Best Practice Recommendations for Preparing the Wound Bed: Update 2006

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Abstract

This article updates the concept of *Preparing the wound bed* by considering the whole patient (treatment of the cause and patient-centred concerns) before treating the wound. Local wound care consists of tissue debridement, control of persistent inflammation or infection, and moisture balance before considering advanced therapies for wounds that are not healing at the expected rate. The best practice recommendations are based on scientific evidence and expert opinion, and should include patient preference. They are intended for translation into practice.

This update of the *Preparing the wound bed* approach has the benefit of connecting the recommendations to the evidence as identified through the Registered Nurses' Association of Ontario's (RNAO) Nursing Best Practice Guidelines. To date, the RNAO has published three guidelines related to the treatment of wounds (pressure, venous and diabetic), and the components related to local wound care are included in this review.

Introduction

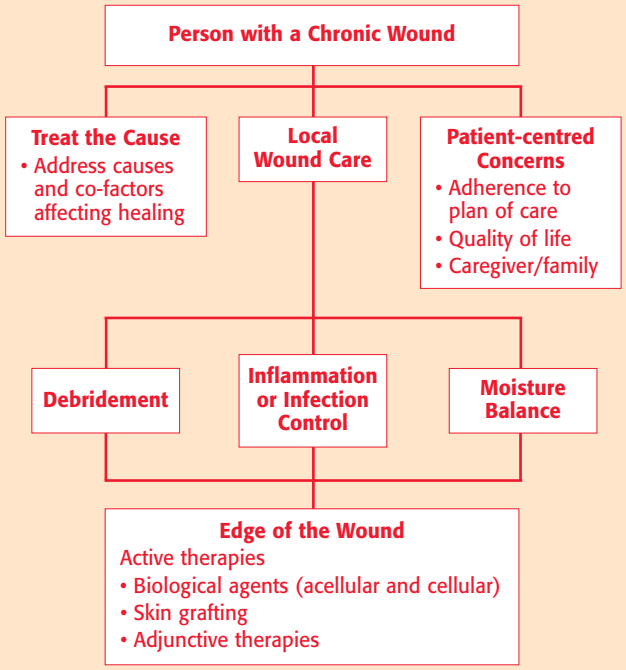
The concept of *Preparing the wound bed* was first described in 2000 by Sibbald et al. and Falanga.[1,2] This approach to wound management stresses that successful diagnosis and treatment of patients with chronic wounds require holistic care and a team approach. The whole patient must be considered before looking at the wound itself. Figure 1 illustrates that wound bed preparation is the promotion of wound closure through diagnosis and appropriate treatment of the cause, attention to patient-centred concerns, and correction of the systemic and local factors that may be delaying healing.

Local factors can be represented by DIME (**D**ebridement, **I**nfection or **I**nflammation, **M**oisture balance and **E**dge of wound). A template is presented as a basis for the discussion of the evidence base and expert opinion corresponding to each step in the paradigm of preparing the wound bed (See Figure 1).

The Canadian Association of Wound Care (CAWC) best practice articles are not comprehensive but are meant to provide a practical, easy-to-follow guide or *bedside enabler for patient care*. The recommendations are based on the best available evidence and are intended to support the wound-care clinician and team in planning and delivering the best clinical practice. For more detailed information, refer to the following RNAO Nursing Best Practice Guidelines or the designated references.

FIGURE 1

Preparing the Wound Bed Paradigm



Adapted from Sibbald RG, Orsted HL, Schultz GS, et al.[6]

