripping over cables, etc.

PICO® (Smith & Nephew) is a small, lightweight ultra-portable, negative pressure system, which consists of a dressing supplied with a small negative pressure pump powered by two AA batteries. The pump produces negative pressure at -80mmHg continuously, and therapy can be started or paused using the single orange button (*Figure 1*). The PICO system is designed to be used for less acute wounds, which do not have the large volumes of exudate which require the larger NPWT systems. 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 which is anchored on the dressing.

The dressing consists of a silicone wound contact layer, a patented airlock layer, a super-absorbent layer and a high moisture vapour transmission rate (MVTR) foam. The airlock layer allows negative pressure to be distributed evenly across the dressing, the superabsorbant layer absorbs exudate, and the transparent film allows moisture vapour to transfer from the back of the dressing. This allows a PICO system to manage up to 300ml of exudate over a week.

Early pre-clinical testing demonstrated the ability of the dressing to transmit negative pressure to the wound bed using both gauze and foam as fillers. It is ideal for use in the community and could also broaden the scope of negative pressure use in acute care.

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INDICATIONS FOR PICO

Clinical indications for PICO include:

- Moderate to highly exuding wounds
- Pressure ulcers
- Leg ulcers
- Surgical wounds
- Fasciotomy wounds
- Cavity wounds
- Skin grafts.

In addition to the wound types normally associated with standard NPWT, such as leg ulcers, cavity wounds and pressure ulcers, PICO is an ideal product for the treatment of closed surgical wounds. Stannard et al (2005) and Atkins et al (2009) studied the role of negative pressure wound therapy in high-risk incisions. The idea of incision management in high-risk patients has proven extremely beneficial in patient groups where surgical dehiscence and infection are problematic (Atkin, 2009). PICO is designed to help prevent build-up of haematoma within the wound, to reduce oedema and help to reduce tension in the wound by helping to maintain apposition of the wound edges.

IMPROVING THE UPTAKE OF NEGATIVE PRESSURE WOUND THERAPY IN THE COMMUNITY

The use of negative pressure in the community has been limited, given pressures to reduce the cost of wound care and the time constraints placed on community nursing staff (Ousey and Milne, 2009). There are a number of

Figure 4: Primary closure of the wound.

Figure 5: The uneven nature of the wound following primary closure.

Figure 6: PICO dressing in situ.

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Figure 7: Following one week of PICO therapy, wound edges were apposed and there were no signs of infection.

perceived barriers to the use of negative pressure in community settings relating to the size of the system, patient concordance, training issues and possible supply issues. The introduction of a more portable, easy-to-apply and easy-to-operate negative pressure system may help to alleviate some of these issues, such as training and patient concordance, with patients much more able to mobilise and return to a normal lifestyle while using the system.

The application of the product is simpler than traditional negative pressure therapy and requires less training to use. PICO is less expensive than traditional negative pressure dressings, which should help improve cost-effectiveness, in addition to reducing the frequency of dressing changes.

Each system contains one pump and two dressings to provide a week's worth of therapy. The pump is completely disposable and the batteries will be disposed of separately. The materials for a week of traditional NPWT would cost approximately £146.10 — this does not include nursing time. This is also based on a long-term system rental model with one specific company (therefore, this price could be higher depending on the supplier) (Searle and Milne, 2010). PICO, on the other hand, would cost £120 per dressing pack.

CASE STUDY

This case featured a 40-year-old male patient with a clinical history of diabetes, acute pancreatitis, peritoneal sepsis and an ischiorectal abscess. The abscess was drained in theatre and a section of necrotising fasciitis in the anterior abdominal wall, which was uncovered during surgery, was excised.

Temporary abdominal closure was achieved using an abdominal dressing (Renasys-F/AB; Smith & Nephew) and the Renasys® EZ Plus NPWT pump (Smith & Nephew) (*Figure 2*). Temporary abdominal closure is a recognised technique for use in patients where there is a risk of developing abdominal compartment syndrome. This patient was at particular risk due to sepsis, peritonitis and infection in the abdominal cavity (Cheatham et al, 2010). However, the patient developed a ruptured diverticulum and required further surgery. A Hartmann's procedure was performed, following which a further period of NPWT — using the equipment mentioned above — was used to manage the open abdomen.

Following this further treatment with the negative pressure dressing, the wound was treated with gauze-based NPWT until it was ready for primary closure. Given the potential risks of wound breakdown, due to the patient's condition and clinical history, PICO was applied to help reduce the risk of wound breakdown in the postoperative phase.

In theatre the surgeon prepared the wound for closure and the wound was sutured (*Figures 3 and 4*). At closure the wound was fairly uneven and the suture line was poor from a cosmetic point of view (*Figure 5*). PICO was applied at this point (*Figure 6*), with a small area of the wound covered by a Hydrofiber and hydrocolloid dressing while an adequate-sized dressing was ordered that could cover the whole wound.

RESULTS

Figure 7 shows the wound following removal of the PICO product after one week of therapy. The wound had healed and the suture line had improved cosmetically. More importantly, the wound edges were apposed and there was no sign of infection.

CONCLUSION

Negative pressure wound therapy has undoubted benefits for patients and can improve the quality and cost-effectiveness of care (Searle and Milne, 2010). Standard negative pressure systems may not be ideal for all patients, particularly in community settings, due to the size of the systems and potential issues of concordance.

The introduction of a small, portable and lightweight system could help more patients in the community to have the benefits of negative pressure therapy, without the need to use a large system which may inhibit mobility and day-to-day activity.

The use of NPWT should always be based on good wound assessment being carried out prior to any decision about care or therapy. Many wounds will require negative pressure to help manage the wound due to the wound dimensions and the levels of exudate. PICO is designed for less acute wounds, which the clinician feels would benefit from NPWT. WUK

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