NEGATIVE PRESSURE WOUND THERAPY
WITH INSTILLATION: THE CURRENT STATE OF THE ART

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Negative Pressure Wound Therapy with Instillation: The Current State of the Art

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ABSTRACT

Traditional negative pressure wound therapy (NPWT) has revolutionized the treatment of complex wounds for nearly 20 years. A decade ago, a modification of the original system added intermittent automated instillation of topical wound irrigation solutions to traditional negative pressure wound therapy. This combined therapy, termed negative pressure wound therapy with instillation (NPWTi), has been shown to be effective in the treatment of a variety of complex wounds.

Negative pressure wound therapy with instillation has been shown to reduce bioburden and biofilms present in wounds helping heal clinically infected wounds. It has also been used with success to jump-start stalled wounds, in relieving wound pain and treating infected foreign bodies including infected orthopedic hardware and some types of exposed abdominal wall mesh.

The system includes a foam dressing placed in the wound covered by a semi-occlusive drape. A tubing placed over a hole cut in the drape connects the foam dressing to a pump run by a computerized microprocessor that delivers negative pressure to the dressing and wound. A preset volume of instillation fluid is automatically delivered via the instillation tubing to the wound. The fluid is held in the foam to bathe the wound for a predetermined time period. Negative pressure is then re-started draining the irrigation fluid and any wound exudate into a collection canister. The entire sequence is automated and consists of three
phases: (1) fluid instillation; (2) holding the fluid for a period of time in the wound, which is fully expanded since the negative pressure is off during this phase; and then (3) a cycle of continuous negative pressure. The entire sequence repeats itself automatically. Typically the dressing is changed three times a week.

The variables involved in treating patients with negative pressure wound therapy with instillation include: the indicated wound types; the system settings; the choice of the irrigation solution and the duration of therapy.

This article will serve as a reference to help the clinician navigate through treating patients with NPWT from patient selection, system settings to the completion of therapy.

INTRODUCTION

Traditional negative pressure wound therapy (NPWT) revolutionized the treatment of complex wounds after it became commercially available in 1995. It is a system made up typically of an open-cell reticulated polyurethane foam cut to size and placed into a wound. The foam is covered by a semi-permeable clear drape. A suction tubing is placed over a hole cut in the drape. The other end of the tubing is attached to a pump that delivers negative pressure to the wound in a continuous or intermittent fashion and is controlled by a computerized microprocessor. NPWT had been shown to cause macrodeformation by contracting the foam and thus exaggerating wound contraction and microdeformation of the cells in the wound as they are drawn into the interstices of the foam, stimulating cellular division to help fill in and heal the wound. It also helps create a favorable wound healing environment by stimulating granulation tissue formation, decreasing the amount of edema in the wound, increasing perfusion, and removing activated white blood cells and other factors that can delay normal wound healing. In vitro data suggest that NPWT can promote mitochondrial function and improve the cellular energy status. It has been shown to upregulate neurotransmitters, modulate inflammation, and regulate growth factors and proteases important in helping the wound progress through the normal phases of wound healing.

Different foams have been used with the classic NPWT system. The most commonly used foam, V.A.C. GranuFoam™ (Kinetic Concepts, Inc., San Antonio, TX), is a reticulated open-cell foam that is hydrophobic, thus possessing little ability to absorb fluid. Because of this characteristic, wound fluid and exudate readily pass through the foam into the collection canister. It has a low tensile strength, so it can be torn, remaining stuck to the wound, if there is some ingrowth of tissue while it is packed deeply into a tunneled area in the wound.

A second foam, V.A.C. WhiteFoam, is composed of polyvinyl alcohol and has the characteristics of being hydrophilic and much more dense. It helps keep the wound moist, and being very dense it is easy to place and remove from tunnels and areas of undermining in a wound. The increased density limits the amount of granulation tissue formed with its use. V.A.C. GranuFoam Silver™ is a silver-impregnated foam and provides a sustained continuous release of silver ions into a wound. The silver is microbonded throughout the foam, so even if cut to size, there will still be silver delivered to the wound from the dressing. V.A.C. GranuFoam Silver™ provides an effective barrier to bacterial penetration and may help reduce infections in wounds.

Traditional NPWT has been used with success for many years in treating infected wounds. Though there may not be a decrease in bacterial counts in wounds treated with traditional NPWT, studies have still demonstrated improved wound healing.

In 2003, a modification of the NPWT system added automated intermittent instillation of topical wound irrigation solutions to traditional NPWT. The modified system is indicated for wounds that would benefit from negative pressure wound therapy combined with intermittent instillation of topical wound solutions and suspensions.

