Introduction
Negative pressure wound therapy (NPWT) offers clinicians an important option for the advanced management of many wound types\(^1\). Over the past 15 years NPWT has revolutionised care for many patients with chronic and acute wounds and has prompted the development of new NPWT systems, including portable, single-use and wound-specific devices. This requires a clear understanding of the characteristics of the various NPWT systems and applications. The V.A.C.Ulta™ Therapy System (KCI) is a new device that combines V.A.C.® Therapy (KCI) with the added option of the controlled delivery of topical instillation solutions to the wound bed using V.A.C. VeraFlo™ Therapy (KCI).

Authors: Rycerz A, Vowden K, Warner V, Jørgensen B. Full author details can be found on page 5.

What is the V.A.C.Ulta™ NPWT System?
The V.A.C.Ulta™ System is an integrated negative pressure wound therapy (NPWT) system that offers standard NPWT (V.A.C.® Therapy) and an instillation option using V.A.C. VeraFlo™ Therapy (Figure 1). This combination system allows instillation solutions to be delivered to the wound bed to help manage complex, difficult-to-heal wounds, before converting to standard NPWT for further wound therapy. The V.A.C.Ulta™ System eliminates the need for a separate NPWT unit and manual application of a topical instillation solution between NPWT cycles.

How does the V.A.C.Ulta™ System deliver controlled wound instillation?
The V.A.C.Ulta™ System incorporates V.A.C. VeraFlo™ Therapy. This new technology combines V.A.C.® Therapy with the automated, controlled delivery and removal of topical wound instillation solutions at the wound bed (Figure 2).

This includes the following functions:
- **The Fill Assist Tool** — this allows the clinician to visually assess the correct instillation volume. Once set, the same amount of solution will be delivered for each subsequent instillation phase
- **The Test Cycle Tool** — this runs an abbreviated instillation cycle to ensure that the system is set up and functioning as intended
- **The Dressing Soak Tool** — this allows the clinician to soak the dressing with instillation solution, making dressing removal easier and increasing patient comfort.

V.A.C. VeraFlo™ Therapy uses specially engineered dressings — the V.A.C. VeraFlo™ Dressing and the V.A.C. VeraFlo Cleanse™ Dressing — which have an open-pore structure that is similar to V.A.C.® GranuFoam™ Dressings. These dressings help to promote wound healing and have reduced hydrophobic properties. They also provide greater mechanical strength for use during instillation therapy, helping to prevent tearing at dressing changes.

The V.A.C. VeraFlo Cleanse™ Dressing is composed of denser material than the V.A.C. VeraFlo™ Dressing and is typically chosen when wound cleansing is the primary goal of therapy. Both dressings enhance fluid delivery and removal when used in combination with the V.A.C.Ulta™ System\(^2\).

How does the V.A.C.Ulta™ System deliver NPWT?
V.A.C.® Therapy is an established method of NPWT and has been used in the treatment of a variety of wounds since mid 1990s\(^1\). The NPWT delivered by the V.A.C.Ulta™ Therapy System is the same as that provided by all other KCI V.A.C.® Therapy Systems and offers two therapy modes, both of which are monitored by SensaTRAC.™ technology:
- **A traditional continuous mode**, which delivers negative pressure to the wound bed in the range of -25mmHg to -200mmHg
- **Dynamic Pressure Control™ (DPC)**, which evolved from intermittent therapy and provides cycles of negative pressure to the wound bed. This maintains a low level of negative pressure (-25mmHg) between cycles to minimise the risk of leaks and fluid accumulation at the wound site. DPC may also help minimise patient discomfort from foam expansion that can occur when the negative pressure at the wound bed returns to 0mmHg.

---

**Figure 1** The V.A.C.Ulta™ Therapy System

**What does the V.A.C.Ulta™ Therapy System offer?**
The V.A.C.Ulta™ Therapy System is a new device that combines V.A.C.® Therapy and V.A.C. VeraFlo™ Therapy. V.A.C.® Therapy is an established method of NPWT, while V.A.C. VeraFlo™ Therapy allows for the automated, controlled delivery and removal of topical wound instillation solutions at the wound bed. The V.A.C.Ulta™ Therapy System allows for the use of NPWT with or without the addition of instillation fluid.
When is wound irrigation indicated?

It is now recognised that wound bed preparation plays a key role in creating an optimal wound healing environment. Regular cleansing of the wound can help to address the barriers to healing by removing devitalised tissue, debris, infectious agents and exudate to help prepare the wound bed for closure.

