



# The Role of Negative Pressure Wound Therapy in the Spectrum of Wound Healing

## A Guidelines Document

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Supported by ConvaTec In.

This supplement was subject to *Ostomy Wound Management* peer-review process. It was not subject to the *WOUNDS* peer-review process and is provided as a courtesy to *WOUNDS* subscribers.

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**Potential Conflicts of Interest:** Dr. Bollero has no financial relationships to disclose. Dr. Driver has received research grants from 3M Health Care, Abbott Labs, Baxter, Integra LifeSciences Corporation, KCI, Ogenix, Sanuwave, Inc., Tissue Repair Company and Biotest Microbiology Corporation. Dr. Glat is a paid consultant for and has received speaker honoraria from ConvaTec Inc. Dr. Gupta xxxxx. Dr. Lázaro-Martínez has no financial relationships to disclose. Dr. Lyder is a paid consultant for ConvaTec Inc. Dr. Ottonello xxxxx. Dr. Pelham xxxxx. Ms. Vig has received speaker honoraria from KCI, ConvaTec Inc., and Smith & Nephew. Dr. Woo has no financial relationships to disclose.

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# The Role of Negative Pressure Wound Therapy in the Spectrum of Wound Healing

## Abstract

Wound care clinicians have a wide array of available treatment options to manage and help heal acute and chronic complex wounds that require a systematized and comprehensive approach to address the complexity of wound care and to optimize patient outcomes. The treatment of wounds represents a major cost to society. Public policies increasingly focus on quality of care, patient outcomes, and lowering costs. Wound care clinicians are not immune to these pressures. Wound care clinicians must ensure that their assessments, treatment pathways, and product selections are both clinically and economically sound.

Negative pressure wound therapy (NPWT) has been demonstrated to be an efficacious option to promote healing in a variety of acute and chronic complex wounds. Previous guidelines on the use of NPWT have focused on application but have not provided recommendations on when it is most appropriate to use NPWT; there are few criteria for 1) when to initiate NPWT based on various wound types, 2) pre-application management to optimize treatment outcomes, 3) identification of appropriate candidates for NPWT, 4)

benchmark indicators for treatment response, and 5) recommendations on when to transition between NPWT and moist wound healing (MWH) or another treatment modality.

In September 2009, an international panel of wound care experts from multiple disciplines convened to develop a document to guide clinicians in making decisions about the appropriate use of NPWT within the spectrum of wound healing. Where empirical research was lacking, clinical experiences and patient factors were considered to ensure the clinical utility of the document. The goal of these guidelines is to encourage responsible wound management across the healthcare continuum and spectrum of wound pathologies to achieve positive, cost-effective patient outcomes.

**Key Words:** negative pressure wound therapy, moist wound healing, traumatic and surgical wounds, pressure ulcers, diabetic foot ulcers, venous ulcers and arterial ulcers

**Index:** *Ostomy Wound Management*. 2010;56(5 Suppl):1–18.

# The Role of Negative Pressure Wound Therapy in the Spectrum of Wound Healing

A wide array of treatment options is available to facilitate the healing of acute and chronic complex wounds. Moist wound healing (MWH) dressings and other treatment modalities such as negative pressure wound therapy (NPWT) have been successfully used in the management of wounds. However, it is important to understand where these advanced therapies fit within the spectrum of wound management, taking into consideration the cost of care and optimal patient outcomes.

In September 2009, an international panel of wound care experts from multiple disciplines convened to develop a document to guide clinicians in making decisions on the appropriate use of NPWT within the spectrum of wound healing. Aiming to combine scientific evidence with expert opinion and patient considerations, this guidance document was developed to provide healthcare professionals with an understanding of how NPWT fits into treatment paradigms for complex acute and chronic wounds, including surgical/traumatic wounds, pressure ulcers, and diabetic foot and leg ulcers. Experiences and opinions were shared through open and interactive discussion at the face-to-face meeting to reach a consensus for each recommendation. This document addresses the criteria to initiate NPWT based on various wound types, pre-application management to optimize treatment outcomes, identification of appropriate candidates for NPWT, benchmark indicators for treatment response, and recommendations for when to terminate NPWT and transition to MWH or another treatment modality.

It is generally accepted that moisture balance is essential to all phases of wound healing.<sup>1-3</sup> Exposed cells on the wound surface require surface moisture for viability. While too little moisture can cause cell death, too much moisture can promote maceration and damage the wound edges and periwound skin. The challenge is to strike a balance to avoid extremes that can delay healing.

The volume and composition of wound exudate affect moisture levels within the wound bed and, consequently, a wound's potential for healing. When there

**Table 1. Fundamental management principles for optimal healing outcomes\***

Optimize the patient's health status	<ul style="list-style-type: none"> <li>• Nutritional support</li> <li>• Adequate hydration</li> <li>• Glycemic control</li> <li>• Optimal control of comorbid diseases such as pyoderma gangrenosum† and anemia</li> <li>• Smoking cessation</li> <li>• Moderate alcohol intake</li> </ul>
Treat the underlying cause of the wound	<ul style="list-style-type: none"> <li>• Improve blood flow and tissue perfusion (eg, revascularization)</li> <li>• Apply compression therapy for edema and venous insufficiency in the absence of arterial disease</li> <li>• Use offloading devices and other techniques to optimize the management of diabetic foot ulcers and pressure ulcers               <ul style="list-style-type: none"> <li>– Pressure redistribution</li> <li>– Reduction of friction/shear stress</li> <li>– Surgical intervention to correct physical deformities</li> </ul> </li> </ul>
Optimize the wound bed and local wound environment	<ul style="list-style-type: none"> <li>• Debride the wound</li> <li>• Treat increased bacterial burden or deep infection               <ul style="list-style-type: none"> <li>– Osteomyelitis</li> <li>– Surrounding cellulitis</li> </ul> </li> <li>• Maintain moisture balance</li> <li>• Maintain normothermic wound environment</li> </ul>
Address patient and family concerns	<ul style="list-style-type: none"> <li>• Provide wound care education</li> <li>• Address patient concerns               <ul style="list-style-type: none"> <li>– Pain management</li> <li>– Anxiety/depression</li> </ul> </li> <li>• Provide good follow-up care               <ul style="list-style-type: none"> <li>– Monitor for signs of infection</li> <li>– Monitor treatment compliance‡</li> </ul> </li> </ul>

\* Not all considerations will be applicable to every patient or in every wound type.

† Pyoderma gangrenosum is a rare skin disorder that is characterized by the development of large ulcers that have an undermined border and necrotic exudative base. The disorder is frequently associated with an underlying systemic disease such as inflammatory bowel disease, arthritis, or leukemia. Early identification and treatment of pyoderma gangrenosum is recommended as its presence can delay chronic ulcer healing.

‡ Throughout this paper, the term "compliance" is used to refer to a patient's adherence to a recommended course of therapy in order to avoid confusion with the "adherence" of a dressing to a wound site.

is inflammation, increased wound exudate may be expected because of alterations in capillary permeability, vasodilatation, and the migration of inflammatory cells. Acute wound exudate promotes healing by providing the moisture, nutrients, and growth factors necessary for re-epithelialization. However, when wounds are slow to heal and become chronic, the composition of wound exudate is predominated by high levels of oxidative enzymes, cytokines, leukocytes, and proteases (eg, matrix metalloproteinases [MMPs]), all of which impede healing.<sup>4-6</sup> This enzyme-rich and caustic exudate, if present in excess levels, may spill into the wound margins, causing maceration, epidermal erosion (eg, loss of part of the epidermis despite maintaining an epidermal base), and pain.