One of the early misconceptions about NPWT was that it should not be used in patients with infected wounds. An algorithm indicating the multiple appropriate options a clinician has for using the various foams and the NPWT or NPWT systems in treating infected wounds was developed by an expert panel convened to explore the treatment of infected wounds with negative pressure wound therapy.

Continuous vs. Intermittent Instillation Systems

The majority of the experience with NPWT has been with systems that intermittently instill fluid into the wound. The V.A.C. Instill® and V.A.C. Ultra VeraFlo™ therapy system (Kinetic Concepts, Inc., San Antonio, TX) allows the fluid to dwell in the wound for a predetermined time period while the negative pressure is turned off. This allows the entire wound with all of its cracks, areas of tunneling, and undermining to be expanded and thus come in contact with the instilled fluid. This process is repeated automatically.

The fluid dynamics of the system appear to be more complex than just a simple fluid exchange at each instillation cycle. An amount of fluid remains in the foam as a residual volume that mixes with the next fluid instilled. Initially, more frequent irrigation cycles may help equilibrate the fluid in the foam more quickly.

On the other hand, with continuous instillation systems, the fluid is being continuously instilled while negative pressure is being applied, and the entire wound is contracted including areas in the wound containing cracks, crevices, tunnels, and undermining. Because these areas are pulled together by the suction they are inaccessible to the irrigated fluids.
In an *in vitro* study, a more extensive and uniform distribution of the irrigation fluid was observed with intermittent instillation therapy compared to fluid being instilled in a continuous fashion (with simultaneous negative pressure being applied and the wound contracted). Using an agar-based model, continuous instillation @30 cc/h with negative pressure showed isolated exposure of the instilled fluid to wound beds. In contrast, periodic instillation showed exposure of the fluid to the entire wound including undermined and tunnel areas. Because most of the clinical experience and published data are with instillation therapy done in an intermittent fashion, the remainder of this article will focus only on that mode of therapy.

**Intermittent Instillation Systems**

The original NPWTi system, V.A.C. Instill<sup>®</sup> (Kinetic Concepts Inc., San Antonio, TX) delivered fluid to the wound by a gravity-feed system. Excellent clinical results were seen with this system including number of treatment days, time to clear clinical infection, time to wound closure, and total days in the hospital, even considering the variability of volume instilled to the wound when the fluid is delivered by gravity. The amount of fluid delivered to the wound in a gravity-feed system can vary due to changes in the height of the fluid container in relationship to the level of the patient’s wound. Unfortunately, there was not a means to accurately record and confirm the correct delivery of the instillation fluid. The next generation instillation system, the V.A.C. Ulta™ (Kinetic Concepts Inc., San Antonio, TX) therapy unit delivers fluid to the wound by a gravity-feed system. In addition, using the V.A.C. VeraFlo™ therapy feature NPWTi can also be administered (Fig. 1). This new system added several advancements to the original V.A.C. Instill™ system. The first major advancement of this instillation system is that the fluid is automatically administered by a dedicated pump at every cycle as a preset volume. At the initial system setup, use of the “fill assist” tool allows the clinician to manually start and stop the instillation process. An appropriate amount of fluid is determined by observing how much fluid it takes to fill the foam and wound without delivering too much fluid, which would make it difficult to maintain a seal and allow the possibility of fluid leaking out around the drape. The volume that flows when the trial instillation is stopped by the clinician is determined and programmed into the pump. This volume is then automatically delivered at each subsequent instillation cycle. The clinical use of this system is illustrated in Case Study 1.

A second advancement of the system is an event log that confirms the accurate functioning of the system including verification that the preset volume of fluid was delivered by the pump and held in the wound according to the preset protocol.

Fluid instillation in a low-pressure closed system such as the V.A.C. VeraFlo™ prevents the tissue damage and environmental contamination that may be associated with a hand-delivered pulsatile lavage. Another addition to the system is the introduction of two new foams with unique characteristics that are preferable for use with instillation. The V.A.C. VeraFlo™ dressing (ROCF-V, Kinetic Concepts Inc., San Antonio, TX) is a reticulated, open-cell polyurethane foam that is more hydrophilic and has a higher tensile strength, making it ideal for use in areas of tunneling and undermining. This is illustrated in Case Study 2. VeraFlo Cleanse<sup>™</sup> has also been shown to promote granulation tissue formation.