Wound irrigation is a long-standing practice that has been widely accepted for removal of these barriers to wound healing. Compared with swabbing or bathing, wound irrigation is considered to be the most consistently effective method of wound cleansing.

The role of instillation fluids in wound therapy

Instillation therapy combined with NPWT was introduced in 1998 for the management of septic wounds that had failed to respond to conventional therapy. Initially, this system was used in infected wounds using antimicrobial solutions. This combined therapy has now been expanded to include cleansing regimens that can help to remove debris, exudate, infectious agents and healing inhibitors.

Several publications describe various clinical applications of instillation therapy, most of which focus on the treatment of wound infection. Gabriel et al. looked at the use of instillation therapy on soft tissue infections, demonstrating that instilling silver nitrate helped reduce bioburden, decreased time to wound closure and allowed early hospital discharge. The instillation of a polyhexanide (PHMB) solution by Schintler et al. and Timmers et al. showed effective treatment of soft tissue necrotising fasciitis and osteomyelitis, respectively, when used in combination with other treatments. Lehner et al. reported that the same regimen was an effective adjunctive therapy for acutely and chronically infected orthopaedic implants.

Evidence for V.A.C VeraFlo Therapy in biofilm management

Data using a biofilm model with pig skin explants have shown that V.A.C. VeraFlo Therapy, when combined with an appropriate antimicrobial solution (eg. 0.1% PHMB), may have the ability to disrupt mature biofilms and to reduce bacterial load after 24 hours. This research needs to be confirmed in human trials, while further work is needed to determine the most appropriate solutions, and optimal concentrations, for use in the management of biofilms. Another bench study has shown that V.A.C. VeraFlo Therapy allows for more controlled wound cleansing with less aerosolisation compared with standard techniques, reducing the potential spread of biofilm-producing microorganisms during wound cleansing.

What is the optimal time for wound irrigation?

There are no national or international guidelines on the optimal time for irrigating wounds. However, some investigators have shown that early intervention is important.

The role of biofilm management in wound care

It is now widely accepted that many chronic wounds contain biofilms. Biofilms develop when free floating microorganisms attach to the wound surface, quickly replicating and forming colonies that are tolerant to antibiotics, antiseptics and disinfectants. As a result, systemic antimicrobial therapy may not be effective. Good wound bed preparation and topical antimicrobials are known to play an important role in the management of biofilms.
A study of open tibial fractures showed a significantly higher infection rate in patients with wounds treated more than five hours after trauma compared with those treated within five hours. All wounds were treated with debridement without instillation therapy. More recently, it has been suggested that appropriate debridement of extremity wounds should be undertaken as soon as practical followed by lavage-irrigation using low-pressure delivery systems.

### What pressure is recommended for wound lavage-irrigation?

There are various wound irrigation techniques used to clean wounds, including traditional lavage-irrigation systems, which are administered at low or high pressures. In several studies, it was found that bacterial burden could be reduced using lavage-irrigation with high-pressure systems. However, concerns have been raised regarding damage to

---

Table 1  *In-vitro and animal model evidence for V.A.C.Ultra™ and V.A.C VeraFlo™*

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
<th>Aim</th>
<th>Method</th>
<th>Main findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lessing et al. Wounds 2011; 23(10):309-19</td>
<td>Negative pressure wound therapy with controlled saline instillation (NPWTi): dressing properties and granulation response in vivo</td>
<td>Effect on granulation tissue formation</td>
<td>In vivo pig model with full-thickness wounds (5cm diameter) to evaluate granulation tissue thickness over a 7-day period</td>
<td>After 7 days, a significant increase in granulation tissue thickness (43%; p&lt;0.05) was observed with V.A.C. VeraFlo™ Therapy compared to V.A.C. Therapy alone. Histological findings demonstrated that the increase in granulation thickness was the result of new tissue deposition, not swelling</td>
</tr>
<tr>
<td>Ryczew et al. Int Wound J 2012; doi: 10.1111/j.1742-481X.2012.00968.x</td>
<td>Distribution assessment comparing continuous and periodic instillation in conjunction with negative pressure wound therapy using an agar-based model</td>
<td>Distribution of instillation fluid over the wound bed</td>
<td>Benchtop agar wound models with and without tunneling and undermining</td>
<td>The findings suggest that periodic V.A.C.VeraFlo™ Therapy allowed better solution distribution across the wound surface, including tunnels and undermining, when compared with irrigation</td>
</tr>
<tr>
<td>LaBarbera et al. Presented at 22nd Annual Meeting of the Wound Healing Society, 2012</td>
<td>The effects of pulsed lavage and instillation therapies on porcine wounds</td>
<td>Effects of wound cleansing and tissue damage</td>
<td>In vivo pig full-thickness wounds (5cm diameter) allowed to granulate for 5 days</td>
<td>V.A.C.VeraFlo™ Therapy resulted in significantly less tissue swelling (ie change in wound volume; p&lt;0.05) and trauma than did pulsed lavage and may provide a more gentle technique for wound cleansing</td>
</tr>
</tbody>
</table>

