Special considerations in wound bed preparation 2011: an update

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Keywords: wound bed preparation, stalled wound, chronic wound, holistic approach, leg and foot ulcers, healable and nonhealable wounds, maintenance wounds

Abstract

This article builds and expands upon the concept of wound bed preparation introduced by Sibbald et al in 2000 as a holistic approach to wound diagnosis and treatment of the cause and patient-centered concerns such as pain management, optimizing the components of local wound care: Debridement, Infection and persistent Inflammation, along with Moisture balance before Edge effect for healable but stalled chronic wounds.

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Background

This article incorporates a framework for assessment, diagnosis, and treatment of wounds along the continuum toward optimal healing.¹ The authors will introduce evidence-based and best clinical practice-based strategies for providing holistic and patient-centered care. It is important to treat the whole patient and not just the “hole” in the patient. The preparation and optimization of the wound bed for functional healing may not always result in complete healing, despite the clinicians’ comprehensive team efforts. It is also important to recognize that some wounds may remain in the static or “stalled” phase of the wound-healing trajectory.

The authors recognize that wound-healing trajectories can be heterogeneous and nonuniform. They will explore several concepts to effectively manage the nonhealable wounds or a new category the authors term as “maintenance wounds” that are potentially healable but with existing patient or system barriers to effective treatment. These include patient adherence or competence to participate in treatment plans or systems-based errors embracing logistical issues that impede optimal healing. By reading this article, clinicians will comprehend and apply clinical criteria to help select and use the appropriate topical agents for superficial critical colonization versus systemic anti-infective agents for deep and surrounding tissue infection utilizing the mnemonic NERDS and STONEES. Clinicians will also be able to interpret new bedside diagnostic tests introduced in this article that may identify wounds stuck in the inflammatory stage.

This 2011 wound bed preparation (WBP) update also links evidence-informed practices to the evidence summarized in the recent Best Practice Guidelines of the Registered Nurses Association of Ontario. To date, 3 best practice documents related to the treatment of wounds (pressure, venous, and diabetic) have been issued by the Registered Nurses Association of Ontario, and the components related to local wound care have been considered for this summary along with updated literature searches. The information is organized with a quick reference guide of the key bedside assessment and treatment steps organized with the components of the WBP paradigm.
**Introduction**

As the population ages, acute and chronic wounds will become more frequent and prevalent, with increased chronicity. Any wound greater than 6 weeks old is considered chronic. Preparing the wound bed was first described in 2000 by Sibbald et al and Falanga with sequential updates by Sibbald et al in 2003 and 2006–2007 and reprinted by the World Health Organization (WHO) in 2010. The 2011 updated evidence-informed practice documents are presented that link the WBP paradigm to the evidence-based literature, expert opinion, the clinical environment, and organizational context. In Table I, the 3 components of Sackett’s triad have been accommodated: clinical evidence and expert opinion with the need to address patient preference (patient-centered concerns). In addition, the WoundPedia Best Practice summaries (www.woundPedia.com) utilized in this update are meant to provide a practical, easy-to-follow guide or as a bedside enabler for patient care. The levels of scientific evidence-based grading systems are outlined in Table II. For more detailed information on this grading system, the reader is referred to the Registered Nurses Association of Ontario Best Practice Guidelines (www.rnao.org/bestpractices.com) and/or the designated references.

**Chronic wounds: nonhealable and maintenance wound categories**

The holistic approach to healable wound management as outlined in Table I stresses an accurate diagnosis and successful treatment with a team approach. (See Enabler: Persons With Healable Chronic Wounds(s).) For patient wounds that do not have the ability to heal,

<table>
<thead>
<tr>
<th>#</th>
<th>Recommendations for wound bed preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Treat the cause</strong></td>
</tr>
<tr>
<td>a</td>
<td>Determine if there is adequate blood supply to heal.</td>
</tr>
<tr>
<td>b</td>
<td>Identify the cause(s) as specifically as possible or appropriate referrals.</td>
</tr>
<tr>
<td>c</td>
<td>Review cofactors/comorbidities (systemic disease, nutrition, medications) that may delay or inhibit healing.</td>
</tr>
<tr>
<td>d</td>
<td>Evaluate the person’s ability to heal: healable, maintenance, non-healable.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Develop an individualized plan of care.</strong></td>
</tr>
<tr>
<td>a</td>
<td>Treat the cause(s) related to specific wound etiology/diagnosis.</td>
</tr>
<tr>
<td>3</td>
<td><strong>Patient-centered concerns</strong></td>
</tr>
<tr>
<td>a</td>
<td>Assess and support individualized concerns:</td>
</tr>
<tr>
<td>b</td>
<td>Pain;</td>
</tr>
<tr>
<td>c</td>
<td>Activities of daily living;</td>
</tr>
<tr>
<td>d</td>
<td>Psychological well-being;</td>
</tr>
<tr>
<td>e</td>
<td>Smoking;</td>
</tr>
<tr>
<td>f</td>
<td>Access to care, financial limitations.</td>
</tr>
<tr>
<td>4</td>
<td><strong>Provide education and support to the person and his/her circle of care [including referral to increase adherence (coherence) to the treatment plan.]</strong></td>
</tr>
<tr>
<td>5</td>
<td><strong>Local wound care</strong></td>
</tr>
<tr>
<td>a</td>
<td>Assess and monitor the wound history and physical exam.</td>
</tr>
<tr>
<td>6</td>
<td>Gently cleanse wounds with low-toxicity solutions: saline, water and acetic acid (0.5-1.0%). Do not irrigate wounds where you cannot see where the solution is going or cannot retrieve (or aspirate) the irrigating solution.</td>
</tr>
<tr>
<td>7</td>
<td><strong>Debride:</strong> Healable wounds - sharp or conservative surgical, autolytic, mechanical, enzymatic, biological (medical maggots); Non-healable and maintenance - conservative surgical or other methods of removal of nonviable slough.</td>
</tr>
<tr>
<td>8</td>
<td>Assess and treat the wound for superficial critical colonization/Deep infection/Abnormal Persistent Inflammation (mnemonic NERDS), deep infection (mnemonic STONEES), or persistent inflammation: any 3 NERDS - treat topically: Non-healing, ↑ Exudate, Red-friable tissue, Debris, Smell; any 3 STONEES - treat systemically: ↑ Size, ↑ Temperature, Os, New breakdown, ↑ exudate, ↑ Erythema/Edema (cellulitis), Smell; Persistent Inflammation (non-infectious): Topical/or systemic anti-inflammatories.</td>
</tr>
<tr>
<td>9</td>
<td>Select a dressing to match the appropriate wound and individual person characteristics.</td>
</tr>
<tr>
<td>a</td>
<td>Healable wounds: Autolytic debridement: alginates, hydrogels, hydrocolloids, acrylics; Critical colonization: silver, iodides, PHMB, honey; Persistent inflammation: anti-inflammatory dressings.</td>
</tr>
<tr>
<td>b</td>
<td>Moisture balance: foams, hydrofibers, alginates, hydrocolloids, films, acrylics</td>
</tr>
<tr>
<td>c</td>
<td>Non-healable, Maintenance Wounds: chlorhexidine, povidone-iodine</td>
</tr>
<tr>
<td>10</td>
<td>Evaluate expected rate of wound healing: Healable wounds should be 30% smaller by week 4 to heal by week 12. Wounds not healing at the expected rate should be reclassified or reassessed, and the plan of care revised.</td>
</tr>
<tr>
<td>11</td>
<td>Use active wound therapies (skin grafts, biological agents, adjunctive therapies, etc) when other factors have been corrected and healing still does not progress (stalled wound).</td>
</tr>
<tr>
<td>12</td>
<td><strong>Provide organization support</strong></td>
</tr>
<tr>
<td></td>
<td>For improved outcomes, education and evidence-informed practice must be tied to interprofessional teams and improved cost-effective patient care outcomes with the cooperation of healthcare systems.</td>
</tr>
</tbody>
</table>

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Table II: Chronic wounds: nonhealable and maintenance wound categories

<table>
<thead>
<tr>
<th>Levels of evidence employed by RNAO guideline development panels (2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ia</td>
</tr>
<tr>
<td>Evidence obtained from meta-analysis or system review of randomized controlled trials.</td>
</tr>
<tr>
<td>Ib</td>
</tr>
<tr>
<td>Evidence obtained from at least one randomized controlled trial.</td>
</tr>
<tr>
<td>Ia</td>
</tr>
<tr>
<td>Evidence obtained from at least one well-designed controlled study without randomization.</td>
</tr>
<tr>
<td>Ii</td>
</tr>
<tr>
<td>Evidence obtained from well-designed, non-experimental descriptive studies such as comparative studies, correlation studies and case studies.</td>
</tr>
<tr>
<td>Iv</td>
</tr>
<tr>
<td>Evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities.</td>
</tr>
</tbody>
</table>
Wound Bed Preparation: Special considerations in wound bed preparation 2011: an update

...the approach is different. (See Enabler: Persons With Nonhealable or Maintenance Wound(s).) These individuals with the inability to heal (nonhealable wound) may be due to inadequate blood supply and/or the inability to treat the cause or wound-exacerbating factors that cannot be corrected. The second category, a maintenance wound, is when the patient refuses the treatment of the cause (e.g., will not wear compression) or a health system error or barrier (no plantar pressure redistribution is provided in the form of footwear or the patient cannot afford the device). These may change, and periodic re-evaluation may be indicated (see Enabler).