The V.A.C. Ultra™ system has other desirable improvements including a 15-minute pause option that allows enough time for a dressing change to be done without having to re-enter the settings.

**NPWTi INDICATED WOUND TYPES**

Negative pressure wound therapy with instillation is indicated for use by the U.S. Food and Drug Administration in chronic, acute, traumatic, sub-acute, and dehisced wounds, partial thickness burns, ulcers (such as diabetic, pressure, and venous insufficiency), flaps, and grafts. It has been used clinically with success in a variety of wound types (Table I). NPWTi should not be the sole treatment for most wounds, rather it should be part of a comprehensive treatment strategy that includes repeated debridements as necessary.

Some of the wound types for which NPWTi has been used clinically warrant additional consideration.
Case Study 1

A 73-year-old male underwent a right carotid endarterectomy to treat symptoms of amaurosis fugax with an associated 80% right internal carotid artery stenosis. Twenty-three days post-op he presented at his surgeon’s office with evidence of a wound infection. He was taken to the operating room the next day and underwent incision and drainage of the postoperative wound infection. The infection was mainly contained in the superficial wound, but a small area of a bovine pericardial tissue patch was exposed. The wound was initially packed with gauze soaked in a bacitracin/polymyxin solution. Cultures grew methicillin-resistant Staphylococcus aureus.

NPWTi using Microcyn® instillations was begun on post-op day 2. The NPWTi dressing was changed the next day. NPWTi was continued for 4 days total until the wound could be loosely re-approximated with Steri-Strips. The wound went on to heal uneventfully without any infection. The patient remained free of any evidence of infection at a 10-month follow-up.

Settings: Instill 8 cc, hold 10 minutes, –100 mmHg pressure, repeat every 2 hours. Solution: Microcyn®
Case Study 2

A 60-year-old male had a complex right postero-lateral chest wall wound following surgery to treat recurrent lung and chest infections. With a long, narrow, chest wall wound, a foam that has a high tensile strength and that can promote granulation tissue formation while keeping the wound moist is desirable when using negative pressure wound therapy with instillation (NPWTi).

Settings: Instill 28 cc, hold 10 minutes, –125 mmHg pressure, repeat every 3 hours. Solution: Microcyn®
Infected Wounds with Exposed Hardware

NPWTi has been reported to be used adjunctively for acute bone and soft tissue infections. It has also been used in conjunction with debridement and systemic antibiotics to treat post-traumatic osteomyelitis of the pelvis and lower extremities. In this study, NPWTi significantly reduced the need for repeated surgical interventions and the rate of recurrent infections, compared with the use of antibiotic impregnated beads, in patients with post-traumatic osteomyelitis of the pelvis and lower extremities who were also receiving systemic antibiotics (p < 0.001).19

Debridement of any infected, devitalized tissue and bone should be done prior to the initiation of NPWTi. In most other wound types the foam is placed on top of the tissue in an open wound (Fig. 2). A different foam placement technique is used when adjunctively treating infected wounds with exposed hardware. In this instance the foam is imbedded in the wound around the implant and the skin is closed on top of the foam (Fig. 3). First experiences of NPWTi in the treatment of infected orthopedic implants reported an 86.4% salvage of acutely infected (less than 8 weeks from surgery) orthopedic implants and 80% salvage of chronically infected (>8 weeks from surgery) implants treated with NPWTi with a 4 to 6 month follow-up. Polyhexanide was used as the instillation solution in 31 of the 32 patients in this study. The average length of treatment of these wounds was 16.4 days.20 It is important that the wound is debrided at the initiation of treatment and as indicated at each dressing change. This technique to treat infected implants is commonly used in Europe, but treatment of infected implants by this technology would be considered an off-label use in the United States.

Diabetic Foot Ulcers

NPWTi has been used with success in the treatment of diabetic foot ulcers. Its use should especially be considered when: there is diffuse or extensive osteomyelitis encountered; there may be incomplete debridement; there is exposed bone or an exposed joint after debridement; and there is a wound that is critically colonized and may have stalled. NPWTi appears to be more successful than the use of antibiotic beads to treat these types of wounds.21 Adjunctive NPWTi in conjunction with systemic antibiotics and debridement has been reported to be effective in the treatment of infected wounds, which may also be a major contributing factor to the delay in healing of a diabetic foot ulcer.22

For successful healing other factors that may also be contributing to the formation and persistence of the diabetic foot ulcer also need to be addressed, such as restoring inadequate circulation, providing adequate off-loading of pathologic plantar pressure, optimizing glucose control, and performing debridement as indicated for any devitalized tissue.23