Clinical evidence for NPWT plus instillation (various applications)

- **Bernstein and Tam. Wounds 2005; 17(2):37-48**
  - Combination of sub-atmospheric pressure dressing and gravity feed antibiotic instillation in the treatment of post-surgical diabetic foot wounds
  - Effect of NPWT plus instillation of saline, polymyxin B and bacitracin in diabetic foot wounds
  - Six hours of NPWT followed by instillation therapy in 5 wounds
  - Decrease in hospital stay and amputation rate

- **Gabriel et al. Int Wound J 2008;5(3):399-413**
  - Negative pressure wound therapy with instillation: a pilot study describing a new method for treating infected wounds
  - Effect of NPWT plus instillation (normal saline, sterile water or silver nitrate solution) in patients with complex, infected wounds
  - Pilot study of 15 patients with complex infected wounds compared to retrospective control of 15 patients treated with moist gauze wound care
  - Patients managed with negative pressure plus instillation required fewer days treatment and achieved wound closure sooner with fewer hospital inpatient days compared with controls (all p<0.001)

- **Timmers et al. Wound Repair Regen 2009;17(2):278-86**
  - Negative pressure wound treatment with polyvinyl alcohol foam and polyhexanide antiseptic solution instillation in posttraumatic osteomyelitis
  - Effect of NPWT plus instillation, polyvinyl alcohol foam and polyhexanide solution in patients with osteomyelitis of the pelvis or lower extremity
  - Retrospective case control cohort study of 30 patients
  - Patients managed with negative pressure plus instillation had a 10% recurrence of infection rate compared to 58.5% for controls. Total duration of hospital stay was significantly shorter (36 vs 73 days) and the number of surgical procedures was significantly smaller than controls (2 vs 5; both p<0.0001)

- **Schintler et al. Infection 2009;37(Suppl 1): 31-2**
  - The impact of V.A.C. Instill® in severe soft tissue infections and necrotizing fasciitis
  - Effect of NPWT plus instillation (polyhexanide) in patients with skin and soft tissue infections
  - Series of 15 patients treated with NPWT and instillation therapy
  - Infection was controlled and complete healing achieved in all patients

- **Lehner et al. Int Orthop 2011;35(9):1415-20**
  - First experiences with negative pressure wound therapy and instillation in the treatment of infected orthopaedic implants: a clinical observational study
  - Effect of NPWTi (polyhexanide) on orthopaedic implant retention following acute or chronic infection
  - Observational study of 32 patients with an infected orthopaedic implant treated with NPWTi (polyhexanide)
  - Following treatment, nineteen patients (86%) with acute infection and eight patients (80%) with a chronic infection retained their implant at 4-6 months follow-up
bone and the surrounding tissues caused by pulsed lavage\textsuperscript{20–21}.

Traditionally, wound lavage-irrigation has been conducted at pressures less than 15 PSI (lb/in\textsuperscript{2}) using fluid that does not cause trauma to the surrounding tissue\textsuperscript{22–23}. V.A.C. VeraFlo\textsuperscript{\textregistered} Therapy uses an instillation technique in which fluid is slowly introduced into a cavity under a minimal pressure of <3 PSI and is allowed to remain for a pre-specified length of time before being withdrawn. It therefore falls into the low-pressure category and may provide a less traumatic wound irrigation method.

**Evidence for using NPWT plus instillation**

Pre-clinical trials have shown that the use of the V.A.C. Ulta\textsuperscript{\textregistered} System with the V.A.C. VeraFlo\textsuperscript{\textregistered} Therapy setting increases granulation tissue thickness when compared to NPWT alone\textsuperscript{2}, reduces tissue swelling and cleanses the wound bed by irrigating the wound with saline and antiseptics (see Table 1). In addition, clinical studies have shown that NPWT plus instillation (various methods) can be an effective therapy in patients with complex, infected wounds (see Table 1).