TABLE 1

Quick Reference Guide: Preparing the Wound Bed

No.	Recommendations	Level of Evidence
	Identify and Treat the Cause	
1	Assess the patient's ability to heal. Adequate blood supply must be present as well as the correction of other important host factors to support healing.	IV
2	Diagnose and correct or modify treatable causes of tissue damage.	IV
	Address Patient-centred Concerns	
3	Assess and support the management of patient-centred concerns (pain and quality of life) to enable healing.	IV
4	Provide patient education and support to increase adherence to treatment plan.	IV
	Provide Local Wound Care	
5	Assess and monitor the wound history and physical characteristics (location + MEASURE*).	IV
6	Debride healable wounds by removing non-viable, contaminated or infected tissue (through surgical, autolytic, enzymatic, mechanical or larval [biologic] methods). Non-healable wounds should have only non-viable tissue removed; active debridement to bleeding tissue is contraindicated.	Ib
7	Cleanse wounds with low-toxicity solutions (such as normal saline or water). Topical antiseptic solutions should be reserved for wounds that are non-healable or those in which the local bacterial burden is of greater concern than the stimulation of healing.	III
8	Assess and treat the wound for increased bacterial burden or infection (distinguish from persistent inflammation of non-bacterial origin).	IIa
9	Select a dressing that is appropriate for the needs of the wound, the patient and the caregiver or clinical setting.	IV
10	Evaluate expected rate of wound healing. If suboptimal, reassess recommendations 1 to 9.	III–IV
11	Use active wound therapies (biological agents, skin grafts, adjunctive therapies) when other factors have been corrected and healing still does not progress.	Ia–IV
	Provide Organizational Support	
12	For improved outcomes, education and evidence base must be tied to interprofessional teams with the co-operation of health-care systems.	IV

* MEASURE is an acronym for **M**easure, **E**xudate, **A**ppearance, **S**uffering, **U**ndermining, **R**e-evaluate and **E**dge. For a fuller explanation, see page 21.

Levels of Evidence Employed by RNAO Guideline Development Panels (2005)

Ia Evidence obtained from meta-analysis or systematic review of randomized controlled trials.

Ib Evidence obtained from at least one randomized controlled trial.

IIa Evidence obtained from at least one well-designed controlled study without randomization.

IIb Evidence obtained from at least one other type of well-designed quasi-experimental study, without randomization.

III Evidence obtained from well-designed, non-experimental descriptive studies such as comparative studies, correlation studies and case studies.

IV Evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities.

The guidelines that are important for local wound care include

1. Registered Nurses' Association of Ontario (RNAO) *Nursing Best Practice Guideline: Assessment and Management of Foot Ulcers for People with Diabetes* (2005).[3]
2. Registered Nurses' Association of Ontario (RNAO) *Nursing Best Practice Guideline: Assessment and Management of Venous Leg Ulcers* (2004).[4]
3. *Anti-infective Guidelines for Community Acquired Infections* (2005).[5]