Exposed Abdominal Wall Mesh

NPWTi has been successfully used in the treatment of exposed abdominal wall mesh under specific conditions.18,24 It is very difficult, if not impossible, to totally eradicate infections in most types of mesh used to treat abdominal wall hernias. Success has been reported in salvaging some synthetic monofilament mesh (polypropylene) or biologic meshes such as Strattice™ Reconstructive Tissue Matrix (LifeCell Corporation, A KCI company, Branchberg, NJ) or AlloDerm® Regenerative Tissue Matrix (LifeCell Corporation, A KCI company, Branchberg, NJ). The foam is placed directly on top of the mesh without an interface layer. Typically, the NPWTi is continued for about 2 weeks until there is enough serum coming through the mesh to support a thin, split-thickness skin graft, flap, or delayed primary closure. When grafting over a biologic mesh, a thinner graft (6/1,000 to 10/1,000 of an inch) is used and is bolstered with traditional NPWT for 6 to 7 days (1 to 2 days longer than commonly used for skin grafts).20

Table I

Reported Wound Types for Negative Pressure Wound Therapy with Instillation (9, 10, 18, 21, 24, 25, 31)

<table>
<thead>
<tr>
<th>Type of Wound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wounds with invasive infection or extensive biofilm present</td>
</tr>
<tr>
<td>Contaminated wounds or wounds at a high risk of becoming infected</td>
</tr>
<tr>
<td>Wounds that have stalled with conservative wound care</td>
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<tr>
<td>Wounds that have stalled after a trial of traditional V.A.C. therapy</td>
</tr>
<tr>
<td>Complex sternotomy wounds with infection</td>
</tr>
<tr>
<td>Diabetic foot ulcers</td>
</tr>
<tr>
<td>Post-op diabetic foot wounds with a question of incomplete debridement or large areas of post-debridement exposed bone</td>
</tr>
<tr>
<td>As an alternative to antibiotic impregnated beads in infected orthopedic wounds</td>
</tr>
<tr>
<td>Painful wounds</td>
</tr>
<tr>
<td>Infected wounds with a foreign body in place</td>
</tr>
<tr>
<td>Wounds with a very viscous exudate</td>
</tr>
<tr>
<td>Compound (open) fractures to prevent the subsequent development of a wound infection or osteomyelitis</td>
</tr>
<tr>
<td>Necrotizing fasciitis</td>
</tr>
<tr>
<td>Wounds that are at an increased risk of likely needing a major amputation unless there is a drastic improvement due to the nature of the wound and the associated medical comorbidities of the patient.</td>
</tr>
<tr>
<td>Large areas of exposed bone in the wound</td>
</tr>
<tr>
<td>Wounds with exposed mesh either biologic or synthetic monofilament</td>
</tr>
<tr>
<td>Large, infected venous leg ulcers</td>
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</tbody>
</table>

NPWTi Settings

The different treatment settings that need to be programmed in the system include: the amount of fluid to be instilled into the wound, how long the fluid will be held in the wound, the level of negative pressure applied, and how often the entire sequence is to be repeated. Factors that influence the settings chosen include the wound type, wound size, and the pharmacology and mechanism of action of the solution being used.
Setting 1: The Volume of Fluid Instilled

The volume of fluid instilled is an amount that saturates the foam and wound without overfilling of the dressing. An appropriate amount of fluid is not a precise volume but actually a narrow range of volumes that will saturate the foam and wound. Over-filling may increase the risk of losing the seal created by the sticky drape and cause leakage of fluid out of the dressing. Using the “fill assist” tool, the instilled volume should be recalculated at each dressing change, as it may be different based on changes of the technique used when the new dressing is applied.

Setting 2: Time the Fluid Is Held in the Wound

With V.A.C. VeraFlo™ therapy the fluid may be held in the wound from 1 second to 30 minutes. With a short hold time the fluid will likely only be able to wash out the foam, wound debris, and exudate, but likely will be in such short contact with the wound that it will be unable to cause any major alterations of the environment and biology of the wound surface. A longer hold time may, in addition to washing out the foam and wound, allow the instilled fluid to be in contact long enough to react to any associated wound debris and thereby provide a greater cleansing. On the negative side, it is also possible that a longer hold time may increase the toxicity to the tissue of the solution instilled and also increase the likelihood there may be a loss of the water-tight seal of the dressing. Instillation therapy results in a moist wound environment, which can be favorable for the growth of yeast. Use of a topical antiseptic with activity against yeast should solve this issue.