**What instillation solutions can be used with the V.A.C.Ulta\textsuperscript{\textregistered} System?**

A range of solutions has been assessed for compatibility for use with the V.A.C. VeraFlo\textsuperscript{\textregistered} Therapy components. Solution classes include:

- **Isotonic solutions such as normal saline solution and lactated Ringer's solution**
- **Hypochlorite-based solutions (eg hypochlorous acid, sodium hypochlorite) such as Dakin's solution**
- **Sulphur-based solutions (eg sulphamides) such as mafenide acetate (ie sulfamylon)**
- **Biguanides (eg polyhexamethylene biguanide, polyhexanide) such as Prontosan\textsuperscript{\textregistered} and Lavasept\textsuperscript{\textregistered} (B. Braun)**
- **Cationic solutions (eg octenidine, benzalkonium chloride) such as Ocentillin\textsuperscript{\textregistered} (Schülke), Zephrinan\textsuperscript{\textregistered} (sanofi-aventis).**

Although these solutions have been deemed compatible with V.A.C. VeraFlo\textsuperscript{\textregistered} components, further work is required to provide evidence of clinical efficacy. Instillation cycle duration and frequency with V.A.C.VeraFlo\textsuperscript{\textregistered} Therapy vary with respect to the wound type, patient characteristics and solution used. It is important that clinicians

**Table 1**

<table>
<thead>
<tr>
<th>Solution Type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isotonic</td>
<td>Normal saline solution, lactated Ringer's solution</td>
</tr>
<tr>
<td>Hypochlorite-based</td>
<td>Hypochlorous acid, sodium hypochlorite</td>
</tr>
<tr>
<td>Biguanides</td>
<td>Polyhexamethylene biguanide, polyhexanide</td>
</tr>
<tr>
<td>Cationic</td>
<td>Octenidine, benzalkonium chloride</td>
</tr>
</tbody>
</table>

**Using V.A.C.Ultra\textsuperscript{\textregistered} System with the V.A.C.VeraFlo\textsuperscript{\textregistered} Therapy setting in a patient with a post-incisional hernia repair: a case study**

A 68-year-old man presented with an 18-month history of an abdominal wound following surgical dehiscence post-incisional hernia repair and Hartmann's procedure. The wound had been treated with NPWT and healing had progressed, but three deep sinuses and a superficial abdominal wound remained.

The patient underwent surgery to remove parts of an infected mesh and was initially treated with a Penrose drain for exudate management. The patient subsequently developed sepsis and wound contamination with Enterococcus, Coliforms and Pseudomonas.

**Treatment**

Following consultation with the surgical team a decision was made to initiate the V.A.C.Ultra\textsuperscript{\textregistered} System with V.A.C. VeraFlo\textsuperscript{\textregistered} Therapy setting to allow for instillation on a regular basis. A hydrocolloid dressing was used to protect the surrounding skin and superficial abdominal wound. At the start of the treatment all sinuses were 6 cm deep. V.A.C.VeraFlo Cleanse\textsuperscript{\textregistered} Dressings were used due to the ease of application and atraumatic removal from the sinuses.

A 0.1% polyhexamethylene biguanide solution (Prontosan\textsuperscript{\textregistered}) was used as the instillation fluid of choice. The sinuses were irrigated six times within a 24-hour period using 85 mL of solution with 15 minutes soak times with VeraFlo\textsuperscript{\textregistered} Therapy followed by NPWT at -125 mmHg. Dressing changes were performed every two days and wound volume was found to be reducing as measured by the amount of irrigation solution used.

Initially the SensaT.R.A.C.\textsuperscript{\textregistered} Pad was placed over the middle sinus (Figure 1) and this resulted in leakage around this site. Following review, the pad was bridged away from the sinuses (Figure 2) and no further leakage occurred.

**Outcome**

The wounds were assessed after one week of therapy using the V.A.C.Ultra\textsuperscript{\textregistered} System with the V.A.C.VeraFlo\textsuperscript{\textregistered} Therapy setting. The sinuses were noted to have decreased in depth by 4 cm and were producing less viscous exudate. Wound swabs showed mixed skin and enteric flora. Due to the improvement in the wound bed, the patient's discharge from the hospital was planned and therapy was changed to standard V.A.C.\textsuperscript{\textregistered} Therapy at -125 mmHg on continuous therapy.
When is the V.A.C. Ultra™ System appropriate?