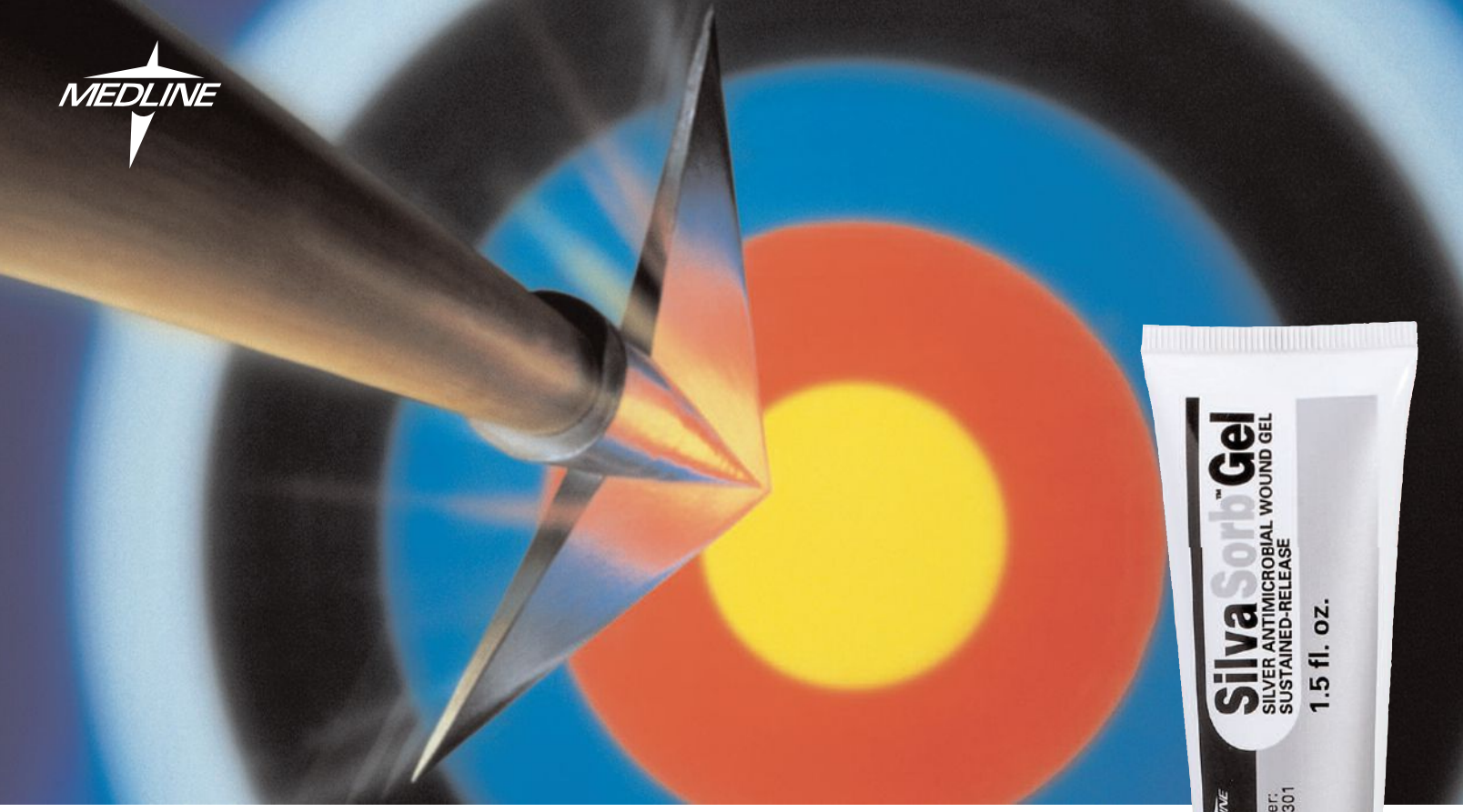
Identify and Treat the Cause

Recommendation 1: (Level of Evidence: IV)

Assess the patient's ability to heal. Adequate blood supply must be present, as well as the correction of other important host factors to support healing.

Discussion

There are several important factors that determine the patient's ability to heal. The patient must be assessed to determine if the blood supply is adequate to support healing. If a regional pulse can be palpated, the



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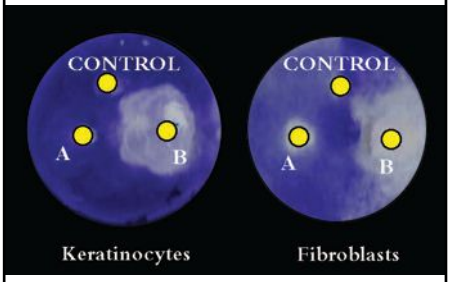

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local arterial flow will usually support healing. If the dorsalis pedis pulse is present, there is approximately 80 mm of mercury (Hg) or higher pressure. The radial pressure can be palpated at 70 mm Hg and the carotid at 60 mm Hg. If a pulse cannot be felt, special studies may include Doppler to assess the ankle-brachial pressure index or toe pressures. In specialized centres such as hyperbaric facilities, transcutaneous oxygen saturation equipment is often available. Benchmark values that indicate potential to heal include ABPI over 0.5 with a biphasic or triphasic pattern, toe pressure of 50 mm Hg or greater and transcutaneous oxygen pressure over 30 mm Hg. Below these levels, healing may still occur if all other contributing factors are optimized (Table 2).

Clinicians must remember that in the presence of calcified arteries an ankle-brachial pressure index may be falsely elevated and any value over 1.2 is likely due to calcified vessels, unless proven otherwise. Remember that the ability to heal and the criteria to apply compression are different. An ABPI will give information on arterial blood supply, but the diagnosis of venous disease must be based on clinical parameters and special duplex Doppler evaluation of the venous system.

Once the presence of adequate arterial flow is established, other criteria that may influence the healablilty of chronic ulcers must be examined:

- A careful ***Drug*** history (and known allergies) should be obtained. Immunosuppressive agents and systemic steroids can impair healing.
- Uncontrolled ***Edema*** can impair healing. The area around a chronic wound should be examined, and edema, if present, needs to be corrected.
- Nutritional status can be screened for serum ***Albumin,*** with levels below 30 g/L delaying healing, and those below 20 g/L often representing non-healable wounds.
- ***Anemia,*** with HgB levels below 100 g/L delaying healing and levels below 70 to 80 g/L representing very hard-to-heal or non-healing wounds.
- Persons with chronic ***Diseases*** that impair immunity may also be a challenge for the wound-care clinician. These include rheumatoid arthritis, collagen vascular diseases (lupus, scleroderma, dermatomyositis), persons with organ transplants and individuals receiving cancer chemotherapy or therapeutic radiation.