The major consideration of how long to leave the fluid in the dressing and wound should be based on the recommendations of the manufacturer of the solution used based on its pharmacology. Hypochlorous acid, which has been reported to disrupt proteins in cell membranes causing loss of integrity of the membranes, with resultant swelling of the interior of the cells and then eventual cell lysis with cellular death. In an in vitro study, bacteria exposed to hypochlorous acid started demonstrating swelling within 30 seconds of exposure, and virtually all the cells had lysed and were killed within 5 minutes. Often a 10-minute hold time is used when Microcyn®/Derma-cyn® (hypochlorous acid) is used as the instillation fluid in the NPWTi system. The results in an actual patient’s wound will depend on multiple factors including the amount of protein and debris in the wound, along with a patient’s immune response and the characteristics of the bacteria present.

Setting 3: Pressure Settings

The pressure setting used during the vacuum phase of the cycle is typically chosen between –100 mmHg, –125 mmHg, or –150 mmHg. Lower pressures may be used if the patient experiences pain during the therapy itself or to try not to decrease perfusion to an ischemic wound.

Setting 4: Cycle Repeat Setting

Typically, the entire cycle is repeated every 2 to 4 hours. In larger wounds it may be preferable to repeat the cycle every 4 to 6 hours. A longer cycle will limit the number of times the fluid container and collection canister will need to be changed and make it less likely the system will need to be tended to in the middle of the night.

Completion of Therapy

Determining the goal of therapy at the beginning will help guide the clinician as to when to stop the therapy. The goal may be to prepare the wound for a graft, flap, or delayed primary closure. This may be achieved by decreasing the bioburden in the wound and removing any slough, debris, exudate, and inhibitory factors. Granulation tissue may be enhanced for primary closure or application of a skin graft. NPWTi may improve the wound so a less complex reconstruction will be required.
A variety of different solutions have been used with NPWTi. Based on in vitro data, instillation of normal saline alone may improve wound healing. The majority of clinicians now use an antiseptic solution with NPWTi. Determining the ideal solution to use with NPWTi, and if there is an advantage in using an antiseptic over normal saline, will be the subject of future investigations for some time to come.

### Normal Saline Installations
The effect of NPWTi with instillation of normal saline alone on wound healing has been studied. In an in vitro model, instillation of normal saline twice a day with either a 5- or 60-minute hold time was demonstrated to speed up wound fill with higher-quality granulating tissue composed of increased collagen. Some suggested the improved healing could be explained by the fact that the setting in this experiment was in effect an intermittent therapy (which in itself was found to increase the amount of granulation tissue formed). After further investigation, the positive effect noted on wound healing of NPWTi with saline was found to be greater than could be explained by intermittent therapy alone. A cleansing of the foam and wound is one of the proposed mechanisms of action accounting for the improvements observed.

### NPWTi Solutions
Unfortunately, to date there have been no published randomized controlled trials investigating whether there is an advantage to instilling an antibiotic or antiseptic over normal saline alone. If normal saline is being used as an instillation solution, the effect will be mainly one of flushing out the foam and wound of any debris, planktonic bacteria, and wound inhibitory factors. In a prospective clinical study of 131 patients treated with NPWTi with normal saline as the irrigation solution, favorable results were seen in 98% of the cases with a mean duration of NPWTi of 12 to 19 days.

Knowing that wounds heal more quickly if there is not an associated infection present, it would seem that the use of topical antibiotics and antiseptics as the instillation fluid could decrease the bioburden in wounds. This would make the wound environment more favorable for wound healing. One concern with the use of antiseptics is the toxicity and destruction of normal cells needed for wound healing. The toxicity of an antiseptic may be decreased if it is diluted. Which antiseptics when diluted will remain effective and are associated with decreased toxicity has been investigated in an in vitro model (not using NPWTi). The tested solutions that have the desired biocompatibility index \( >1 \) are polyhexamethylene biguanide (PHMB) (Lavasept®) and octenidine dihydrochloride (OCT). (If used in the NPWTi system, the preferred formulation is Octenilin® Wound Irrigation Solution, Schulpke & Mayr GmbH, Norderstedt, Germany.)

### Antibiotic and Antiseptic Instillation Solutions
A variety of solutions have been used with NPWTi systems. Early after the introduction of NPWTi, topical antibiotics were often used with this system. The use of systemic antibiotics as a topical solution is considered off-label in the U.S. There is also a concern about the development of bacterial resistance to the instilled antibiotics. Making that less likely is the fact that much higher concentrations of the antibiotic solution can be delivered directly in the wound bed than can be achieved if administered systemically. This will more likely lead to cell death than to the development of bacterial resistance.