In a healthy and immunocompetent individual, acute wounds typically heal in a timely and orderly manner. However, when complications arise or a patient's underlying medical conditions compromise healing ability, wound healing may stall. Among the reasons a wound may deviate from the expected trajectory for healing and become chronic in nature: inadequate blood supply, poor tissue perfusion, untreated deep infection, and the presence of a foreign body in the wound bed (eg, prosthetic joint, retained suture), all of which may inhibit new granulation tissue's growth.<sup>7</sup>

Chronic wound fluid has been shown to contain high levels of pro-inflammatory cytokines, such as tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ), and MMPs, which also may impair healing by inducing prolonged inflammation and excessive degradation of the extracellular matrix of healthy skin, respectively.<sup>4-6</sup> *In vitro* studies have demonstrated that fluids taken from chronic wounds suppress the proliferation of keratinocytes, fibroblasts, and vascular endothelial cells.<sup>8</sup> In addition, an increased number of senescent fibroblasts may delay wound healing. Fibroblasts have a limited life span and show an age-related decrease in cellular activity, sensitivity to growth factors and, therefore, rate of proliferation.<sup>9,10</sup>

## OPTIMIZATION OF WOUND HEALING

**Optimize the patient's health status.** Optimization of the patient's overall health status is critical to the success of any wound healing therapy. An interdisciplinary approach may aid in achieving optimal outcomes. Preparation of the patient begins with identifying and correcting the local and systemic factors that can potentially impair wound healing, including a disease-specific mechanism or alterations in tissue perfusion or overall metabolism. **Table 1** provides guidance regarding com-

prehensive and holistic patient management as an integral part of wound management; however, not all these recommendations apply to every patient or every wound type.

**Treat the underlying cause of the wound.** The first step in wound management is to identify and treat the cause of the wound. Acute wounds usually result from trauma, infection, or surgical procedures. Chronic wounds, however, such as pressure ulcers, diabetic foot ulcers (DFUs), and venous and arterial leg ulcers, are more complex in that multiple causative factors often work in concert to produce the injury. Each factor needs to be addressed to maximize healing potential and prevent recurrence of the wound.

Arterial/venous insufficiency or poor tissue perfusion caused by edema can delay wound healing. Surgical revascularization may be required to restore blood flow in patients with chronic leg ulcers or DFUs when the arterial blood supply is not sufficient to support healing. When there is venous insufficiency, compression therapy will aid in reducing edema and controlling exudate levels.

It is generally accepted that chronic pressure, friction, and shear forces act in concert to produce and perpetuate tissue injury, leading to the development of DFUs and pressure ulcers. Patients at high risk include persons with neuropathy secondary to diabetes and persons who are immobile (eg, chairfast or bedfast). For a wound healing therapy to be effective, these mechanical forces need to be neutralized through the use of patient repositioning, offloading devices, specialized mattresses that achieve pressure redistribution, and specialized dressings that minimize friction and shear.

**Optimize the wound bed and local wound environment.** Wound bed preparation provides clinicians with a comprehensive approach for removing the barriers to healing, thereby stimulating the growth of new tissue and wound closure. The first step is aggressive debridement through the use of surgical, autolytic, mechanical, or biological methods to remove all necrotic tissue, slough, and firm eschar, since each of these impede healing. Debridement may also promote healing by creating a clean wound surface free of senescent cells and biofilms, which shield bacterial colonies and may make them more resistant to infection management.

Once the wound bed has been debrided, any surrounding cellulitis should be treated. If there is deep infection or infection of the bone, systemic antibiotics in addition to debridement should be considered to eliminate the infection. The wound bed and periwound area then should be protected with a dressing that provides a moist environment with good temperature control. In many wounds, appropriate debridement followed by the application of an

Responsible wound management requires both clinical and economic considerations.

**Table 2. Common goals of MWH**

<ul style="list-style-type: none"> <li>• To maintain a moisture-optimized wound in which there is no maceration of the edges and no sign of desiccation in the wound bed</li> </ul>
<ul style="list-style-type: none"> <li>• To promote re-epithelialization, neovascularization, and rapid closure of the wound               <ul style="list-style-type: none"> <li>- To enhance the synthesis of growth factors</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>• To ensure hemostasis and aid in the identification of areas that require further debridement</li> </ul>
<ul style="list-style-type: none"> <li>• To minimize infection by providing a barrier to and cross-contamination of bacteria</li> </ul>
<ul style="list-style-type: none"> <li>• To provide thermal insulation</li> </ul>

MWH dressing is sufficient therapy to promote healing in a timely fashion. However, in wounds in which healing is delayed alternative therapy to achieve wound healing may need to be considered.

**Address patient concerns.** Chronic wounds can be painful and can negatively impact quality of life (QoL) by limiting mobility, interfering with the activities of daily living, restricting the use of leisure time, and disrupting functionality at work; anxiety and depression can develop as a result.<sup>11</sup> Constant debilitating pain can also adversely affect patient compliance with the treatment plan and, therefore, the rate of wound healing.

By recognizing the potential for wound-related pain and providing good pain management through the use of oral analgesics, atraumatic dressings, and topical anesthetics during dressing changes, clinicians can greatly minimize patient distress during the healing process. Patient empowerment through active participation in treatment decisions is another tool that can positively affect the day-to-day physical and psychological consequences of living with a chronic wound.

**Treatment with MWH dressings is often sufficient to promote the healing of both acute and chronic wounds when the patient's medical status, local wound environment, and wound bed have been optimized for treatment.**

## UNDERSTANDING THE ROLE OF MWH

The main goal of MWH is to maintain optimal levels of moisture in the wound bed and surrounding tissue through the use of specialized dressings that either trap moisture within the wound bed or absorb excess exudate (see **Table 2**).

Support for the importance of moisture balance in wound healing was provided nearly 50 years ago by George Winter and Charles Hinman in two pivotal studies that demonstrated a two- to threefold increase in the rate of re-epithelialization in acute wounds that were maintained in a moist local environment versus wounds that were allowed to desiccate uncovered.<sup>13,14</sup> Since then, other research has validated that a moist wound environment accelerates the

re-epithelialization process, facilitates the action of growth factors, increases keratinocyte and fibroblast proliferation, enhances collagen synthesis, and promotes angiogenesis and early wound contraction.<sup>14-24</sup>

Clinical studies have demonstrated several advantages of using modern MWH dressings over gauze dressings in the treatment of all types of wounds. For example, dressings that maintain optimal moisture levels are easier to apply and easier to remove.<sup>20,25</sup> Because moist dressings do not adhere to the underlying tissue, they are atraumatic upon removal and cause little to no mechanical injury to the healing wound.<sup>26</sup> As a result, patients require less procedural pain medication and report experiencing significantly less pain and anxiety during dressing changes.<sup>18,20,25,26</sup>

MWH dressings are rated as more comfortable than traditional gauze due to their cushioning effect and ability to maintain flexibility as they conform to the wound.<sup>25,27-29</sup> By providing a soothing and protective environment for exposed nerve endings, MWH dressings reduce pain at the wound site and are associated with less burning and stinging during wear.<sup>18,25</sup> MWH dressings also have longer wear times than gauze dressings, resulting in less-frequent dressing changes and notably reduced nursing time.<sup>26,30</sup>