Remember the mnemonic DEAAD: **D**rugs, **E**dema, z**A**lbumin, **A**nemia, **D**iseases.

Recommendation 2: (Level of Evidence: IV)
Diagnose and correct or modify treatable causes of tissue damage.

Discussion

It is important to treat the cause of an ulcer as outlined in other articles of this series in this issue of *Wound Care Canada*.

- Pressure ulcers require pressure redistribution and attention to other co-factors such as friction, shear, mobility, nutrition and control of external moisture, including feces.
- Venous ulcers require edema control, with the cornerstone being compression therapy and activity modifications to activate the calf-muscle pump.
- Persons with diabetic foot ulcers require pressure offloading and appropriate control of diabetes and its complications, including infection.

There are personal and health-care-system factors that may prevent adequate correction of the cause. When it is not possible to provide best practice, clinicians may consider treating the wound to prevent complications and to improve quality of life rather than have healing as the primary outcome. Enoch and Price[8] ask us to consider alternate endpoints to healing. This type of wound can be referred to as a "maintenance" wound. If the goal is not wound healing, it is important to use resources to support alternate endpoints such as quality of life (through care support) and prevention of complications (through specialty surfaces), rather than as wound-healing resources (dressings). The RNAO Assessment and Management guidelines[3,4] outline the importance of not just practice recommendations but also recommendations relating to educational and operational needs.

Address Patient-centered Concerns

Recommendation 3: (Level of Evidence: IV)
Assess and support the management of patient-centred concerns (pain and quality of life) to enable healing.

Discussion

Unresolved pain can negatively affect wound healing which, in turn, has a negative impact on quality of life.[9] Pain can cause activation

TABLE 2

Vascular Assessment Criteria for Healing

ABPI	Toe Pressure	Toe Brachial Index	Ankle Doppler Waveform	T_cpO_2	Diagnosis
> 0.8	> 55 mm Hg	> 0.6	Normal	> 40 mm Hg	No significant arterial disease
> 0.6	> 40 mm Hg	> 0.4	Biphasic/ Monophasic	30-39 mm Hg	Arterial disease; compression can be used with caution
> 0.4	> 20 mm Hg	> 0.2	Biphasic/ Monophasic	20-29 mm Hg	Arterial disease
< 0.4	< 20 mm Hg	< 0.2	Monophasic	< 20 mm Hg	High risk for critical limb ischemia

Adapted from Browne et al. (2001).[7]

TABLE 3

Causes and Management of Pain

Causes of Pain	Characteristics	Management Strategies
Background pain	Pain at rest (related to wound etiology, infection, ischemia)	Treat the underlying etiology of the wound and associated pathologies. Provide analgesic and non analgesic options per WHO Pain Ladder.
Incident pain	Pain during day-to-day activities (coughing, friction, dressing slippage)	
Procedural pain	Pain from routine procedures (dressing removal, application)	Preparation and planning of the procedure are key to preventing pain. Analgesics per WHO Pain Ladder should be administered before a procedure and may be required post procedure. Dressing selection is key to pain management with dressing removal and application.
Operative pain	Pain associated with an intervention that would require an anaesthetic (cutting of tissue or prolonged manipulation)	

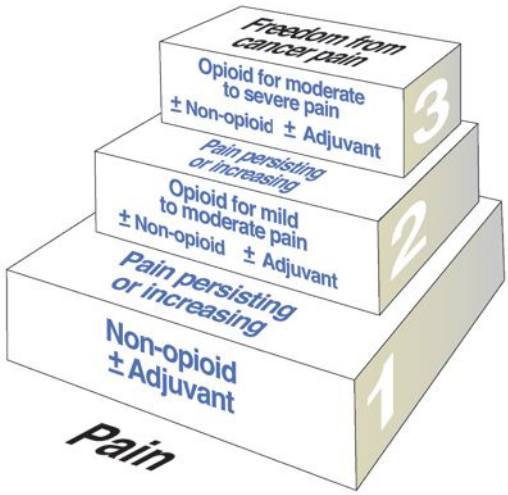
of the sympathetic branch of the autonomic nervous system, leading to tissue hypoxia. Pain can also stimulate the hypothalamic-pituitary-adrenal axis, causing a release of cortisol. Both impact negatively on wound healing. Experienced clinicians need to take an initial full pain history to provide information about the patient's pain experience, with ongoing pain assessment occurring at each patient visit.