Chronic wounds are disabling and constitute a significant burden on patients’ activities of daily living (ADLS) and the healthcare system. Of persons with diabetes, 2% to 3% develop a foot ulcer annually, whereas the lifetime risk of a person with diabetes developing a foot ulcer is as high as 25%. It is estimated that venous leg ulcers (VLUs) affect 1% of the adult population and 3.6% of people older than 65 years. As our society continues to age, the problem of pressure ulcers (PrUs) is growing. Each of these common types of chronic wound will require accurate and concise diagnosis and appropriate treatment as part of holistic care.

Local wound care may also be difficult to optimize. Chronic wounds are often recalcitrant to healing, and they may not follow the expected trajectory that estimates a wound should be 30% smaller (surface area) at week 4 to heal in 12 weeks. If all 5 components of WBP have been corrected (cause, patient-centered concerns, and the 3 components of local wound care) and a healable wound is stalled, re-evaluation of the current diagnosis and treatment plan is necessary to be sure each component has been idealized before considering active local advanced therapies (edge effect). This update will clarify the system outlined above, dividing chronic wounds into healable, nonhealable, or maintenance.
maintenance, and nonhealable categories. The authors will develop the clinical parameters around critical colonization with any 3 or more of the 5 NERDS mnemonic criteria for topical therapy versus or any 3 or more of the 7 STONEES mnemonic criteria associated with the deep and surrounding skin infection for systemic antimicrobial agents.

The updated WBP 2011 quick reference guide is intended for all wound-healing practitioners from basic to intermediate or advanced levels ideally organized in transdisciplinary teams. To clarify the rationale for the evidence-informed practices, the authors discuss each item individually with reference to key supporting literature and enablers for practice where indicated.

Identify and treat the cause(s) of the wound

1A: Determine if there is adequate blood supply to heal

This is often important, especially for ulcers on the leg or foot. It is important to inspect the foot and lower leg for signs of arterial compromise (dependent rubor, pallor on elevation, and loss of hair on the foot or toes), as well as palpating for a plantar pulse (dorsalis pedis or posterior tibial). Practitioners need to remember that a small percentage of patients may have an anomalous or anatomical variance resulting in absence of the dorsalis pedis artery. A palpable pulse indicates a foot arterial pressure of 80 mm Hg or higher. The authors record a pulse as present or absent. However, a palpable pulse may not always exclude an arterial etiology. Although a foot pulse might be palpable, the nonhealing wound might be situated in a different angiosome that has to be revascularized in order to induce healing (angiosome model).15 Doppler examination of the Ankle Brachial Pressure Index (ABPI) is indicated if the pulse is not palpable or to assess the appropriateness of high or modified compression bandaging for venous ulcers (Table II).

The audible Doppler signals may also be useful diagnostically: a triphasic normal sound, a biphasic sound indicative of arterial compromise, and the monophasic or absent signal with advanced ischemia. Complete segmental lower-leg arterial Doppler examinations are needed if there is a possibility of a proximal lesion or arterial restriction or blockage that is amendable through surgical bypass or endovascular dilatation. If blood supply is inadequate or cannot be immediately determined, dressing selection should be based on a maintenance wound program with moisture reduction and bacterial reduction until further assessments are performed.

Toe pressures are useful because about 80% of people with diabetes and 20% of the nondiabetic population have calcified large leg arterial vessels that are nonplicable and stiff, leading to falsely high ABPI levels often greater than 1.3.13 When ABPI levels are this high, no conclusions can be drawn about the quality of limb perfusion without further investigation. In Table III, the arterial status is correlated to the vascular testing results.

1B: Identify the cause(s) as specifically as possible or make appropriate referrals

A comprehensive wound assessment is required to determine the cause of the wound. In order to achieve this, a holistic approach to the patient assessment is needed. An interprofessional team approach will facilitate a comprehensive review of the whole patient, the environmental factors, and the wound. In a recent community, comprehensive interprofessional assessment of leg and foot ulcer patients, more than 60% of diagnoses were changed or made more specific, leading to the implementation of best practices, thus facilitating the optimization of WBP and improving healing rates of chronic wounds.16

1C: Review cofactors/comorbidities (systemic disease, nutrition, medications) that may delay or inhibit healing

Wound healing can be delayed or interrupted in persons with a coexisting systemic disease and the multiple comorbidities associated with chronic wounds. In the case of diabetes, excess glycosylation of hemoglobin due to poor diabetic glucose control can result in prolonged inflammatory phase in addition to decreased neutrophil and macrophage phagocytosis of bacteria. Furthermore, diabetes affects the erythrocytes’ ability to deliver oxygen to the wound, a fundamental step in collagen synthesis and tissue proliferation17 along with numerous other important factors in wound healing. An original investigation by Markuson et al18 demonstrated that individuals with lower hemoglobin A1c (HgbA1c) levels had improved and shorter healing time. This translated to a cost reduction because the closed wounds had decreased risk of infection compared with the ulcers that were still in the healing phase.

A detailed review and clinical analysis of patient cofactors and comorbidities that may influence healing should be carried out in a systems-based approach. Systemic diseases such as diabetes or autoimmune disease may interfere with the stages of wound healing and stall or prevent healing.

A low protein intake or relative deficiency can prevent the production of granulation tissue that will contribute to a stalled healing environment

Table III: Arterial status is related to vascular results

<table>
<thead>
<tr>
<th>ABPI</th>
<th>Toe pressure, mm Hg</th>
<th>Toe brachial Index</th>
<th>Ankle Doppler waveform</th>
<th>TCP02, mm Hg</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 0.8</td>
<td>&gt; 80</td>
<td>&gt; 0.6</td>
<td>Normal/triphasic</td>
<td>&gt; 40</td>
<td>No relevant arterial disease</td>
</tr>
<tr>
<td>&gt; 0.5</td>
<td>&gt; 50</td>
<td>&gt; 0.4</td>
<td>Biphasic/monophasic</td>
<td>30-39</td>
<td>Some arterial disease: Modify compression</td>
</tr>
<tr>
<td>&gt; 0.4</td>
<td>&gt; 30</td>
<td>&gt; 0.2</td>
<td>Biphasic/monophasic</td>
<td>20-29</td>
<td>Arterial disease predominates</td>
</tr>
<tr>
<td>&lt; 0.4</td>
<td>&lt; 30</td>
<td>&lt; 0.2</td>
<td>Monophasic</td>
<td>&lt; 20</td>
<td>High risk for limb ischemia</td>
</tr>
</tbody>
</table>

Modified (with permission) from Browne and Sibbald14 and Sibbald et al15
for the wound. A given albumin measurement in a patient implies nutritional status over a few months, and these levels are a gross indicator of long-term nutritional deficit. Albumin levels measure the large reservoir of amino acids that serve as the fundamental building block for wound healing. Several other patient stressors can influence albumin levels. Normal serum albumin levels are 3.4 to 5.4 g/dL, and levels 2.0 to 3.4 g/dL are associated with potential delayed healing and may need to be treated as a maintenance wound until they are corrected. Prealbumin (transthyretin) is a more sensitive indicator of protein deficiency, reflecting levels over 18 to 21 days. Transferrin is often thought of as an indirect measurement of nutrition; however, levels elevate in response to infection or inflammation; therefore, results can be misleading in persons with a chronic wound. Cost and access to transferrin level testing may be a challenge in some practice settings.

Published literature attributes recumbent positioning of patients with a direct decrease in serum liver proteins such as albumin, prealbumin, and transferrin. Therefore, in utilizing the “whole patient” concept, we should optimize activity and mobilization.