NPWT has a well-established place in the management of a variety of complex and hard-to-heal wounds. Three basic criteria guide the selection of wounds for NPWT:

- Need for exudate management
- Need to establish a granulating wound bed
- Need to stabilise wound margins.

Whether to select standard NPWT or to add instillation therapy should be based on the need for wound cleansing or treatment with topical antimicrobials or antiseptics.

Clinical applications

Patients suitable for therapy with the V.A.C. Ultra™ System may range from those with infected prosthetic material in the wound to non-healing surgical or amputation wounds. Patients with chronic wounds, such as pressure ulcers and diabetic foot ulcers, could also be considered.

Contraindications and precautions

Contraindications to the use of the V.A.C. Ultra™ System are the same as those currently listed for standard NPWT applications. In addition, V.A.C. VeraFlo™ Therapy should not be used for wound irrigation in abdominal or thoracic cavities, while all wounds should be explored prior to use to avoid the instillation of solutions to adjacent cavities. Octenisept® (Schülke), hydrogen peroxide and alcohol-based solutions are not suitable for use with V.A.C. VeraFlo™ Therapy components. The V.A.C. Ultra™ System is not recommended for use in the outpatient setting. Ideally, clinicians should wait until a patient’s wound can be managed with standard NPWT before discharging them.

Benefits of using the device

The V.A.C. Ultra™ System offers clinicians the flexibility to switch therapy modes to customise care for individual patients.

Using the V.A.C. Ultra™ System with the V.A.C. VeraFlo™ Therapy setting in a patient with an infected ischeal sinus: a case study

A 55-year-old male paraplegic presented with an infected ischeal sinus resulting from a Category 4 pressure ulcer that had been previously treated for chronic osteomyelitis. He was admitted to hospital and underwent a washout and surgical debridement of the sinus. Following debridement the sinus was found to track from the top of the patient’s thigh to the ischeal region to a depth of 12cm (Figure 1).

Treatment

It was decided to start therapy with the V.A.C. Ultra™ System using the V.A.C. VeraFlo™ Therapy setting (instillation fluid: 0.1% polyhexamethylene biguanide solution [Prontosan®]). The sinus was irrigated with 40mL six times in 24 hours with 15 minutes soak times using the V.A.C. VeraFlo™ Therapy, followed by NPWT at -125mmHg.

V.A.C. VeraFlo Cleanse™ Dressings were used due to the ease of application and the reduced risk of leaving foam fibres in the sinus. The sinus opening on the top of the thigh was covered with a hydrocolloid to maintain a seal and encourage wound granulation. Dressing changes were undertaken every two days. After 11 days of V.A.C. VeraFlo™ Therapy the wound showed significant improvement and the therapy was changed to Dynamic Pressure Control™ Therapy 3:3 without V.A.C. VeraFlo™ Therapy, although V.A.C. VeraFlo Cleanse™ Dressings continued to be used due to the ease of application.

Outcome

After a further 10 days the upper thigh sinus had closed and the depth of the ischeal sinus had decreased to 3cm. NPWT was discontinued and appropriate dressings applied. The patient was discharged from hospital to the community with appropriate dressings (Figure 2) and remained healed at the time of writing.
Using the V.A.C. Ulta™ with the V.A.C. VeraFlo™ Therapy setting in a patient with a diabetic foot ulcer: a case study

A 59-year-old man with type 1 diabetes was admitted with a Wagner grade IV wound resulting from a prior left foot amputation and multiple revisions (Figure 1). The patient had previously undergone revascularisation of the affected limb. Klebsiella and Enterococcus were present in the wound.

Treatment
To manage the infection and optimise granulation, V.A.C. Ulta™ Therapy was initiated with the V.A.C. VeraFlo™ Therapy setting (instillation fluid: 0.1% gentamycin prepared by the local pharmacists, with advice from the local microbiologist). Solution soak time was set for 20 minutes per session, followed by V.A.C.® Therapy for 3.5-hours at a pressure of -75mmHg. V.A.C. VeraFlo™ Dressings were used.

Outcome
Total length of V.A.C. Ulta™ Therapy with the V.A.C. VeraFlo™ Therapy setting was 17 days, at which stage the wound was clean and granulation well established. The wound was closed by split-skin grafting 6 days after cessation of the V.A.C. Ulta™ Therapy (Figure 2) and progressed to healing.

Note: As with any case study, the result and outcomes of the cases presented in this made easy should not be interpreted as a guarantee or warranty of results. Individual results may vary depending on the patient’s circumstances and condition.

References