MWH dressings are associated with a lower risk of secondary infection than gauze dressings.<sup>19,31</sup> This may be due to the creation of a barrier that prevents bacteria from entering the wound and minimizes cross-contamination by releasing

notably fewer airborne bacteria during dressing changes.<sup>32</sup> In addition, some specialized dressings that form a cohesive gel upon contact with wound exudate have been shown to encapsulate and immobilize pathogenic bacteria under the gel surface, thereby reducing the potential for secondary infection.<sup>33</sup>

MWH dressings are efficacious in the treatment of both partial- and full-thickness wounds. For example, in DFUs, the use of MWH dressings is reportedly associated with up to a 60% reduction in ulcer size, 63% reduction in ulcer depth, and a trend toward overall wound improvement with less deterioration after 8 weeks of treatment.<sup>34</sup> In traumatic and surgical wounds, improved management of exudate, fewer complications, and a trend toward faster healing have been observed with MWH dressings in comparison to providone-iodine gauze or a nonwoven polyester dressing coated with acrylic adhesive.<sup>25,35</sup> Lastly, when MWH dressings are used to treat pressure ulcers and chronic leg ulcers, the periwound skin reportedly remains healthy, wound area decreases, and wound healing proceeds with varying degrees of improvement or complete resolution.<sup>27,29,36</sup>

Dressing selection is a clinical decision based largely on dressing features such as conformability, cushioning, ease of removal, and ability to minimize pain at the wound site and during dressing changes, all of which contribute to patient comfort. In addition, performance measures such as ease of application, absorbency, wear time, barrier properties, and the ability to protect the periwound area and control wound odor, as well as economics, should be considered.<sup>7,29,36,39,40</sup> Treatment with MWH dressings is often sufficient to promote the healing of both acute and chronic wounds when the patient’s medical status, local wound environment, and wound bed have been optimized for treatment. However, when wounds stall and do not follow the expected temporal pathway for healing, other therapies, such as NPWT, should be considered.

**UNDERSTANDING THE ROLE OF NPWT**

NPWT enhances the ability of endogenous repair mechanisms to heal wounds of all types. However, it is most appropriate, however, for wounds that are deep, cavitary, or full thickness. NPWT assists in the management of deep wounds by increasing the rate at which new granulation tissue fills the wound bed.<sup>41,42</sup> This allows healing to proceed to the point where the wound can be surgically closed, reconstructed with a graft or flap, or transitioned to another treatment modality.<sup>43-45</sup> A variety of specialized dressings now exist to serve as the interface between the subatmospheric pressure and the wound bed. These include reticulated open-cell foam, gauze, and nonadherent micro-domed polyester. Customized dressings for wounds of particular characteristics and locations also have been developed.

The healing mechanism of NPWT is based on the assumption that uniform negative pressure exerts three-dimensional mechanical stress on the wound bed. This stress then is transmitted down to cellular and cytoskeletal levels, resulting in the activation of signal transduction pathways, which trigger cell recruitment, angiogenesis, growth factor expression, and cell proliferation.<sup>47-50</sup> The growth of granulation tissue is stimulated as a result, and wound healing may proceed at a faster rate than that seen with the application of moist wound healing dressings alone.<sup>42,45</sup>

Preclinical and clinical studies have shown that NPWT stimulates angiogenesis and a three- to fivefold increase in cutaneous blood flow adjacent to the wound edges.<sup>42,49,51</sup> This should increase the availability of oxygen and vital nutrients needed for tissue regeneration.<sup>52</sup> The application of negative pressure has the added benefit of removing wound exudate and infectious material, which in turn reduces bioburden and

**Table 3. Common goals of negative pressure wound therapy**

• Promote rapid reduction in wound volume
• Promote growth of granulation tissue and contraction of wound edges
• Manage exudate
• Prepare the wound bed for transition to another treatment modality such as MWH, surgical closure, or a flap or graft
• Reduce bioburden*
• Decrease hospital stay length
• Decrease morbidity and mortality
• Decrease frequency of dressing change
• Prevent deterioration of the wound
• Minimize contamination and wound odor by providing a temporary barrier
• Improve quality of life
<small>*Bioburden is the degree of microbial contamination or microbial load.</small>

decreases local edema that can constrict the microvasculature.<sup>42,44,53</sup> By removing pro-inflammatory cytokines and MMPs, negative pressure can alter the composition of wound exudate to produce a favorable healing environment.<sup>4,5,54,55</sup>

Studies have shown that NPWT increases the rate of granulation tissue formation and decreases the time to

achieve wound closure in DFUs, chronic leg ulcers, and acute wounds requiring open management before surgical closure.<sup>41,45,56</sup> Reports indicate that NPWT also shortens the drainage time in acute wounds such as partial-thickness burns, surgical wounds with hematoma, and high-energy fractures.<sup>53,57</sup> NPWT has been used successfully as a bridge to definitive closure in deep wounds of all types and has been shown to shorten the time for wound bed preparation before skin graft reconstruction.<sup>43-45</sup>

Additional benefits of NPWT include fewer secondary amputations in diabetic patients with chronic foot ulcers in comparison to moist wound dressings.<sup>41,58</sup> This may be due to NPWT’s ability to decrease the time to wound closure and, hence, minimize the risk of re-infection.<sup>41,59</sup> Finally, preclinical and clinical reports suggest that NPWT may prevent burn progression in partial-thickness burns when initiated in the early stages of therapy, presumably by reducing edema formation and increasing tissue perfusion.<sup>57,59</sup> Although the specific goals of NPWT will vary according to the type of wound and the setting

**When choosing an NPWT system, it is important to consider the type of dressing/wound interface. Some dressings are designed to decrease pain upon dressing removal. This is significant, because pain at dressing change can cause patient noncompliance with NPWT.<sup>46</sup>**

**Table 4. Contraindications and precautions with negative pressure wound therapy use<sup>60</sup>**

Contraindications	Precautions
<p>Do not use NPWT in wounds where there is evidence of the following:</p> <ul style="list-style-type: none"> <li>• Exposed vital organs</li> <li>• Inadequate debridement of the wound</li> <li>• Untreated osteomyelitis or sepsis within the vicinity of the wound</li> <li>• Untreated coagulopathy</li> <li>• Necrotic tissue with eschar</li> <li>• Malignancy in the wound</li> <li>• Allergy to any component required for the procedure</li> </ul>	<p>Reasons to use NPWT with caution:</p> <ul style="list-style-type: none"> <li>• Active bleeding or a risk of bleeding (eg, there is difficulty achieving wound hemostasis, patient is taking anticoagulants)</li> <li>• An exposed blood vessel close to the wound</li> <li>• Difficulty maintaining a seal</li> <li>• Uncontrolled pain</li> <li>• Evidence of previous patient noncompliance with or intolerance to the procedure</li> </ul>

in which treatment is initiated, a number of common goals are shared across clinical settings (see **Table 3**).

If there are no contraindications, NPWT can be initiated after the patient's health and wound status have been fully optimized (see **Table 1**). NPWT is contraindicated when there is inadequate debridement, necrotic tissue with eschar, or the presence of untreated osteomyelitis or sepsis in the wound area.<sup>60</sup> NPWT also is contraindicated if there is untreated coagulopathy, an exposed vital organ, or malignancy in the wound, or if the patient is allergic to any vital component of the dressing, drape, or NPWT device.<sup>60</sup> If a cardiac bypass graft or any large blood vessel is exposed, NPWT should not be used without first obtaining a surgical consult and establishing a clear pathway of clinical responsibility.