Individualized patient medicine reconciliation should take place as part of any wound management protocol. Several medications that may alter the healing processes on the cellular level need to be identified. Some medications important to note in the assessment of a wound are high doses of systemic steroids, immunosuppressive drugs, and antimetabolite cancer chemotherapy. Vitamin E intake of more than the recommended 100 IU daily can impair healing because of its oxygen-scavenging property at the tissue level that is opposite to the oxygen-sparing property of vitamin C.

1D: Evaluate the person’s ability to heal: healable, maintenance, nonhealable

Categorizing a wound according to its ability to heal (healability) assists the clinician in determining an accurate diagnosis along with a realistic individualized treatment approach. Adequate tissue perfusion is necessary for a healing wound. As outlined above, decreased vasculature will increase the risk of infection and decrease healing. In order to be classified as a healing wound, the wound should have several attributes including an adequate blood supply; the cause of the wound must be corrected; existing cofactors, conditions, or medications that could potentially delay healing must be optimized or ideally corrected. A maintenance wound is a wound that may be healable but that either healthcare system factors or patient-related issues are preventing the wound from healing. A nonhealable wound is a wound that does not have adequate blood supply to support healing or the cause cannot be corrected. In nonhealable wounds, moist interactive healing is contra-indicated and debridement should be on a conservative basis only (expert opinion for SCALE document).

Woo et al (Table IV) assessed patients with lower leg and foot ulcers. The healing percentages of consecutive consenting home care patients with leg and foot ulcers from Toronto and Mississauga (Ontario, Canada) districts have been tabulated in the final column of Table II. The results indicated that most subjects had a demonstrated ability to correct the cause and achieve adequate circulation for healing (69.9%). Determining if a patient is healable, nonhealable (5.2%), or maintenance (24.9%) allows the clinician to identify and address specific individualized challenges, particularly for the nonhealable and maintenance wound patients. Along with the patient’s input, the clinician is able to tailor the nonhealable or maintenance care plan, facilitating responsible use of available resources along with realistic treatment goals. In general, advanced active therapies are not indicated for maintenance or nonhealable wounds.

When a healing wound does not progress at the expected rate, a chronic and stalled wound results. These wounds are more prevalent in older adults and are attributed to the aged skin and comorbidities, such as neuropathy, coexisting arterial compromise, edema, unrelieved pressure, inadequate protein intake, coexisting malignancy, and some medications. Persistent inflammation may be the cause of a stalled wound and in some cases may not be correctable. The presence of multiple comorbidities in some older adult patients implies that healing is not a realistic end point. For nonhealable or maintenance wounds, pain and quality of life may be indicated as the primary goals of care. Palliative wound care often includes nonhealable wounds, but patients undergoing palliative care may have maintenance or even healable wounds.

Frequently, skin changes at life’s end may be associated with individual risk factors and comorbidities. In 2009, an 18-member international expert panel explored the issues and research literature surrounding end-of-life skin and wound care, including the Kennedy Terminal Ulcer (case series evidence) and the concept of skin compromise. The panel developed a consensus document entitled “Skin Changes At Life’s End” (SCALE). A modified Delphi process

**Table IV: Determining the healability of a wound**

<table>
<thead>
<tr>
<th>Wound prognosis</th>
<th>Treat the cause</th>
<th>Blood supply</th>
<th>Coexisting medical conditions/drugs</th>
<th>No. of wounds + ability of wound to heal*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healable</td>
<td>Yes</td>
<td>Adequate</td>
<td>Not prevent healing</td>
<td>121 (69.9%)*</td>
</tr>
<tr>
<td>Maintenance</td>
<td>No*</td>
<td>Adequate</td>
<td>± Prevent healing</td>
<td>43 (24.9%)*</td>
</tr>
<tr>
<td>Nonhealable including Skin</td>
<td>No</td>
<td>Usually</td>
<td>May inhibit healing</td>
<td>9 (5.2%)*</td>
</tr>
<tr>
<td>Changes at Life’s End (SCALE)</td>
<td>Inadequate</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Modified from Sibbald, Krasser; Lutz SCALE document 2010

*Results from comprehensive inter-professional assessments of leg and foot ulcers.
with 52 international distinguished reviewers was utilized to reach consensus on the document. The 10 final consensus statements have clarified the authors’ views on skin and wound conditions at the end of life.

Of the 10 SCALE consensus statements, statement 1 is key: “Physiologic changes that occur as a result of the dying process may affect the skin and soft tissues and may manifest as observable (objective) changes in skin color, turgor, or integrity, or as subjective symptoms such as localized pain. These changes can be unavoidable and may occur with the application of appropriate interventions that meet or exceed the standard of care.”

The panel explored the work by Kennedy, where a descriptive study describes the phenomenon of PrUs that occur in the sacral area of dying patients was observed in a long-term care facility. Kennedy’s work was the first modern descriptive research to discuss this issue that was depicted in 1877 by Jean-Martin Charcot and termed the decubitus ominosus.

In an observational study that took place in a 10-bed large teaching hospital palliative care unit, the staff reported that 5% of the patients had skin changes of reddish-purple discoloration ranging from 2 hours to 6 days prior to death. These areas of intact skin rapidly became full-thickness PrUs. The staff turned patients hourly. Within minutes of the prior skin assessment, skin changes that were reddish purple and found over various areas of the body appeared shortly before death. This study provides observational data on some of the unavoidable skin changes at life’s end.

2A: Develop an individualized plan of care

Following the wound assessment as described above, an individualized wound plan of care should be developed by the interprofessional team.

The plan must be tailored to the individual, taking into consideration his/her unique biopsychosocial needs including:

- Risk factors comorbidities;
- Quality-of-life issues;
- Support systems/circle of care;
- Access to care;
- Personal preferences.

As discussed by Sackett et al, individualized patient preference must be honored and reflected in the wound care plan. Sackett et al recognized 3 dimensions of equal importance: best available scientific evidence, clinical expertise, and patient preference. This model of evidence-based medicine has been one of the most important healthcare trends in the past 20 years. Interprofessional, individualized patient-centered care must drive the care process.

The wound care plan of care should be as follows:

- In writing and part of the permanent healthcare record;
- Routinely evaluated and updated;
- Updated with any significant change in the individual’s health status.

2B: Treat the cause(s) related to specific wound etiology/diagnosis

Once an accurate type of wound is established, the treatment can be planned and implemented (Table V).

For example, in a person with a venous ulcer, compression therapy is contraindicated when ABPI is 0.5 or less, and a vascular consult is required for limb preservation. Under the care of an expert wound care team, modified compression therapy for patients with ABPI between 0.5 and 0.8 is beneficial and assists perfusion by increasing pulsatile flow, thereby decreasing venous pressure and facilitating the arterial-venous gradient.

Importance of holistic interprofessional coordinated care

Accurate wound diagnosis and development of successful treatments plans can be a challenging undertaking, given the complexity of chronic wounds. A holistic interprofessional approach is required. Each member of the team possesses a unique professional skill set and knowledge base that should contribute to the individualized plan of care. Implemented treatment plans that do not yield wound-healing rates at the expected trajectory require a timely referral to an interprofessional team that can re-evaluate the diagnosis and causative factors. Redefining the treatment goals with the input from the patient, family, and healthcare provider is essential as well.

### Table V: Types of wounds and treatment

<table>
<thead>
<tr>
<th>Type of wound</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venous ulcers</td>
<td>Compression therapy wraps for healing and stockings for maintenance</td>
</tr>
<tr>
<td></td>
<td>High compression in absence of arterial disease if Ankle Brachial Pressure</td>
</tr>
<tr>
<td></td>
<td>Index &gt;0.8 (ABPI or ABI)</td>
</tr>
<tr>
<td></td>
<td>Modified compression for mixed vascular disease with ABPI 0.65–0.8</td>
</tr>
<tr>
<td></td>
<td>(extreme caution 0.5–0.65)</td>
</tr>
<tr>
<td>Arterial ulcers</td>
<td>Revascularization where possible</td>
</tr>
<tr>
<td></td>
<td>Angioplasty, stents or bypass (grafting or synthetic)</td>
</tr>
<tr>
<td>Pressure ulcers</td>
<td>Pressure redistribution to reduce pressure, friction and shear forces</td>
</tr>
<tr>
<td></td>
<td>Optimize mobility</td>
</tr>
<tr>
<td></td>
<td>Incontinence and moisture management</td>
</tr>
<tr>
<td>Diabetic foot ulcers</td>
<td>V = Confirm adequate vascular supply</td>
</tr>
<tr>
<td></td>
<td>I = Infection treatment</td>
</tr>
<tr>
<td></td>
<td>P = Plantar pressure redistribution according to local provisions</td>
</tr>
<tr>
<td></td>
<td>S = Sharp surgical serial debridement</td>
</tr>
</tbody>
</table>
2C: Modify (if possible) systemic factors/other cofactors that may impair healing: medications, nutrition, hemoglobin, HgbA1c, blood pressure, creatinine, congestive heart failure (CHF), liver function tests (LFTs), and so on

A good example of systemic factors that affect wound healing is the hemoglobin level. Because hemoglobin carries the oxygen that is essential for new tissue building, hemoglobin levels should be optimized. Potential negative influences for adequate hemoglobin are common in patients living with other chronic illnesses such as renal disease, sickle cell, and other anemias, to name a few.