There are two types of pain: nociceptive (an appropriate physiological response to painful stimuli [acute or chronic]) and neuropathic (an inappropriate response caused by a primary lesion or dysfunction in the nervous system). The World Union of Wound Healing Societies (WUWHS) Consensus Panel on pain identified categories related to the cause of pain (Table 3) that, in turn, support the development of management strategies for pain control. Psychological factors such as age, sex, culture, anxiety and depression, as well as environmental factors such as resources, the setting and the timing of the procedure can all affect the patient's pain experience. Describing pain and monitoring the impact of management strategies for pain control begins by listening to how the patient describes the pain. Pain intensity can be measured using tools such as a visual faces scale or numerical rating scale, and pain frequency (and intensity) can be monitored using a pain diary.

The World Health Organization (WHO) originally developed the pain ladder to simplify the management of cancer pain, but it is now used in a more generalized fashion (Figure 2).[10] The ladder provides a treatment algorithm that recommends a step-wise approach to alleviating persistent pain. Each progressive step on the ladder represents medications with higher potency for increased severity of pain. The WHO ladder, however, does not take into account neuropathic pain. Patients with neuropathic pain need to be referred to a specialist who is able to diagnose and treat neuropathic pain.[9] Neuropathic pain is often identified with non-stimulus dependent, burning, stinging, shooting and stabbing pain. It can be treated with tricyclic antidepressants, especially agents that have high anti-noradrenalin activity such as nortriptyline or desipramine. Gabapentin will also treat neuropathic pain. These agents can be started in a low dose with a gradual increase in dosage that balances therapeutic effect and side effects. Chronic wound pain often benefits from combining treatment for nociceptive and neuropathic pain.

FIGURE 2

WHO Pain Ladder



Reprinted with permission from the World Health Organization.[10]

Recommendation 4: (Level of Evidence: IV)
Provide education and support for patient-centred care to increase adherence with a treatment plan.

Discussion

In the 2000 article,[1] the focus was on patient compliance to health-care-provider recommendations, briefly touching on the term *adherence*. Adherence has become the cornerstone of patient-centred care, providing an open dialogue for patients and clinicians to discuss the rationale for care and its impact on the patient's life. The word *adherence* is preferred by many health-care providers, because

compliance suggests that the patient is passively following the health-care provider's orders and that the treatment plan is not based on a therapeutic relationship established between the patient and the provider. Osterberg and Blaschke state that, "Poor adherence to medication regimens is common, contributing to substantial worsening of disease, death, and increased health-care costs."[11] They recommend that, during patient visits, practitioners look for indications of poor adherence by asking the patient how easy it has been to follow the treatment plan and by assessing clinical response to treatment, pill counts/rates of refill and physiologic markers. Support for adherence to treatment regimens can occur in several ways, but appears most effective when several strategies are used in combination:

1. Emphasize the value of the patient's regimen and the positive effects of adherence.
2. Make the patient's regimen simple with simple, clear instructions.
3. Listen to the patient and customize the regimen to their lifestyle.
4. Enlist support from family, friends and community services when needed.

Health-care interventions that incorporate a non-judgemental attitude as well as a collaborative approach to care augment patient adherence. Innovative methods of managing chronic diseases have had some success in improving adherence when a regimen has been difficult to follow. New technologies such as reminders through cell phones and personal digital assistants and pillboxes with paging systems may be needed to help patients who have the most difficulty meeting the goals of a regimen.

Provide Local Wound Care

The Preparing the Wound Bed Paradigm in Figure 1 illustrates a holistic approach to caring for a person with a wound. Table 4 focuses on the components of local wound care and emphasizes the expected outcomes from clinical actions.

Recommendation 5: (Level of Evidence: IV)
Assess and monitor the wound history and physical characteristics (location + MEASURE).