NPWT should be used with caution when there is active bleeding or an increased risk of bleeding because the patient is taking anticoagulants.<sup>60</sup> Complete hemostasis should be attained before applying the NPWT device. NPWT also should be used cautiously on areas such as the groin and anus, where maintaining seals is difficult. Using a skin glue/sealant may help anchor the device in these circumstances. If there is an exposed blood vessel in close proximity to the wound, take care when applying the dressing interface. Additionally, use caution in patients who have uncontrolled pain or have demonstrated previous noncompliance with or intolerance to the NPWT procedure.

**Table 5** lists the universal criteria for discontinuation of NPWT for all wound types. NPWT should be discontinued when exudate levels have been sufficiently reduced or when wound volume/size has decreased to the point that the wound can be surgically closed or transitioned to another treatment modality such as MWH dressings. New granulation tissue should be clean; free of fibrotic, necrotic, and other nonviable tissue; and should cover the bone in the case of osteomyelitis.

NPWT also should be discontinued if the wound fails to improve or deteriorates. It is important to avoid setting time limits or strict criteria for improvement because the

healing of each wound will be different. However, it is also important to set regular intervals at which to monitor the progression of wound healing. In general, the rate of change in wound volume should decrease as the wound heals, and the wound bed should become shallow and appear almost flat with no tunneling.

Complications such as worsening infection, periwound maceration, excessive bleeding, or the inability to maintain an adequate seal around the negative pressure device are other reasons for discontinuation. NPWT also should be discontinued if the patient is noncompliant with or intolerant to the procedure. Patient intolerance or noncompliance should prompt evaluation of the wound dressing interface. Switching to a system that has a non-adherent dressing or adding a nonadherent barrier may help reduce pain and wound trauma, major causes of patient noncompliance and intolerance.

Responsible wound management requires both clinical and economic considerations. Appropriate wound healing therapy selection depends on the type of wound and its anatomical location, therapeutic goals, health status of the patient, and cost of care. Specific characteristics such as wound size, the amount of exudate, the presence/absence of infection, and patient preference need to be considered. For some wounds, advanced dressings may be the most appropriate choice, and for some — but not all — wounds, NPWT may be considered first-line or adjunctive therapy.

## THE PRESENT GUIDELINES

This document contains recommendations for the treatment of acute wounds (surgical/traumatic wounds and skin grafts) and chronic wounds (pressure ulcers, DFUs, leg ulcers) that wound care professionals are likely to encounter in their practice. Panel members agree that NPWT is not the most appropriate choice for every wound type. Therefore, recommendations for its use are made on three levels: 1) strongly consider as first-line therapy, 2) consider on a patient-by-patient basis, and 3) not recommended.

## ACUTE WOUNDS

### Traumatic and Surgical Wounds

Although panel members recognize that surgical wounds, traumatic wounds, and burns are acute wounds with different etiologies, the present guidelines treat them as a single group because the goals of therapy are similar.

The treatment of patients with traumatic and surgical wounds should be coordinated by the appropriate trauma team, burn unit, or other wound care specialist. All patients with simple and complex dehisced surgical incisions should be referred back to the attending surgeon for reassessment. Simple dehisced surgical incisions and wounds that do not extend beyond the fascia will typically heal without surgical intervention. However, wounds that extend to the fascia or beyond will require reconstructive surgery, such as a flap or graft.

The main role of NPWT in traumatic and surgical wounds is to lead to definitive surgical closure or to achieve delayed primary closure using a fasciocutaneous flap, muscle flap, or skin graft, or secondary closure with an MWH dressing. NPWT can be initiated immediately after surgical debridement, provided a clean wound surface and hemostasis have been obtained. If the clinician questions the adequacy of the debridement or some bleeding continues at the site, the wound may be covered with a MWH dressing and reassessed after 24 hours.

**Considerations for use.** If there are no contraindications (see **Table 4**), and the patient’s health status, wound bed, and local wound environment have been fully optimized (see **Table 1**), NPWT should be considered first-line therapy.

» Strongly consider the use of NPWT as first-line therapy for wounds that have a large amount of soft tissue loss, dehisced surgical incisions that do not require re-exploration, abdominal compartment syndrome (ACS), and open extremity fractures that are complex and have significant soft tissue loss.

- *Wounds with a large amount of soft tissue loss.* Where there is a large amount of soft tissue loss, NPWT provides temporary coverage of the wound, thus preventing bacterial contamination. It also facilitates wound bed preparation and graft-take by stimulating angiogenesis and the growth of healthy granulation tissue.
- *Dehisced surgical incisions.* Dehisced surgical incisions that do not require re-exploration are wounds that have no dead space, exposed hardware or joint spaces, or stripped bone. These wounds have retained

#### The main roles of NPWT in traumatic and surgical wounds are

- to provide a bridge to definitive surgical closure
- to achieve delayed primary closure using fasciocutaneous flap, muscle flap, or skin graft
- to achieve secondary closure with an MWH dressing

their skin elasticity, which facilitates wound healing. The application of NPWT increases the rate at which new granulation tissue fills the wound bed and thereby facilitates wound healing, presumably by producing macrodeformations on the wound edges, which stimulate contracture and draw

**Table 5. When to discontinue negative pressure wound therapy**

<ul style="list-style-type: none"> <li>• Achievement of desired goals:                             <ul style="list-style-type: none"> <li>– Exudate volumes have reduced sufficiently to allow patient to be transitioned to another treatment modality</li> <li>– The wound bed is sufficiently prepared with granulation tissue</li> <li>– The wound is prepared for a flap or graft</li> <li>– Wound is optimized for surgical closure</li> <li>– Wound becomes superficial</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>• Failure to improve:                             <ul style="list-style-type: none"> <li>– Deterioration of wound</li> <li>– Worsening infection</li> <li>– Significant periwound maceration</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>• Complications develop:                             <ul style="list-style-type: none"> <li>– Excessive bleeding</li> <li>– Inability to obtain an adequate seal</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>• Poor patient compliance</li> </ul>
<ul style="list-style-type: none"> <li>• Patient cannot tolerate therapy (eg, due to pain, allergy)</li> </ul>

the wound edges together.<sup>62</sup> It is therefore most effective in deep, dehisced surgical wounds.

- *ACS.* Patients who develop ACS after blunt trauma often require surgical decompression and coverage of the open abdomen with a temporary skin closure to permit re-entry if ACS recurs. Members of the expert panel agree that NPWT is an appropriate treatment for ACS. NPWT stabilizes the abdominal wall and provides a temporary closure that prevents bacterial contamination and can be easily removed while continuously removing exudate and infectious material from the wound bed.<sup>62</sup>
- *Complex, open extremity fractures with significant tissue injury.* Consultation with an orthopedic surgeon is recommended for patients with complex, open extremity fractures with significant soft tissue injury. The use of NPWT allows clinicians to easily check bone vitality during dressing changes and determine if further soft tissue or bone debridement is necessary. Depending on the underlying condition of the bone, NPWT will facilitate the growth of clean granulation tissue for acceptance of a graft or flap.