Persons with cardiopulmonary disease; cardiovascular disease, including congestive heart failure; and related conditions have diminished extremity tissue perfusion as a result of reduced ejection fractions. In particular, heart failure and associated decreased tissue perfusion to the periphery results in edema accumulation in the lower extremities, creating higher risk for lower-leg wound formation or delayed healing in existing wounds. In many cases, an internal medicine or subspecialty referral can optimize heart function and manage fluid balance and edema reduction. The offending co-contributors and cofactors that impede wound healing should be adjusted and corrected. By improving as many factors as possible may contribute to overall improvement of the patient's quality of life, reducing pain, improving mobility, and facilitating improved wound outcomes.

A patient with a chronic wound may require a thorough nutritional assessment by a registered dietitian, to address any underlying and correctable nutritional deficits. Proteins have a fundamental role throughout the wound-healing cycle influencing the function of leukocytes, phagocytes, monocytes, lymphocytes, and macrophages, all integral to a normal healing trajectory. A multinational European, prospective randomized controlled, double-blind trial has studied the effects of specific oral nutritional supplementation in nonmalnourished patients specific to PrU healing. The provision of a high-protein, micronutrient-enriched and arginine supplement resulted in improved healing rates and less wound care intensity for the care providers.

Medications that may inhibit or delay wound healing should be reviewed, including the benefit, risk, and dose of each medication. Refer to section 1C for more detail.

---

**Figure 1:** Wound associated pain (WAP) model: the wound, the cause, the patient

<table>
<thead>
<tr>
<th>Venous ulcer pain</th>
<th>Ischemic ulcer pain</th>
<th>Pressure ulcer pain</th>
<th>Diabetic foot ulcer pain</th>
<th>Other causes pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edema</td>
<td>Ischemia</td>
<td>Pressure</td>
<td>Sensory neuropathy</td>
<td>Infection</td>
</tr>
<tr>
<td>Lipodermatosclerosis</td>
<td>Claudication</td>
<td>Shear</td>
<td>Deep tissue destruction</td>
<td>Inflammation (vasculitis, PG)</td>
</tr>
<tr>
<td>Phlebitis</td>
<td>Vasospasms</td>
<td>Friction</td>
<td>Autonomic dysfunction</td>
<td>Malignancy</td>
</tr>
<tr>
<td>Atrophie Blanche</td>
<td>Reperfusion injury</td>
<td>Immobility</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Tissue debridement and trauma**
  - Selection of dressings and frequency of change
  - Adhesives (high peel force)
  - Wound cleansing/irrigation
  - Tissue debridement

- **Infection/inflammation**
  - Increased bioburden/infection
  - Increased inflammatory mediators
  - Topical application of irritants/allergens

- **Moisture balance**
  - Too little
    - Adherent dressing
    - Bleeding
    - Trauma
  - Too much
    - Heavy exudation
    - Periwound maceration
    - Malador

- **Patient-centered concerns**
  - Past pain experience
  - Psychological: depression, anxiety, stress
  - Patient’s expectation and treatment goals
  - Awareness of disease/pain/treatment
  - Active patient involvement (coherence)
Address and treat individualized concerns

3A: Pain

McCafery\(^4\) has stated that pain is what the patient says it is. Every person experiences pain differently. Clinicians cannot treat pain that they do not know patients are experiencing. Pain measurement is subjective; however, the universally accepted measurement techniques are the utilization of visual analog scales (10-cm line with no pain at one end and worst possible pain at the other end, and the patient places an “x” at the appropriate point), Faces Pain Scale (various levels of happy and sad faces), or the numerical rating scale. The numerical rating scale asks if the patient has any pain on a 0-10-point scale with the anchors that 0 is no pain, 5 is the pain associated with a bee sting, and 10 would be the amount of pain experienced by slamming the car door on your thumb. Even in patients who cannot respond verbally, such as those with dementia, pain still needs to be assessed. There are pain scales for these patients that rely on nonverbal clues such as facial grimaces and pupil dilatation. (Assessment of pain for people with dementia can be found at www.hartfordign.org.) Pain levels should be recorded before dressing change, during dressing change, and after dressing reapplication.

Krasner has defined wound associated pain at dressing change (intermittent and recurrent) versus incident pain from debridement or the persistent pain between dressing changes. Woo carried the Krasner concept further and demonstrated that anxiety and other patient-related factors could intensify the pain experience. The Wound Associated Pain model of Woo and Sibbald (Figure 1) defines pain from the cause of the wound as often being persistent or present between dressing changes and distinguishes this pain from the pain associated with local wound care components (dressing change, debridement, infection, lack of moisture balance). All of these factors can be modified by patient-centered concerns, including previous pain experience, anxiety, depression, mobility and awareness or lack of comfort with the setting, and the procedure or treatment plan. Pain is an under-recognized and undertreated component of chronic wound care that has been demonstrated to be more important to patients than healthcare professionals. Causes of pain at dressing change include the dressing material adhering to wound base, skin stripping from strong adhesives, and aggressive trauma from cleansing technique (eg, scrubbing with gauze).

Many patients also express chronic persistent pain between dressing changes even at rest. A systematized approach should examine other systemic and disease factors that may play a role in precipitating and sustaining persistent wound-related pain. Common systemic factors are bacterial damage from superficial critical colonization or deep and surrounding compartment infections, deep structural damage (eg, acute Charcot foot in patients with diabetes), abnormal inflammatory conditions (eg, vasculitis, pyoderma gangrenosum), or periwound contact irritant skin damage from enzyme-rich wound exudate.

The impact of chronic unremitting pain can be devastating, eroding the individual’s quality of life and constituting a significant amount of stress. Increased levels of stress have been demonstrated to lower pain threshold and decrease tolerance. The result is a vicious cycle of pain, stress/anxiety, anticipation of pain, and worsening of pain. Increased stress also activates the hypothalamus-pituitary-adrenal axis, producing hormones that modulate the immune system compromising normal wound healing. Medications including nonnarcotic for moderate pain and narcotic analgesics for moderate to severe pain are required to treat severe pain as outlined below. A consult from a pain and symptom management team may be considered. Comprehensive management should also include careful selection of atraumatic dressing, prevention of local trauma, treatment of infection, patient empowerment, stress reduction, and patient education.

The medical treatment of Wound Associated Pain and other components of pain management are outlined in the World Union of Wound Healing Societies documents.\(^45\) In general, wound-associated pain is both nociceptive and stimulus dependent (gnawing, aching tender, throbbing) versus neuro-pathic or non–stimulus-dependent or spontaneous pain (burning, stinging, shooting, stabbing). Nociceptive pain is treated with the WHO pain ladder medication starting with aspirin and nonsteroidal anti-inflammatory drugs and then progressing to weak and strong narcotics.\(^42\) Short-acting agents are often used to determine the dose of longer-acting agents, and then the short-acting agents may be used for breakthrough. The neuropathic pain often responds to tricyclic agents, particularly second-generation agents high in antinoradrenaline activity (nortriptyline and desipramine are often better than amitriptyline) and for nonresponders with alternate agents gabapentin and pregabalin or other antiepileptic agents. Neuropathic pain occurs even with the loss of protective sensation and can awaken persons with neuropathy at night with lightning-like flashes of pain.