Discussion

Consistent and reliable wound assessment remains a clinical challenge for wound-care clinicians. Wound assessment must include a global assessment of the patient and the environmental factors that may affect wound healing, as well as local assessment of the wound itself (see Figure 3). The MEASURE[13] mnemonic presented in Table 5 is a simple conceptual framework that may act as a basis for a consistent

TABLE 4

Preparing the Wound Bed: Clinical and Physiological Mechanisms of Action

Clinical Observations	Molecular and Cellular Problems	Clinical Actions	Effect of Clinical Actions	Clinical Outcome
Debridement	Denatured matrix and cell debris impair healing	Debridement (episodic or continuous) autolytic, sharp surgical, enzymatic, mechanical or biological	Intact, functional extracellular matrix proteins present in wound base	Viable wound base
Infection, inflammation	High bacteria, cause Yinflammatory cytokines Yproteases Zgrowth factor activity Zhealing environment	Topical/systemic antimicrobials anti-inflammatories protease inhibitors growth factors	Low bacteria, cause Zinflammatory cytokines Zproteases Ygrowth factor activity Yhealing environment	Bacterial balance and reduced inflammation
Moisture imbalance	Desiccation slows epithelial cell migration Excessive fluid causes maceration of wound base/margin	Apply moisture-balancing dressings	Desiccation avoided Excessive fluid controlled	Moisture balance
Edge of wound – non-advancing or undermined	Non-migrating keratinocytes Non-responsive wound cells, abnormalities in extracellular matrix or abnormal protease activity	Re-assess cause, refer or consider corrective advanced therapies • bioengineered skin • skin grafts • vascular surgery	Responsive fibroblasts and keratinocytes present in wound	Advancing edge of wound

Adapted from The International Wound Bed Advisory Board.[12]

TABLE 5

MEASURE: A Pocket Guide for Clinicians

Measurement Parameter	Clinical Observation	Indicator
Measure	Length, width, depth, area	Reduction or increase in wound surface area and/or depth
Exudate	Amount, quality	• Decreased or increased amount • Decreased or increased purulence
Appearance	Wound bed appearance, tissue type and amount	• Increased or decreased percentage of granulation tissue • Increased or decreased percentage of necrotic tissue • Friability of granulation tissue
Suffering	Patient pain level using validated pain scale	Improved or worsening wound-related pain
Undermining	Presence or absence	Decreased or increased amount
Re-evaluate	Monitor all parameters on regular basis—every one to four weeks	Parameters sequentially documented in patient record
Edge	Condition of wound edge and surrounding skin	• Presence or absence of attached edge with advancing border of epithelium • Presence or absence of erythema and/or induration • Presence or absence of maceration

Adapted from Keast DH, Bowering K, Evans W, et al.[13]

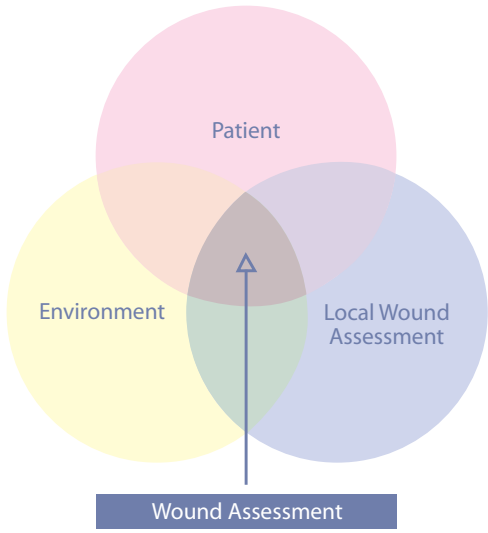
approach to local wound assessment. The most common parameters evaluated include size, wound edges, wound bed appearance, presence or absence of undermining, exudate and pain. When assessed at an appropriate frequency, these parameters give the clinician important decision-making information and create a comprehensive wound history. Clinicians are reminded that local wound assessment must occur in the context of a global assessment of the patient and of the environment.

Change in wound surface area is emerging as the most reliable predictor of outcomes in wound healing. The challenge is to measure wound surface areas in a valid and reliable manner. Consistently done simple ruler methods may be adequate for most clinical practice settings, but for greater reliability, acetate tracings or digitizing systems should be considered.

Regardless, wound assessments need to be consistently done and documented in the patient record. Multiple wound assessment tools have been developed to assist the clinician. The tool selected for use should be both valid and reliable and should detect change over time. In 1999, Woodbury et al.[14] critically appraised the tools existing at the time. The PSST (also known as the BWAT) and Sessing tools showed the best evidence for their use with pressure ulcers. Since that time, further work on validation of the PUSH tool[15] has been completed, and it can be recommended for use. The PWAT[16] tool is useful for all types of ulcers and can be scored reliably from 35 mm photographs. Most recently, the Leg Ulcer Measurement Tool (LUMT)[17] has been validated for use with leg ulcers. The tool used must be appropriate for the setting and the users.