Table 6. Recommendations for the use of negative pressure wound therapy in patients with traumatic or surgical wounds	
Recommendation	Indication
Strongly consider	<p>Wounds with a large amount of soft tissue loss</p> <ul style="list-style-type: none"> <li>• Necrotizing fasciitis</li> <li>• Degloving injury</li> <li>• Subcutaneous infiltration injuries with extravasation</li> <li>• Abscess</li> <li>• Open amputation</li> <li>• Post-tumor ablation</li> </ul> <p>Dehiscenced surgical incisions that do not require re-exploration</p> <p>Abdominal compartment syndrome</p> <p>Open-extremity fractures that are complex and have significant soft tissue loss</p>
Consider on a patient-by-patient basis	<p>Complex dehiscenced surgical incisions</p> <ul style="list-style-type: none"> <li>• Open sternal wounds</li> <li>• Exposed surgical implant or bone</li> <li>• Large cavity</li> <li>• Dead space</li> <li>• Flap salvage</li> </ul> <p>Fasciotomy sites</p> <p>Burns</p> <p>Open extremity fractures with low complexity and minimal or no soft tissue loss</p>

» Consider using NPWT on a patient-by-patient basis for complex dehiscenced surgical incisions, fasciotomy, burns, sternal wounds, or open extremity fractures with low complexity and minimal or no soft tissue loss.

- *Complex dehiscenced surgical incisions.* NPWT can be used to promote the healing of complex dehiscenced surgical incisions that have dead space, a large cavity, or an exposed vital structure, bone, or surgical implant if the primary surgeon indicates that surgical re-exploration is not necessary. NPWT may be most effective for treating deep wounds, as it expedites healing by both immediate (skin elastic properties) and secondary contraction. Early intervention is optimal to prevent bacterial contamination of the wound.

NPWT may be considered when a primary surgical incision or secondary flap closure fails to heal or re-opens after soft tissue cancer resection and the development of lymphedema. Treatment can be safely initiated only after a histological specimen has demonstrated that the wound margins are free of malignancy. NPWT is beneficial in this type of wound because it effectively

removes the lymphatic fluid and optimizes moisture levels to facilitate healing.

The goal is to obtain flat granulation tissue that fills the wound bed so it can be grafted or healed with an MWH dressing. Wounds in this category include open sternal wounds, degloving injuries, and wounds requiring flap salvage. For a wound with a large subcutaneous cavity but small skin defects, a nonadherent dressing that can be inserted into the cavity without enlarging the superficial opening may be preferable.

- *Fasciotomy.* In fasciotomy wounds, there is no significant skin loss and the periwound skin has retained its elastic properties, which should facilitate wound closure. Consequently, these wounds are good candidates for NPWT. After fasciotomy and surgical debridement, the wounds should be covered with a hemostatic dressing for 24 hours to control bleeding. NPWT then can be applied once hemostasis has been achieved. The initial goal of NPWT in fasciotomy is to remove excess exudate and decrease the edema that made the fasciotomy necessary. Secondary goals include continued management of exudate levels, re-epithelialization, and wound closure.
- *Burns.* NPWT should be considered on a patient-by-patient basis for deep burns with exposed tendon or bone, as well as for localized third-degree burns. It is not useful in the treatment of superficial, first-, or second-degree burns. The decision to use NPWT should ultimately be made by a specialist within a burn unit. If deemed appropriate, NPWT can be initiated immediately after wound debridement, provided a clean wound surface and hemostasis have been obtained. NPWT is best used on confined areas during the early stages of burn therapy. Good candidates for NPWT should have at least 2 cm of healthy tissue or scar tissue encircling the burned area to permit application of the NPWT device and maintenance of a good vacuum seal.

Evidence suggests that the application of NPWT to deep partial-thickness burns during the first 6 to 12 hours post-injury decreases edema and stops burn progression, possibly by inducing massive hyperperfusion in the tissue surrounding the burn.<sup>59,62</sup> NPWT is recommended before the grafting of full-thickness burns to optimally prepare the wound bed for graft acceptance by promoting the growth of healthy granulation tissue over exposed tendons and bone and after grafting to help secure the graft to the wound bed and facilitate graft-take.

- *Sternal wounds: mediastinitis.* Mediastinitis secondary to a deep sternal wound is a serious postoperative complication associated with notable morbidity and mortality if it is recognized late or treated inappropriately. Traditionally, treatment has consisted of extensive debridement fol-

lowed by the administration of antibiotics and flap reconstruction.<sup>63</sup> However, two recent reports indicate that NPWT may be an effective post-debridement adjunctive treatment for mediastinitis, promoting granulation, resolution of infection, and wound closure without a need for muscle flap or omentoplasty.<sup>63,64</sup>

The efficacy of NPWT in mediastinitis is attributed to its ability to effectively drain exudate, promote granulation tissue formation, isolate and stabilize the chest wall, and allow earlier ambulation so that patients can participate in physiotherapy.<sup>64</sup> The decision to use NPWT in a patient with mediastinitis should be made by a cardiac surgeon.

- *Open extremity fractures without soft tissue injury.* NPWT should be considered on a patient-by-patient basis for open extremity fractures without soft tissue injury because these wounds are usually punctiform after fracture reduction and heal by primary intention or with the application of a MWH dressing. There are cases where NPWT may be clinically effective, however, patients must be carefully selected.

**Use of MWH dressings.** MWH dressings can be used before debridement to prepare the wound for the excision of devitalized tissue or post-debridement to optimize the wound bed for NPWT. Based on clinical experience, the expert panel recommends the use of an antimicrobial MWH dressing during the first 24 hours post-debridement to ensure adequate hemostasis and infection control. MWH dressings also should be considered for use between sequential surgical or sharp debridement because they allow adequate absorption of exudate and are associated with a lower risk of enhanced bleeding.

Once NPWT has been discontinued, the use of MWH dressings may be considered as a transition therapy to promote secondary closure of the wound without surgery.

**Skin Grafts**

**Considerations for use.** If there are no contraindications (see **Table 4**) and the patient’s health status, wound bed, and local wound environment have been fully optimized (**Table 1**), NPWT should be considered first-line therapy.

» Strongly consider NPWT for skin grafts and graft substitutes on complex areas that are subject to shear and movement and more complex anatomical sites, such as the groin, axilla, and joints.

NPWT’s role in skin grafting is to optimally prepare the wound surface for graft acceptance and to enhance post-graft adherence and survival. Skin grafts fail because

**Table 7. Recommendations for the use of negative pressure wound therapy in patients with skin grafts or skin substitutes**

Recommendation	Indication
Strongly consider	For skin grafts and skin substitutes on complex areas: <ul style="list-style-type: none"> <li>• Areas of flexion/extension</li> <li>• More complex anatomical sites:                             <ul style="list-style-type: none"> <li>– Groin</li> <li>– Axilla</li> <li>– Joints</li> </ul> </li> </ul>
Consider on a patient-by-patient basis	Patients who need early mobilization Patients who need rapid hospital discharge
Not recommended	Simple grafts for which cost and length of hospital stay do not warrant its use

of shear forces or the development of a hematoma, seroma, or infection. The application of negative pressure contours the dressing so it conforms to the wound surface. This stabilizes the graft and prevents shearing and removal. The drainage of exudate reduces the risk of

hematoma and seroma while helping maintain an infection-free state. Enhanced granulation facilitates revascularization and attachment of the graft to the wound bed. Finally, the use of non-adherent interfaces prevents overgrowth of granulation tissue into the dressing and decreases the risk of disrupting the graft during the first dressing change.

» Consider using NPWT for skin grafts and skin substitutes on a patient-by-patient basis when early mobilization or rapid hospital discharge is required.

Although there have been no systematic studies to this effect, NPWT may improve patient QoL by eliminating cast trauma and reducing the risk of pressure ulcers and deep vein thrombosis. The results from two published reports<sup>45,65</sup> and the combined clinical experiences of the panel members suggest that NPWT may decrease the time for wound bed preparation (7 days versus 17 days when NPWT is not used) and skin grafts to take (3 to 7 days versus 7 to 10 days when NPWT is not used). After 5 days of NPWT, a skin graft site should appear less congested and less edematous, which would be consistent with improved vascular integrity at this early time point when venous congestion can be a problem.