3B: Activities of daily living

Living with a chronic leg ulcer and ADLs has the largest body of evidence, mainly using qualitative methodology, compared with other ulcer etiologies. Patients reported numerous negative influences on their ability to carry out ADLs including, pain, odor, mobility, finances, and aspects of living.\(^43\) Depression and anxiety were reported in as many as 68% of the subjects. Another recent study highlighted the dominant impact of social isolation in patients suffering from chronic leg ulcers.\(^44\) One study compared patients living with diabetic foot ulcers (DFUs) and those with amputation following foot ulcers and concluded that a higher quality of life was reported in those who underwent previous lower-limb amputations.\(^45\) Assessing the unique individual’s concerns can be time-consuming but a necessary piece in addressing the patient’s holistic needs. This highlights the emotional burden of living with a chronic wound.

3C: Psychosocial well-being

Psychosocial well-being is the dimension of quality of life that most people equate with the quality piece.\(^46\) It includes the individual's
psychological perspectives on his/her wound and overall life. It reflects the person’s ability to socialize and interact with others.

There are many wound care interventions that can address and support a person’s wound-related psychosocial issues. For example:

- If wound odor is an issue, charcoal or other odor-reducing dressings can be utilized.
- Dressing routines can be modified to accommodate individualized hygiene practices. For showers Mondays-Wednesdays-Fridays, dressing changes can be coordinated to Mondays-Wednesday-Fridays right after the shower.

3D: Smoking

Cigarette smoking is a leading preventable health problem causing damage to the endothelial function of arteries throughout the body, contributing to the development of vascular disease of both arterial and venous origin. The direct cutaneous effect of smoking is stated clearly by Rayner. Smoking disrupts the normal healing process at many levels, decreasing cell proliferation and migration to resultant tissue hypoxia. Smoking a single cigarette creates a vasoconstrictive effect for up to 90 minutes, while smoking a packet of cigarettes contains more than 4000 substances, including carbon monoxide, nicotine, and cyanide derivatives, and each substance can potentially negatively influence wound healing. Useful patient smoking cessation strategies, including the pharmacological, behavioral, and effectiveness of these programs, are outlined by Ahn et al.

Delayed wound healing for individuals who use tobacco is attributed to resultant tissue hypoxia. Smoking disrupts the normal healing process at many levels, decreasing cell proliferation and migration across the wound bed. Cigarettes contain more than 4000 substances, including carbon monoxide, nicotine, and cyanide derivatives, and each substance can potentially negatively influence wound healing. Useful patient smoking cessation strategies, including the pharmacological, behavioral, and effectiveness of these programs, are outlined by Ahn et al.

Offering patients these strategies to quit smoking and improve tissue oxygenation may enhance healing.

3E: Access to care, financial limitations

Living with a wound can be a challenge for many patients who may have limited financial resources or access to care. Patients living with chronic illnesses compounded by a wound may have difficulties with transportation for medical appointments, and many are unemployed or on limited incomes. Depending on where the patient lives, there are differing resources available. Healthcare professionals should advocate for required patient resources. When a wound is determined to be maintenance or nonhealing, the healthcare team, along with the patient, can individualize the care plan to be most efficient for both the patient and the system.

4. Provide education and support to the person and his/her circle of care (including referral) to increase adherence (coherence) to the treatment plan

One strategy to provide support and education to a patient is by developing a therapeutic relationship. Trust implies sharing of information and communication, and open dialogue allows the patient and those in their circle of care to understand that each person involved has a meaningful contribution. Active participation by the patient in the development of an individualized plan of care provides reassurance to the patient that the team is working with them to achieve the best possible outcome. This helps to enhance adherence to the agreed upon treatment plan, as there is “trust.” An additional concept in team dynamics is unit cohesion or the process of “sticking together” for the accomplishment of a mission or task. If the patient provides substantive input into the treatment plan, there is a greater chance that the patient will adhere (cohere) to a given plan. By way of example, patient participation, such as removing the dressing at dressing change, should be encouraged as clinically appropriate. People in the patient’s circle of care such as family, caregivers, and healthcare professionals should also be part of the plan, including implementation and re-evaluation. Communication is paramount between healthcare sectors and professionals when managing chronic wounds. Once an expert team has determined that a wound is maintenance or nonhealable wound, it is important that this be communicated to prevent unnecessary investigations or interventions that may have already been unsuccessful. Healthcare professionals should review and educate the patient and family after determining their current knowledge gaps. Teaching the patient to report important signs that could indicate a deterioration of the wound. Strategies to improve adherence have been reported in a comprehensive review by Osterberg and Blaschke.

Local wound care

5. Assess and monitor the wound history and physical examination

Documentation of a detailed patient and wound assessment is a legal requirement from both an organizational and professional standards perspective. Specific details about the wound history and physical will facilitate communication within the patient’s circle of care. This includes the type of wound and history and the patient-centered plan of care and targeted patient-specific goals. The details of the wound assessment should be communicated to other professionals when referrals are made. If a wound is healable, nonhealable, or maintenance, an individualized care plan is made to identify specific interventions and outcomes that the patient and interprofessional team agree upon and modify based on a new holistic interprofessional assessment. One example is the mnemonic MEASURE, which describes the wound location plus MEASURE:

- Measure size - longest length with the widest width at right angles;
- Exudate amount (none, scant, moderate, heavy) and characteristics (serous, sanguinous, pustular, or combinations);
- Appearance [base: necrotic (black), fibrin (firm yellow), slough (soft yellow), or granulation tissue (pink and healthy vs red and friable = easy bleeding, unhealthy)];
- Suffering (pain);
- Undermining (measure in centimeters and use hands of clock to document: 12 o’clock, 6 o’clock, and so on);
• Re-evaluate;
• Edge (hyperkeratotic, macerated, normal).

Using a framework allows consistent documentation of a wound. When a framework is used to assess a wound over time, clinicians can identify if a wound is improving, stalled, or deteriorating.

There are several new electronic technologies available for wound assessment, but they may be costly for clinicians and healthcare systems. Novel camera systems accurately calculate length, width, depth, and surface of exposed wound areas. Limitations include underemphasized areas or sinuses that are not measurable using this technology requiring supplementation by visual clinical inspection and probing. Wound assessment devices markedly differ from computer-based documentation systems that capture multiple data points and assessments about wound parameters inputted by skilled clinicians.

6. Gently cleanse wounds with low-toxicity solutions: saline, water, and acetic acid (0.5%–1.0%). Do not irrigate wounds where you cannot see where the solution is going nor cannot retrieve (or aspirate) the irrigating solution.

The standard of care for wound cleansing is to use those solutions that are gentle and least cytotoxic to the wound as possible: saline, water, and acetic acid (0.5%–1.0%). Research has shown that certain solutions can be cytotoxic to healing cells, such as fibroblasts, in vitro.60

In the analysis of Cochrane Reviews prior to 2008, the authors concluded “There is not strong evidence that cleansing wounds per se increases healing or reduces infection.” The Cochrane Collaboration updated evidence reviews in 2011 on wound cleansing for PrUs and concluded there is “no good evidence to support use of any particular wound cleansing solution or technique for PrUs.”61 A specific type of solution for wound cleansing in adults was an additional evidence review in 2010. The authors concluded that there is no evidence to indicate that using tap water to cleanse an acute wound increased infection rates. In addition, there is no strong evidence demonstrating that cleansing of wounds at all decreases infection or promotes healing.62 Expert opinion recommends that caution should be considered in the use of tap water for immunocompromised individuals, especially the use of nonpotable water, which may be a problem in developing countries.

Avoiding cytotoxic solutions, such as Dakin’s and povidoneiodine, to cleanse healable wounds or using them for only limited periods is reasonably prudent practice. However, there is a place for these agents in the management of maintenance or nonhealable wounds to potentially control bioburden and odor. In these cases, the reduction in bioburden and moisture reduction outweighs the small potential for tissue toxicity.

Wound irrigation has also been the subject of controversy and disagreement between health professionals. In general, the authors recommend that clinicians should not irrigate wounds where they cannot see where the solution is being instilled into the dead space at the base of the wound, or if they cannot retrieve the irrigating solution. More research on wound cleansing is needed. (See Wound Bed Preparation Enabler 2011 for antiseptic solutions and their utility for wound care.)

7. Debride: Healable wounds - sharp or conservative surgical, autolytic, mechanical, enzymatic, biological (medical maggots); nonhealable and maintenance - conservative surgical or other methods of removal of nonviable slough.