Dilute lidocaine has been shown to be very effective in treating the pain that may be associated with negative pressure wound therapy. Some solutions may be administered with lidocaine without inactivation of either fluid. A consensus statement was published by an international group of experts with extensive experience using NPWTi. Three irradiation solutions reached strong consensus (>80% agreement of the panel) to be recommended for use with NPWTi. The three solutions were: Prontosan®, Lavasept®, and Microcyn®/Dermacyn®. Other solutions that were discussed by the panel but did not reach enough support to reach the same strong consensus included: acetic acid, sodium hypochlorite, silver nitrate, and normal saline.

### Lavasept® — Polyhexamidine 0.04%
Lavasept® — polyhexamidine 0.04% (B Braun Melsungen AG, Germany; not available in the U.S.). Polyhexamidine is considered by many as the first-choice antiseptic for contaminant-acutedue wounds, infected or critically colonized wounds, and poorly healing and chronic wounds. It is better tolerated by the tissue than most other antiseptics. With a relatively slow onset of action it may be preferred to use a 15-minute dwell time if used as the solution in the NPWTi system.

### Prontosan® — Polyhexamidine 0.1% plus Betaine
Prontosan® — polyhexamidine 0.1% plus betaine (B Braun Medical Inc., Bethlehem, PA) contains polyhexamidine like Lavasept®. In addition to containing polyhexamethylene biguanide it also contains the surfactant betaine as a preservative. The surfactant may have a complementary role. This solution is not cleared in the U.S. as a topical antimicrobial. There is no loss of effectiveness of Prontosan® in the presence of blood or proteins in the wound. There also is no development of bacterial resistance. Persistence of the activity is noted post-application.

### Microcyn®/Dermacyn® — Hypochlorous Acid
Microcyn®/Dermacyn® — hypochlorous acid (Oculus innovative Sciences, Petaluma, CA). Microcyn®, also called Dermacyn® in some markets, is a neutral-pH stabilized hypochlorous acid solution. It has a 2-year shelf life. Microcyn® Skin and Wound Care with Preservatives demonstrates in vitro activity against a broad spectrum of gram-negative, gram-positive, and yeast species in 30 seconds. It has a low toxicity on the normal tissue in the healing wound. Minimal side effects have been reported with its use. It works by denaturing proteins in the bacterial membranes allowing fluid to enter the cell resulting in cell lysis and death. The mechanism of action appears to be different from that of sodium hypochlorite (Dakin’s solution) illustrated in an in vitro study in which bacteria resistant to sodium hypochlorite were killed by hypochlorous acid.

A partial list of other solutions used with NPWTi that have been reported...
in the literature include: normal saline, silver nitrate, sodium hypochlorite (dilute Dakin’s), octenidine, insulin, doxycycline, dilute betadine, Lactoferrin, polymixin B, bacitracin, and phenytoin.

**Analygec Instillation Solutions**

Instillation with the NPWTi system of analgetics such as dilute lidocaine has been reported to provide relief of the pain that may be associated with therapy. The maximum dose of topical lidocaine is 3mg/kg/q2h. A concentration that is approximately 5% of the maximum recommended topical dose of xilocaine used in a NPWTi system was shown to significantly decrease a patient’s parenteral pain requirement.

The following is an example of how to safely dose lidocaine with NPWTi for a typical patient. If 25 cc of 1% lidocaine is mixed in 500 cc normal saline, for the classic 70 kg (150 lb.) patient, the maximum topical volume of the dilute solution would be 420 cc every 2 hours. In actual practice 20 cc to 40 cc (5% to 10% of the maximal recommended topical dose) is used in most wound types. The NPWTi manufacturer recommends a maximum dose of 0.1% xilocaine without additives in saline for compatibility with the NPWTi dressing and components.

**CONCLUSIONS**

As more extensive experience and expertise is gained with the NPWTi system, there will be a better understanding of the system and more precise recommendations will be able to be made for the ideal solutions to instill and preferred system settings. New wound dressing interfaces are under development and being investigated. The most significant role for NPWTi may be the instillation of specific solutions to accelerate the phases of wound healing and help the wound progress more rapidly through its normal wound healing process.  

**AUTHOR’S DISCLOSURES**

Dr. Wolvos has served as a consultant for Kinetic Concepts Inc. and Oculusis Innovative Sciences.