**MWH healing can be used in traumatic and surgical wounds**

- before debridement, to prepare the wound for the excision of devitalized tissue
- post-debridement, to optimize the wound bed for NPWT
- post-NPWT, to promote secondary closure of the wound without surgery

Graft adherence is also usually more uniform when NPWT is used, which may be due to improved inosculation, as well as decreased hematoma and seroma formation, and frictional disruption of wound bed/skin graft interface. In addition, depending on the location of the graft, many patients are able to ambulate because of the stabilizing effect of the NPWT device. Therefore, all the benefits of early ambulation can be appreciated, including shorter hospital stays.<sup>65-67</sup>

» NPWT is not recommended for simple grafts where the cost of treatment and/or length of hospital stay do not warrant its use.

Simple skin grafts are easily managed and do not require extended hospital stays. Expediting the patient's discharge to home offers a cost-effective advantage to both hospital and patient.

**When to initiate and discontinue NPWT.** Once the patient, wound bed, and local wound environment have been fully optimized, NPWT can be initiated to facilitate wound bed preparation for graft acceptance and then continued after graft application to enhance graft take. Skin grafts and skin substitutes should be examined regularly for signs of deterioration and dressings should be changed every 3 to 5 days. NPWT can be discontinued when the graft shows signs of vascularity and adherence to the wound bed. If used for excessively long periods, NPWT can result in an overgrowth of granulation tissue, which will inhibit epithelialization.

**Use of MWH dressings.** The goal of using MWH dressings in skin grafting is to expedite graft take while minimizing complications such as hematoma, seroma, shear stress, and infection. Grafts will not adhere to nondebrided surfaces and will desiccate and slough if they are placed where there is inadequate moisture control. The application of an appropriate MWH dressing before grafting can maintain a moist, infection-free environment that is optimally prepared to accept the graft. The expert panel suggests that clinicians consider using an antimicrobial MWH dressing that encourages autolytic debridement and promotes granulation while maintaining a noninfected state.

After grafting, the goal of treatment with MWH dressings is to maintain a surface that allows fluid egress and provides mild compression to prevent desiccation and graft loss. This includes the use of nonadherent dressings with antimicrobial agents to reduce the risk of infection. Paying close attention to each of these goals also

will decrease the amount of pain experienced by the patient and improve the level of tolerance to the treatment.

## CHRONIC WOUNDS

### Pressure Ulcers

Pressure ulcers, as the name suggests, are caused by pressure — or a combination of pressure, friction, and shear forces — on the skin and/or underlying tissues of the body, usually over a bony prominence.<sup>68,69</sup> Four categories/stages are used to describe the severity of tissue damage present at the site of the wound.<sup>68</sup>

Cumulative results from 1.94 million start-of-care assessments from the Outcome and Assessment Information Set (OASIS) database generated by Medicare between 2003 and 2004 revealed that 6.8% of the home health population had pressure ulcers.<sup>67</sup> Of these, 23% had category/Stage III/IV ulcers and 31% had nonhealing ulcers.<sup>67</sup> The use of NPWT in this population was associated with lower rates of hospitalization, fewer hospitalizations due to wound problems, and less use of emergency care in comparison to non-NPWT use.<sup>67</sup>

**Considerations for use.** If there are no contraindications (see **Table 4**) and the patient's health status, wound bed, and local wound environment have been fully optimized (**Table 1**), NPWT should be considered first-line therapy.

» Strongly consider NPWT for category/Stage IV pressure ulcers and heavily exuding category/Stage III pressure ulcers.

International guidelines, developed by the European Pressure Ulcer Advisory Panel

(EPUAP) and the National Pressure Ulcer Advisory Panel (NPUAP) in 2009, recommend the use of NPWT for deep category/Stage III/IV pressure ulcers based on level 2–5 clinical studies demonstrating consistent statistical support for the recommendation (see **Table 9**).<sup>70</sup> NPWT can promote rapid healing of deep pressure ulcers that may be unresponsive to other treatment modalities by stimulating the growth of new granulation tissue, which quickly fills the wound bed and draws the edges together.

The volume and density of the exudate are both important factors to consider when deciding if NPWT is appropriate. Because the vacuum created by negative pressure very effectively removes excess

fluids from the site of injury, NPWT is most efficacious in wounds that have a high volume of exudate. The density of the exudate, on the other hand, affects the frequency of dressing changes. Dressings can be more easily removed when there is low-density serous or serosanguinous

For skin graft and skin substitutes, optimization of the wound bed is necessary to achieve maximum benefit from NPWT. This should include excisional debridement, complete infection control and, ideally, complete hemostasis, though minor bleeding will not impair graft-take when NPWT is used for meshed grafts.

The expert panel suggests the application of an antimicrobial MWH dressing before grafting to maintain a moist, infection-free environment that is optimally prepared to accept the skin graft.

**Table 8. Recommendations for the use of negative pressure wound therapy in patients with pressure ulcers**

Recommendation	Indication
Strongly consider	Category/Stage IV ulcers Category/Stage III ulcers with heavy exudate
Consider on a patient-by-patient basis	Category/Stage III ulcers with low exudate Unstageable ulcers
Not recommended	Category/Stage I and II ulcers Suspected deep tissue injury

**Table 9. Pressure ulcer categories/stages<sup>70</sup>**

<b>Suspected deep tissue injuries:</b> Discoloration of intact skin or a blood-filled blister resulting from soft tissue injury due to pressure and/or shear force. Preceding symptoms may include pain, firmness, softening, and localized tissue changes with temperature changes (warmer or cooler)
<b>Category/Stage I:</b> Non-blanchable erythema of intact skin
<b>Category/Stage II:</b> Partial-thickness skin loss of the epidermis, dermis, or both
<b>Category/Stage III:</b> Full-thickness skin loss that extends down to but not through the underlying fascia; bone, tendon, and muscle are not exposed
<b>Category/Stage IV:</b> Full-thickness skin loss, characterized by extensive tissue destruction and necrosis, with exposed bone, tendon, or muscle
<b>Unstageable:</b> Full-thickness tissue loss where the ulcer base is covered by slough and/or eschar in the wound bed

drainage, and wear time is longer than when there is high-density proteinaceous drainage.

» Consider using NPWT on a patient-by-patient basis for category/stage III pressure ulcers with low exudate and unstageable ulcers.

The degree to which the health status of the patient, wound bed, and local environment surrounding the injury can be optimized will factor into the decision-making process of whether to use NPWT or another treatment modality for category/Stage III pressure ulcers with low exudate. NPWT will not compensate for the poor healing of a wound that is stagnating secondary to poor nutrition, infection, or ischemia. Judicious use of NPWT in pressure ulcers with low exudate is advised because NPWT may cause wound desiccation and increased pain upon dressing removal. For unstageable pressure ulcers, first consider debridement, then NPWT, on patient-by-patient basis.

» NPWT is not recommended for category/stage I and category/stage II pressure ulcers and areas of suspected deep tissue injury.