The wound bed is optimally prepared by aggressive and regular debridement of any firm eschar or soft slough if the wound is healable. A firm eschar serves as a proinflammatory stimulus inhibiting healing, whereas the slough acts as a culture media for bacterial proliferation and should be removed.63 Debridement may also promote healing by removing senescent cells that are deficient in cellular activities and biofilms that contain the bacterial colonies.64

Sharp debridement is the most expeditious method but may not always be feasible because of pain, bleeding potential, cost, professional/system regulations, and the lack of clinician expertise. Cardinal et al65 conducted a retrospective review on 366 persons with VLUs and 310 persons with DFUs over 12 weeks observing wound surface area changes and closure rates. Interestingly, VLUs had a significantly higher median wound surface area reduction with surgical debridement (when clinically indicated due to the presence of debris) versus no surgical debridement (34%, P = .019). Centers with more frequent debridement were associated with higher rates of wound closure (P = .007; VLUs, P = .015 DFUs). The debridement frequency did not statistically correlate to higher rates of wound closure. There was some minor evidence of a positive benefit of serial debridement in DFUs (odds ratio, 2.35; P = .069).

Alternatively, autolytic debridement is most accepted by keeping a moist wound environment to enhance the activities of phagocytic cells and endogenous enzymes on nonviable tissues. Mechanical debridement with saline wet-to-dry dressing contributes to local trauma and pain. In the United States, the Centers for Medicare Medicaid Services, in its Tag F314 guidance, cautions that there should be limited use of wet-to-dry dressings. Emerging technology using ultrasonic devices has also been demonstrative WBP without the incument painful and traumatic scraping and cutting associated with sharp and mechanical debridement. When using enzymatic debridement, clinicians should ensure that the cleansing solutions and type of dressing used to cover the wound do not interfere with or cancel out the action of the enzyme.

Select the appropriate method of wound debridement considering the patient, the wound characteristics, and the skill and knowledge of the clinician, along with the available resources. In summary, the different methods of debridement have distinct features in terms of pain potential, cost, healthcare professional time and skill level required, resources used, and wound characteristics. (See the Enabler: Key Factors in Deciding Method of Debridement.)
8. Assess and treat the wound for superficial critical colonization/Deep infection/Abnormal Persistent Inflammation (mnemonic STONEES), or persistent inflammation:

Any 3 NERDS-treat topically: Non-healing, Exudate, Red-trieable tissue, Debris, Smell;

Any 3 STONEES-treat systemically: Size, Temperature, Os, New breakdow, exudate, Erythema/Edema (cellulitis), Smell;

Persistent inflammation (non-infectious): Topical for systemic anti-inflammatories. (See Enabler: Sibbald Cube.)

Chronic wounds containing bacteria and/or the presence of bacteria obtained from a surface swab do not define or portend infection. In fact, the mean number of bacterial species per chronic ulcer has been found to range from 1.6 to 4.4. Critical to wound healing is the achieving of an appropriate bacterial balance and understanding the differences between contamination or colonization or frank bacterial damage with surface critical colonization or surrounding/deep infection. The risk of infection is determined by the number and nature of invading bacteria as well as host resistance as outlined in the following equation:

\[ \text{Infection} = \text{number of organisms} \times \text{organism virulence} \]

Host resistance

Host resistance is the most important factor, and it refers to the host immune response to resist bacterial invasion and prevent bacterial damage. In addition, adequate blood supply is needed for the wound to heal as a decreased or inadequate blood supply favors bacterial proliferation and damage that may prevent or delay healing. Infection is more prevalent in certain disease conditions. For example, individuals with diabetes have at least a 10-fold greater risk of being hospitalized for soft tissue and bone infections of the foot than nondiabetic individuals. Local factors inhibiting healing may include a large wound size, the presence of foreign bodies (prosthetic joints, a thread, or remnants of gauze or a retained suture), and an untreated deeper infection, such as osteomyelitis. External contamination of the wound bed by microorganisms can occur from the ambient environment, dressings, the patient’s secretions and hands, along with the hands of health-care provider (alcohol hand rinses are more effective in reducing hand bacteria than washing with soap and water).

By using this superficial and deep-surrounding tissue separation, the clinician can identify wounds with increased bacterial burden that may respond to topical antimicrobials and deep infection that usually requires the use of systemic antimicrobial agents. The mnemonics NERDS and STONEES represent the initials of the signs to categorize the 2 levels of bacterial damage or infection. This concept was introduced in 2007 and validated in 2009. Three or more of these signs should be sought for the diagnosis in each level. If increased exudate and odor are present, additional signs are needed to determine if the damage is superficial, deep, or both.

There are now at least 5 classes of antimicrobial dressings and some miscellaneous products for use in chronic wounds with critical colonization as defined by any 3 of the NERDS criteria:

- Silver dressings combined with alginates, foams, hydrofibers, and hydrogels;
- Honey dressings in a calcium alginate wafer and hydrogel;
- Iodine in a cadexomer carbohydrate or polyethylene glycol slow release formulation (not available in the United States);
- PHMB (polyhexamethylene biguanidine) derivative of chlorhexidine in a foam or gauze packing;
- Miscellaneous antimicrobial dressings often with a paucity of clinical studies to support their use.

The treatment of critical colonization often takes 2 to 4 weeks in a healable wound where the cause has been corrected and patient-centered concerns have been addressed. There is some, but limited, evidence to show the benefit of these dressings. If the wound is in bacterial balance, antibacterial dressings are not needed for the re-epithelialization stage of wound healing, unless they also provide anti-inflammatory activity. Also they are not efficacious in the treatment of deep and surrounding tissue infection that requires the use of systemic agents. Studies that do not select the proper subpopulation (eg, healable critically colonized wounds without deep infection) or measure complete wound healing have failed to demonstrate any benefit from these dressings.

The use of antimicrobial dressings should be reviewed at frequent and regular intervals every 1 to 2 weeks and discontinued if critical colonization has been corrected or if they do not demonstrate a beneficial effect after 2 to 4 weeks. There is currently a great tendency to overuse antimicrobial dressings, creating a cost-inefficient use of these useful devices. The conflicting evidence and misuse of these dressings have led some European healthcare systems to completely delist silver products.

Silver dressings

The effectiveness of silver-releasing dressings in the management of nonhealing (stalled) chronic wounds was reviewed by a meta-analysis. In comparison to alternative antimicrobials, silver dressings significantly:

- Improved wound-healing rate (95% confidence interval [CI], 0.16–0.39, \( P < .001 \));
- Reduced odor (95% CI, 0.24–0.52, \( P < .001 \)) and pain-related symptoms (95% CI, 0.18–0.47, \( P < .001 \));
- Decreased wound exudate (95% CI, 0.17–0.44, \( P < .001 \)); and
- Had a prolonged dressing wear time (95% CI, 0.19–0.48, \( P = .028 \)) when compared with alternative wound management approaches.

Silver’s broad spectrum of antimicrobial activity can be used in critically colonized chronic wounds that have the ability to heal. Silver must be ionized to exert an antimicrobial effect. Ionized silver requires an aqueous or water environment and should not be used...
in a maintenance or nonhealable wound where the desired outcome is the combination of moisture reduction and bacterial reduction. Silver should not be in close proximity to any oil-based products (eg, petrolatum, zinc oxide) where the oil molecules may interfere with the ionization of the silver. Products that produce a continuous supply of ionized silver are likely to be more efficacious, and higher levels of silver release are often necessary to treat micro-organisms such as pseudomonas in a complete environment, such as a wound. Pseudomonas require a higher silver level for silver to work than most other bacterial organisms. Silver resistance is uncommon because there are at least 3 antimicrobial mechanisms with silver targeting and combining with membranes, cytoplasmic organelles, and DNA.

The amount of silver released from these dressings is a fraction of the silver released from silver sulfadiazine (SSD) cream formulations. Serum silver levels even from high-release silver dressings are in the 1–5 micromolar range. Modern silver dressings seldom exceed normal range unless large surface areas are treated over prolonged time or the patient has a large skin surface area to total weight. Silver dressings can cause periwound temporary staining but not leave permanent silver deposits in the dermis (argyria or blue discoloration of the skin). The silver in the dressing should be combined with the appropriate moisture balance format matched to the wound to control exudate and prevent maceration, but facilitate the delivery of ionized silver to the wound surface.

**Honey, iodine, and PHMB**

The Cochrane Collaboration conducted a systematic review of the honey literature and concluded that honey, as a topical treatment for superficial and partial-thickness burns, may improve healing times compared with some conventional dressings. Jull et al.[26] conducted a multicenter randomized controlled trial on VLUs with compression comparing honey to usual care. There were 187 patients in the honey group and 181 patients in the usual-care group with no difference between the 2 groups for total wound healing at 12 weeks. In clinical practice, honey dressings may be useful for thick eschar that often continuously reforms when treated with other dressings. Some of this action may be due to the antibacterial and hyperosmolar characteristics of the honey. Scoring the wound with a blade to help break down the eschar may facilitate the process.