Category/Stage I and II pressure ulcers are superficial wounds that will respond positively to MWH dressings or another treatment modality.<sup>71</sup> The expert panel recommends that clinicians follow the Pressure Ulcer Prevention and Treatment Clinical Practice Guidelines when caring for patients with category/Stage I and II pressure ulcers as well as suspected deep tissue injury.<sup>71</sup>

**When to initiate and discontinue NPWT.** Patients with category/Stage III/IV pressure ulcers should be assessed for contraindications to NPWT and undergo debridement if appropriate. If there are no contraindications (see

**Table 4**) and the patient’s overall health status, wound bed, and local wound environment have been optimally prepared (see **Table 1**), NPWT can be initiated. The location of the ulcer

(eg, trunk, sacral, gluteal) will determine the effectiveness of NPWT because a wound site in close proximity to the anus or a bony prominence may make obtaining a good seal difficult.

NPWT should be discontinued when the wound has been optimized for surgical closure or has healed sufficiently to transition to MWH dressings or another wound care modality. Although there are many ways to measure wound healing, the most common method is measuring reductions in the area and volume of the wound.<sup>71,72</sup>

Based on clinical experience, the expert panel agreed that NPWT should be continued if there is a 30% reduction in width and depth over 4 to 6 weeks. If a 30% reduction is not achieved within 6 weeks, a transition from NPWT to another treatment modality generally should be considered. Some wounds will not fit this definition because of wound and patient characteristics; they should be evaluated based on the previously selected goals for NPWT. In wounds that do not follow this trajectory, the following factors should be reassessed: the patient; the wound; the adequacy of pressure relief obtained through patient repositioning; and the use of offloading devices, specialized mattresses and bedding, and other strategies designed to redistribute pressure.

**Use of MWH dressings.**

Depending on the severity of the ulcer and its clinical progression, MWH dressings may be used at many points during the healing process. The expert

panel recommends clinicians consider MWH dressings as first-line therapy for category/Stage I/II ulcers that are superficial or partial-thickness, and as appropriate transition therapy for category/Stage III–IV full-thickness ulcers that

NPWT will not compensate for the poor healing of a wound that is stagnating secondary to poor nutrition, infection, or ischemia.

**Table 10. The Wagner classification of diabetic foot ulcers<sup>73</sup>**

Grade	Lesion
0	No open wounds Cellulitis or deformity may be present
1	Superficial wound Wound may be partial or full thickness
2	Ulcer extends to involve such structures as ligaments, tendons, the joint capsule, or deep fascia No abscess or osteomyelitis present
3	Deep ulcer Demonstrates abscess, osteomyelitis, or joint sepsis
4	Localized gangrene of part of the forefoot or heel Involved areas include part of the forefoot or heel
5	Gangrene is extensive and involves the entire foot

have achieved a 75% reduction in size or wound depth (<1.0 cm with NPWT). It is also appropriate for patients who have full-thickness ulcers on challenging anatomical sites that make obtaining good vacuum seals difficult.

Wounds that have high-volume exudate or high-density purulent characteristics may benefit from sharp debridement because these conditions imply a high bacterial count. In addition, sharp debridement may be beneficial when the amount of necrotic or fibronectic material in the wound bed approaches 30%. MWH dressings should be considered for patients who are between surgical or sharp debridement to promote hemostasis and prevent periwound maceration by facilitating the management of wound exudate. MWH dressings also can be used to promote autolysis in the wound bed and thereby aid in the identification of areas requiring further debridement. MWH dressings facilitate autolytic debridement by trapping the moisture that proteolytic and fibrinolytic enzymes (found in chronic wound fluid) require to break down necrotic tissue.<sup>23</sup>

It is the expert panel's recommendation that MWH dressings be considered

- first-line therapy for category/Stage I/II pressure ulcers that are superficial or partial thickness
- an appropriate transition therapy for category/Stage III/IV full-thickness pressure ulcers that have achieved a 75% reduction in size or wound depth < 1.0 cm with NPWT

Diabetic patients should be referred to a foot and ankle wound care specialist as soon as an opening in the skin occurs.

**Diabetic Foot Ulcers**

Arterial insufficiency, neuropathy, pressure, biomechanical abnormalities, foot deformity, and limited joint mobility all contribute to the development of DFUs. Successful

treatment depends upon accurately diagnosing the etiology and severity of the ulcer and maximally managing the underlying causes.

It is recommended that patients with Wagner grades 2–4 DFUs be referred to a foot and ankle wound care specialist to obtain surgical debridement options and recommendations for follow-up treatment. Referral should occur as soon as there is an opening in the skin.

NPWT has the potential to improve QoL in patients with DFUs. Limb salvage and minimization of the level of amputation should result in improved ambulation, increased independence, and the ability to return to work and resume a productive lifestyle. Because NPWT is associated with rapid healing, the time needed to optimize the wound for surgical closure or transition to an alternate wound healing modality should be decreased. This, in turn, should reduce the length of hospital stays.

**Optimization: special considerations for the patient with a DFU.** When addressing comorbid conditions and other health concerns in a patient with a DFU, special attention should be paid to the patient's vascular status to ensure the limb's blood supply will adequately support healing. Referral to a vascular surgeon is mandatory if ischemia is present.

It is also important that diabetes and any comorbidities — such as hypertension, vascular disease, and renal dysfunction — be maximally managed, as each of these could potentially impair healing. The presence of osteomyelitis or cellulitis requires a surgical consultation to immediately drain abscesses and remove

necrotic tissue.

Surgical interventions should be considered to correct deformities that are contributing to ulcer formation, such as bony prominences, biomechanical abnormalities, collapsed foot, or Charcot foot. The use of offloading techniques to reduce pressure and shear forces is required to maximize healing potential.

**Considerations for use.**

If there are no contraindications (see **Table 4**) and the patient's health status, wound bed, and local wound environment have been fully

optimized (**Table 1**), NPWT should be considered first-line therapy.

» Strongly consider NPWT as first-line therapy for debrided Wagner grade 4 foot ulcers.

NPWT is most appropriate for deep ulcers with and without high levels of exudate because it stimulates rapid regrowth of healthy granulation tissue to fill the wound bed. Excessive exudate is normally due to infection or autonomic neuropathy in patients with DFUs. Good management includes resolving these etiologic factors to minimize the deleterious effects that high levels of exudate can have on wound healing. By creating a vacuum seal, NPWT is able to effectively remove excess exudate and thereby decrease the risk of maceration and infection. Wagner grade 4 foot ulcers should be completely debrided before initiating NPWT to remove all dead tissue and any evidence of gangrene.

» Consider using NPWT on a patient-by-patient basis for debrided Wagner grade II/III ulcers with treated infection.

The decision to use NPWT versus an alternate mode of therapy in the treatment of Wagner grade 2/3 foot ulcers is based on the degree to which the patient's health status, wound bed, and local wound environment can be optimized, as determined by clinical judgment. The use of NPWT is contraindicated when there is inadequate revascularization. Patients with an ankle brachial index (ABI) <0.5 and transcutaneous oxygen pressure (TcPO<sub>2</sub>) <20 to 30 mmHg are poor candidates for NPWT because their vascular statuses will not sufficiently support healing. NPWT is also contraindicated when pressure-offloading devices cannot be applied while NPWT is in use.

Although NPWT is used most effectively to facilitate the healing of deep ulcers, patients with Wagner grade 2 ulcers that are wide or have high levels of exudate may be good candidates for NPWT even if the ulcers are not deep.

Wagner grade 2/3 ulcers should be adequately debrided before applying the NPWT device. If there is any doubt that an underlying soft tissue or bone infection has been eradicated, NPWT should be deferred until the clinician is satisfied that the infection has been completely controlled.

» NPWT is not recommended for Wagner grade 1 or 5 ulcers.

NPWT is contraindicated in Wagner grade 5 foot ulcers due to the presence of extensive gangrene and, hence, the potential need for amputation. Although NPWT is not typically recommended for the treatment of Wagner grade 1 ulcers, it can sometimes be used to ensure granulation of a newly debrided but shallow wound on a diabetic foot.

**When to initiate and discontinue NPWT.** NPWT should be initiated under the guidance of a foot and ankle

**Table 11. Recommendations for the use of negative pressure wound therapy in patients with diabetic foot ulcers**

Recommendation	Indication
Strongly consider	Debrided Wagner grade 4
Consider on a patient-by-patient basis	Debrided Wagner grade 2/3 wounds with treated infection
Not recommended	Wagner grade 1 Wagner grade 5

wound care specialist, because patients with DFUs need to be carefully and regularly reviewed. NPWT can be initiated only after infection has been completely controlled and ischemia has been excluded as a cause of the ulcer or revascularization has been successfully achieved.

NPWT should be discontinued when the foot ulcer has been optimized for surgical closure or when the wound bed has been fully granulated and the ulcer has become superficial and flush with the intact skin (eg, Wagner grade I). The granulation tissue should be clean; free of fibrotic, necrotic, and other nonviable tissue; and should cover the bone in the case of osteomyelitis. At this time, the wound can be transitioned to a MWH dressing.

**Use of MWH dressings.** MWH is considered first-line therapy for Wagner grade 1 ulcers that have clean granulation tissue and as transition therapy for full-thickness wounds that have healed to the point NPWT can be discontinued. The use of MWH dressings also may be considered for patients who cannot be placed in appropriate pressure-offloading devices because they interfere with NPWT application.

MWH dressings may be considered for patients who are undergoing sequential surgical or sharp debridement to achieve hemostasis, infection control, and excessive wound fluid drainage. Chronic wound debridement is

essential to enhance wound closure. A multicenter clinical trial found the healing rate of DFUs was lowest in the medical center that performed the fewest aggressive sharp debridements during the 20-week study period.<sup>74</sup>

**Arterial and Venous Leg Ulcers**

Many factors contribute to the development of lower-extremity ulcers. Because the treatment of an ulcer will vary according to its etiology, it is important to obtain an accurate diagnosis before initiating therapy. Successful

MWH dressings may be considered

- first-line therapy for Wagner grade I ulcers
- transition therapy for full-thickness foot ulcers that have become fully granulated during NPWT
- for use between sequential surgical or sharp debridement

**Table 12. Recommendations for the use of negative pressure wound therapy in patients with arterial and venous leg ulcers**

Recommendation	Indication
Strongly consider	Fully optimized venous leg ulcers with high levels of exudate that have failed compression therapy
Consider on a patient-by-patient basis	Ulceration in patients with lymphedema Arterial ulcers that have been successfully revascularized
Not recommended	Arterial leg ulcers with inadequate blood flow

treatment of a venous, arterial, or mixed arterial/venous ulcer depends upon achieving adequate blood flow and correcting the primary underlying pathology.

**Considerations for use.** If there are no contraindications (see **Table 4**) and the patient’s health status, wound bed, and local wound environment have been fully optimized (see **Table 1**), NPWT should be considered first-line therapy.

» Strongly consider using NPWT as first-line therapy for venous leg ulcers that have been fully optimized, have a high level of exudate, and have failed compression therapy.

NPWT should be strongly considered for venous leg ulcers that have a high level of exudate when compression or compression plus an appropriate dressing have failed to adequately control exudate levels.

» Consider using NPWT on a patient-by-patient basis for venous leg ulcers with lymphedema and for arterial ulcers that have been successfully revascularized.

Patients with lymphedema often will have failed other forms of treatment and will have difficult limb shapes that make compression therapy more difficult to apply. These patients should be assessed on an individual basis to determine if they are good candidates for NPWT. NPWT may be considered for ulcers up to 30 cm<sup>2</sup> in size, provided there is good pain management, adequate exudate control, and no infection.

Surgical restoration of vascular blood flow is first-line therapy for an arterial ulcer. Once blood flow has been restored, NPWT may be considered on a patient-by-patient basis to accelerate granulation tissue formation in the recently revascularized arterial ulcer.

NPWT may be considered on a patient-by-patient basis to accelerate granulation tissue formation in the recently revascularized arterial ulcer.

The use of an MWH dressing in combination with compression bandaging or hosiery is recommended as first-line therapy for venous leg ulcers.

NPWT may be indicated when exudate levels are high. However, it should be used cautiously in circumferential ulceration where the application of the NPWT device may cause a tourniquet effect.

» NPWT is not recommended in arterial leg ulcers with inadequate blood flow.

NPWT is not recommended for the treatment of arterial leg ulcers in which the vascular supply to the affected limb is insufficient.

**When to initiate and discontinue NPWT.** It is important to assess the vascular status of a patient with a chronic leg ulcer to ensure the limb has an adequate blood supply to support healing. Referral to a vascular surgeon is mandatory if ischemia is present. NPWT can be initiated if there are no contraindications (see **Table 4**) and the patient’s health status, wound bed, and local wound environment have been fully optimized to receive therapy (see **Table 1**). Optimization includes adequate debridement, treatment of infection, good pain management, control of exudate levels in venous leg ulcers, and revascularization of arterial leg ulcers when indicated.

NPWT should be terminated when the ulcer has been optimized for surgical closure or the wound bed has

become fully granulated and superficial in depth. The granulation tissue should be clean; free of fibrotic, necrotic, and other nonviable tissue; and should cover the bone, in the case of osteomyelitis.

**Use of MWH dressings.** The use of an MWH dressing in combination with compression bandaging or hosiery is recommended as first-line therapy for venous leg ulcers. MWH dressings should be considered for the treatment of arterial ulcers that have insufficient blood flow in parallel with the option to surgically revascularize the tissue. Once the patient has been successfully revascularized and the blood flow in the affected limb is deemed adequate for healing, the use of MWH dressings is recommended.<sup>75</sup>

In addition, the use of MWH dressings should be considered

- as an alternative therapy for both venous and revascularized arterial ulcers that have failed NPWT, provided the patient, wound bed, and local wound environment have been reassessed to ensure that all clinical parameters are fully optimized; and/or
- between sequential surgical or sharp debridement to control bleeding and prevent maceration of the periwound area by absorbing excess exudate.

## CONCLUSION

Wound care clinicians have a wide array of treatment options available with which to manage and help heal acute and chronic wounds. The challenge is to determine the most appropriate treatment strategy while considering many factors regarding the wound, the patient, and the cost of care to ensure that assessments, treatment pathways, and product selections are both clinically and economically sound.

The benefits of managing wounds using advanced dressings that promote MWH have been well established. For many wounds, treatment with MWH dressings is the most appropriate choice. However, some clinical scenarios may indicate the use of NPWT as first-line or adjunctive therapy. NPWT has been shown to benefit the management of many types of acute and chronic wounds. When used in select patients, and after health status, wound bed, and local wound environment have been optimally prepared, NPWT can be an efficacious and cost-effective means to promote wound healing.

This appropriate-use guidance document provides recommendations that may guide clinicians in developing treatment strategies for a variety of acute and chronic wounds. Included in this document are important considerations, such as the criteria to initiate NPWT based on various wound types; pre-application management to optimize treatment outcomes; identification of appropriate candidates for NPWT; benchmark indicators for treatment response; and recommendations on when to transition between NPWT and MWH or another treatment modality.

Wound care clinicians always should assess each case based on individual treatment goals and clinical judgments. Finally, this document serves as a guide to encourage wound management strategies that will lead to positive and cost-effective outcomes. ■

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