There are 10 trials with cadexomer iodine, and some of these trials are old, with venous ulcers treated topically without compression. In a randomized controlled trial study comparing cadexomer iodine with standard care with both groups receiving compression, the daily or weekly healing rates favored cadexomer iodine.[27]

In a pilot study of PHMB foam compared with foam alone, the PHMB dressing resulted in decreased pain and no change in wound size.[28]

**Evaluating evidence of antimicrobials in vitro and animal models: the literature**

Beware of in vitro testing of antimicrobial dressings because these results often do not correlate with clinical activity. Although the studies may demonstrate statistical significance, clinical significance is the parameter of interest; moreover, the strength of evidence for the majority of these in vitro studies is low. When evaluating topical antimicrobial agents for wound treatment, appropriate tests must be used. For instance, the in vitro evaluation of an antimicrobial agent such as silver can be performed with a multitude of tests, but of these, only the logarithmic reduction or decimal reduction time test conducted in serum has been shown to predict clinical outcomes.[79,80] In vivo antimicrobial assays, such as the Walker Mason modified model (rodent) or the Wright model (porcine), can also be used with success to determine antimicrobial efficacy.[81] Similarly, the evaluation of the efficacy of topical agents on wound healing can be evaluated in vitro (cellular culture or tissue explant models) or in vivo (rodent or porcine wound-healing models). However, the only model that predicts a clinical outcome is the porcine model of wound healing.[82]

A recent Cochrane Review explored antibiotic and antiseptic use for persons with VLUs. The authors concluded that there is no evidence for routine use of systemic antibiotics[83] when treating the cause of VLUs.

### 9. Select a dressing to match the appropriate wound and individual person characteristics:

- **Healable wounds**: Autolytic debridement: alginates, hydro-gels, hydrocolloids, acrylics
- **Critical colonization**: silver, iodides, PHMB, honey
- **Persistent inflammation**: anti-inflammatory dressings
- **Moisture balance**: foams, hydrofibers, alginates, hydrocolloids, films, acrylics
- **Nonhealable, maintenance wounds**: chlorhexidine, povidone-iodine

Whenever patients and healthcare professionals are developing a treatment plan for patients with wounds, dressing selection is an important primary focus. Once healable, nonhealable, or maintenance is determined, appropriate holistic interprofessional interventions that address cofactors can be optimized. The dressing selection should be the last part of the process because if the healability is not accurately assessed or other cofactors are unmanaged, then the wound will not heal. Dressing choice needs to consider unit costs and clinical effectiveness. Kerstein[84] explored cost-effectiveness for venous and PrUs and concluded that the purchase price of the dressing should not be the only indicator. Normal saline gauze dressings (least expensive for product) were found to be the most expensive when nursing time and patient feedback were taken into account (Table VI).

### Persistent inflammation

Chronic wounds may be stalled in the inflammatory stage. These wounds demonstrate markedly increased activity of inflammatory cells and associated mediators such as matrix metalloproteinases (MMPs) and elastase.[65] Wound healing is stalled because degradation of extracellular matrix and growth factors occurs more rapidly than their synthesis, hindering the wound from progressing toward the proliferative phase and ultimately re-epithelialization. Harding et
### Table VI: Modern classes of dressings

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>Tissue debridement</th>
<th>Infection</th>
<th>Moisture balance</th>
<th>Indications and contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Films/ membranes</td>
<td>Semipermeable adhesive sheet; impermeable to water molecules and bacteria.</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>Moisture vapour transmission rate varies from film to film. Should not be used on draining or infected wounds. Create occlusive barrier against infection.</td>
</tr>
<tr>
<td>2. Nonadherent</td>
<td>Sheets of low adherence to tissue. Nonmedicated tulles.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Allow drainage to seep through pores to secondary dressings. Facilitate application of topical.</td>
</tr>
<tr>
<td>3. Hydrogels</td>
<td>Polymers with high water content. Available in gels, solid sheets, or impregnated gauze.</td>
<td>++</td>
<td>-/-</td>
<td>++</td>
<td>Should not be used on draining wounds. Solid sheets should not be used on infected wounds.</td>
</tr>
<tr>
<td>4. Hydrocolloids</td>
<td>May contain gelatine, sodium carboxymethyl-cellulose, polysaccharides and/or pectin; sheet dressings are occlusive with polyurethane film outer layer.</td>
<td>+++</td>
<td>-/+</td>
<td>++</td>
<td>Should be used with care on fragile skin. Should stay in place for several days. Should not be used on heavily draining or infected wounds. Create occlusive barrier to protect the wound from outside contamination. Odour may accompany dressing change and should not be confused with infection.</td>
</tr>
<tr>
<td>5. Acrylics</td>
<td>Clear acrylic pad enclosed between 2 layers of transparent adhesive film.</td>
<td>+++</td>
<td>-/+</td>
<td>++</td>
<td>Use on low-to moderately draining wounds where dressing may stay in place for extended time. May observe wound without changing.</td>
</tr>
<tr>
<td>6. Calcium alginate</td>
<td>Sheets or fibrous ropes of calcium sodium alginate (seaweed derivative); have hemostatic capabilities.</td>
<td>++</td>
<td>+</td>
<td>+++</td>
<td>Should not be used on dry wounds. Low tensile strength- avoid packing into narrow deep sinuses. Biodegradable.</td>
</tr>
<tr>
<td>7. Composite dressings</td>
<td>Multi layered, combination dressings to increase absorbency and autolysis.</td>
<td>+</td>
<td>-</td>
<td>+++</td>
<td>Use on wounds where dressings may stay in place for several days.</td>
</tr>
<tr>
<td>8. Foams</td>
<td>Non adhesive or adhesive polyurethane foam; may have occlusive backing; sheets or cavity packing; some have fluid lock.</td>
<td>-</td>
<td>-</td>
<td>+++</td>
<td>Use on moderately to heavily draining wounds. Occlusive foams should not be used on heavily draining or infected wounds.</td>
</tr>
<tr>
<td>9. Charcoal</td>
<td>Contains odour-absorbing charcoal within product.</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>Some charcoal products are inactivated by moisture. Ensure dressing edges are sealed.</td>
</tr>
<tr>
<td>10. Hypertonic</td>
<td>Sheet, ribbon, or gel impregnated with sodium concentrate.</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>Gauze ribbon should not be used on dry wounds. Maybe painful on sensitive tissue. Gel may be used on dry wounds.</td>
</tr>
<tr>
<td>11. Hydrophilic fibres</td>
<td>Sheet or packing strip of sodium carboxymethyl-cellulose; concerts to a solid gel when activated by moisture (fluid lock).</td>
<td>+</td>
<td>-</td>
<td>+++</td>
<td>Best for moderate amount of exudates. Should not be used on dry wounds. Low tensile strength- avoid packing into the narrow deep sinus.</td>
</tr>
<tr>
<td>12. Antimicrobials</td>
<td>Silver, iodides, PHMB, honey aniline dyes with vehicle for delivery: sheets, gels, alginites, foams, or paste.</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>Broad spectrum against bacteria. Should not be used on patients with known hypersensitivities to any product components.</td>
</tr>
<tr>
<td>13. Other devices</td>
<td>Negative-pressure wound therapy applies localized negative pressure to the surface and margins of wounds.</td>
<td>-</td>
<td>+</td>
<td>+++</td>
<td>This negative pressure-distributing dressing actively removes fluid from wound and promotes wound edge approximation. Advanced skill required for patient selection for this therapy.</td>
</tr>
<tr>
<td>14. Biologics</td>
<td>Living human fibroblasts provided in sheets at ambient or frozen temperature; extracellular matrix. Collagen-containing preparations; hyaluronic acid; platelet-derived growth factor.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Should not be used on wounds with infection, sinus tracts, or excessive exudate or on patients known to have hypersensitivity to any of the product components. Cultural issues related to source. Advanced skill required for patient selection for this therapy.</td>
</tr>
</tbody>
</table>

*aUse with caution of critical colonization is suspected.

- No activity
- minimal activity
- moderate activity
- strong activity

Adapted from Canadian Association of Wound Care, revised.
Table VII: Summary of advanced therapy options

<table>
<thead>
<tr>
<th>Substantiated advanced therapies</th>
<th>Indication</th>
<th>RCT or meta-analysis available</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>OASIS</td>
<td>VLU</td>
<td>Yes91</td>
<td>Complete healing</td>
</tr>
<tr>
<td></td>
<td>DNFU</td>
<td>Yes92</td>
<td>Complete healing equal to PDGF</td>
</tr>
<tr>
<td>Growth factors (PDGF)</td>
<td>DNFU</td>
<td>Yes83,84</td>
<td>Complete healing</td>
</tr>
<tr>
<td>Apligraf (epidermal cells, dermal fibroblasts, bovine collagen)</td>
<td>DNFU</td>
<td>Yes85-87</td>
<td>Complete healing</td>
</tr>
<tr>
<td></td>
<td>VLU</td>
<td>Yes88</td>
<td>Complete healing</td>
</tr>
<tr>
<td>Dermabond (fibrin glue)</td>
<td>VLU</td>
<td>Yes89</td>
<td>Complete healing</td>
</tr>
<tr>
<td>Hyperbaric oxygen therapy</td>
<td>VLU</td>
<td>Yes90</td>
<td>Complete healing</td>
</tr>
<tr>
<td>Electrical stimulation</td>
<td>PrU</td>
<td>Yes91</td>
<td>Complete healing</td>
</tr>
<tr>
<td>Therapeutic ultrasound</td>
<td>VLU</td>
<td>Yes92</td>
<td>Complete healing</td>
</tr>
<tr>
<td>Negative-pressure wound therapy</td>
<td>Postsurgical wounds</td>
<td>Yes93</td>
<td>Complete healing</td>
</tr>
<tr>
<td>Promogran VLU</td>
<td>VLU</td>
<td>Yes94</td>
<td>Decrease wound size</td>
</tr>
</tbody>
</table>

Abbreviations: DNFU, diabetic neurotrophic foot ulcer; PDGF, platelet-derived growth factor; PrU, pressure ulcer; RCT, randomized controlled trial

all reported that the longer a wound remains in the inflammatory phase, the more cellular defects are detected with potential delayed healing. Recently, there has been a renewal of interest in wound diagnostic testing that will result in tests for increased MMPs that will be available soon for bedside testing. There are wound dressings with oxidized reduced collagen and cellulose that can trap MMPs, and these dressings can be combined with antimicrobials such as silver. In the Sibbald cube (see Enabler), these specialized dressings can be combined antimicrobials, depending on the presence of the mnemonic NERDS (superficial antibacterial dressing criteria) or mnemonic STONEES (systemic antibiotic criteria) and where the presence of increased inflammation can also be treated topically or systemically.

Appropriate moisture is required to facilitate the action of growth factors, cytokines, and migration of cells including fibroblasts and keratinocytes. Moisture balance is a delicate process. Excessive moisture can potentially cause damage to the surrounding skin of a wound, leading to maceration and potential breakdown. Conversely, inadequate moisture in the wound environment can impede cellular activities and promote eschar formation, resulting in poor wound healing. A moisture-balanced wound environment is maintained primarily by modern dressings with occlusive, semiocclusive, absorptive, hydrating, and hemostatic characteristics, depending on the drainage and other wound bed properties.

10. Evaluate expected rate of wound healing: Healable wounds should be 30% smaller by week 4 to heal by week 12. Wounds not healing at the expected rate should be reclassified or reassessed, and the plan of care revised

It is noted that a 20% to 40% reduction in 2 and 4 weeks is likely to be a reliable predictor of healing. Sheehan noted a 50% reduction at week 4 was a good predictor for persons with DFUs. One measure of healing is the clinical observation of the edge of the wound. If the wound edge is not migrating after appropriate WBP (debridement, bacterial balance, moisture balance) and healing is stalled, then advanced therapies should be considered. The first step prior to initiating the edge-effect therapies is a reassessment of the patient to rule out other causes and cofactors. Clinicians need to remember that wound healing is not always the primary outcome. Consider other wound-related outcomes, such as reduced pain, reduced bacterial load, reduced dressing changes, or an improved quality of life.

11. Use active wound therapies (skin grafts, biological agents, adjunctive therapies, and so on) when other factors have been corrected and healing still does not progress (stalled wound)

A nonhealing wound may have a clifflike edge between the upper epithelium and the lower granulation in comparison to a healing wound with tapered edges like the shore of a sandy beach. Several edge-effect therapies support the addition of missing components: growth factors, fibroblasts, or epithelial cells or matrix components. If all the factors are corrected in a healable wound, active adjunctive therapies may be considered (Table VII).

Provide organization support

12. For improved outcomes, education and evidence-informed practice must be tied to interprofessional teams and improved cost-effective patient care outcomes with the cooperation of healthcare systems

When a patient has a wound, it is important that the team provide education to the patient and his/her circle of care to involve everyone in the treatment plan. Healthcare professionals may assume that patients know more about their wounds than their current understanding. One study surveyed persons with DFUs and their self-foot-care behaviors. Healthcare providers conducted a detailed foot assessment and provided education on each visit. Results indicated that the knowledge base is often less than expected by the healthcare professional and leads to treatment gaps. Behavior of healthcare providers changed during the course of the study, resulting in an increased chance that the patient’s socks were removed, leading to a thorough examination and patient education.
Importance of holistic interprofessional coordinated and collaborate care

Accurate wound diagnosis and development of successful treatments plans can be a challenging undertaking, given the complexity of chronic wounds. A holistic interprofessional approach to care requires that each member of the team has a unique professional knowledge that contributes to the individualized plan of care. The management of patients with DFUs utilizing a team approach and primary healing outcomes can be associated with relatively low costs related to a visit with an interprofessional team, antibiotics, and plantar pressure downloading in the community setting. When healing occurs following an amputation, multiple hospital admissions and extended length of hospital stay are tabulated, with the cost for healing being significantly higher. Implemented treatment plans that do not yield wound-healing rates at the expected trajectory require a timely referral to an interprofessional team that can re-evaluate the diagnosis and causative factors. Redefining the treatment goals with the input from the patient, family, and healthcare provider is essential. Given the geographical and system differences, the ideal full complement of an interprofessional expert team may not always be accessible. Therefore, it is important to realize that only 2 disciplines working collaboratively with the patient and/or family may be successful.

Clinicians must distinguish between interdisciplinary networks with 2 members of the same profession (such as 2 nurses or assistants vs a nurse practitioner who may have a similar role to a physician on an interprofessional team), compared with the physician and nurse of an interprofessional team. For chronic wound care, the physician and nurse are best supplemented with a member of the allied healthcare team (e.g., occupational therapist, physical therapist, foot care specialist, dietitian, social worker, and so on).

Many patients with chronic stalled wounds are complex, older adults who reside with multiple comorbidities, requiring lengthy assessment and coordination of the treatment interventions. This necessitates the healthcare system policy maker to support interprofessional clinician teams to provide the best possible evidence-informed practice.

Conclusion

In summary, the concept of WBP includes the treatment of the whole patient (treat the cause and patient-centered concerns). The approach to the local wound bed has 4 components starting with the mnemonic DIM: Debridement, Infection/ prolonged Inflammation control, and Moisture balance, before the mnemonic DIME that includes the advanced Edge-effect therapies for wounds with the ability to heal.

In addition, this article has introduced the concept of healable, nonhealable, and maintenance wounds along with the integration of clinical criteria for superficial critical colonization (mnemonic NERDS) and topical antimicrobial dressings versus deep and surrounding tissue infections (mnemonic STONEES) requiring systemic agents. Bacterial damage needs to be distinguished from persistent inflammation with soon-to-be available bedside matrix metalloproteases (MMPs) testing. The ultimate treatment process should include the leadership of an interprofessional wound management team, and patient participation is paramount for the best achievable outcome.

After reading this article, clinicians can distinguish between healable, nonhealable, and maintenance wounds and design the appropriate management plans.

Practice pearls

- Clinicians should classify wounds as healable, non-healable, or maintenance. Treatment plans are different depending on healability.
- Distinguish superficial increased bacterial burden to treat topically versus deep and surrounding tissue infection requiring systemic therapy (mnemonics NERDS and STONEES).
- A new topical diagnostic will help distinguish wounds stuck in the inflammatory stage.
- Wound bed preparation emphasizes treating the whole patient and not just the hole in the patient (treat the cause).
- Patient-centered concerns include the accurate documentation and treatment of pain.
- Optimal local wound care for a healable wound includes debridement, infection/inflammation, and moisture balance before the edge effect and the use of advanced therapies.
- If a wound is not 30% smaller by week 4, it is unlikely to heal by week 12. Reassess and consider interprofessional team involvement if “stalled”.

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