FIGURE 3

The Context of Wound Assessment



Recommendation 6: (Level of Evidence: Ib)
Debride healable wounds, removing non-viable, contaminated or infected tissue (through surgical, autolytic, enzymatic, mechanical or larval [biologic] methods). Non-healable wounds should have only non-viable tissue removed; active debridement to bleeding tissue is contraindicated.

Discussion

The recommendation and discussion of appropriate debridement of chronic wounds from the 2000 *Preparing the wound bed* article[1] remains remarkably valid. Review of the Medline, CINAHL and Cochrane databases found very little new literature on the debridement of chronic wounds. A Cochrane review of debridement in diabetic foot ulcers[18] found evidence to support hydrogels over standard gauze, but concluded that there was insufficient evidence for surgical or larval (biologic) therapy. The Steed[19] retrospective analysis, not considered in the Cochrane review, does, however, provide good evidence (Level Ib) for surgical debridement of neuropathic ulcers with adequate circulation to heal. Table 6 has been adapted from the one included in the original paper[1] to include larval (biologic) debridement therapy. This table assists the clinician in choosing the appropriate method of debridement based on key clinical factors. Many clinicians are reluctant to perform debridement, especially in primary care settings, because of the perceived risks.[20] Before clinicians embark on debridement of chronic wounds they must ensure that they have the necessary skills to perform the task, the skill is within their scope of practice, and there is agency or institutional policy in place to support them. The discussions of autolytic, mechanical and surgical debridement in the original article remain current.

TABLE 6

Key Factors in Deciding Method of Debridement

	Surgical	Enzymatic	Autolytic	Biologic	Mechanical
Speed	1	3	5	2	4
Tissue selectivity	3	1	4	2	5
Painful wound	5	2	1	3	4
Exudate	1	4	3	5	2
Infection	1	4	5	2	3
Cost	5	2	1	3	4

Where 1 is most desirable and 5 is least desirable

Adapted from Sibbald RG, Williamson D, Orsted HL, et al.[1]

Enzymatic debridement uses proteolytic agents to break down necrotic tissue. Various commercial preparations containing agents such as collagenase, papain/urea, DNAse/fibrinolysin and trypsin are available in different countries. In general, these agents are safe and specific to necrotic tissue but may cause local irritation due to pH changes. They may provide for faster removal of necrotic tissue than autolysis. Except for collagenase, very little literature exists on their efficacy. One study showed collagenase to be more cost-effective than hydrocolloids in the treatment of Stage IV pressure ulcers.[21] In another study, collagenase was shown to be more effective than other enzymatic debriding agents and mechanical debridement in the form of wet-to-dry dressings.[22] In some countries, non-commercial preparations may be used.[23] Only collagenase has been approved for use in Canada.

Larval debridement therapy, or biological debridement, is gaining in popularity in many clinical settings. In this therapy, sterile larvae of the greenbottle fly *(Lucilia sericata)* are used to remove non-viable tissue from the wound bed. Proteinases secreted by the larvae selectively digest non-viable tissue.[24] Several recent studies have appeared in the literature supporting the use of larval debridement therapy.[24,26] Concern remains regarding infection if non-sterile larvae are used.[27] This method has yet to find general acceptance in Canada largely because of "patient and clinician disgust" but when presented in an appropriate manner may find more acceptance.[28]

Recommendation 7: (Level of Evidence: III)
Cleanse wounds with low-toxicity solutions (such as normal saline or water). Topical antiseptic solutions should be reserved for wounds that are non-healable or those in which the local bacterial burden is of greater concern than the stimulation of healing.

Discussion

In vitro studies have identified the toxicity of many of the topical antiseptic agents as outlined in the previous review (see Table 7).[1,6] To prevent tissue damage, in wounds with the ability to heal, saline and water are recommended as cleansing agents. If a wound is non-healable and bacterial burden is more important than tissue toxicity, antiseptics may be used to dry the wound surface and decrease local bacterial proliferation. This strategy may also be important if deep infection or osteomyelitis is present. Once the deep infection has been controlled, toxic solutions should not be instituted, and moist interactive dressings will promote healing and optimal preparation of the wound bed.

TABLE 7

Cleansing Solutions

Agent	Effects
Sodium hypochlorite solution	High pH causes irritation to skin. Dakins Solution and Eusol (buffered preparation) can select out Gram-negative micro-organisms.
Hydrogen peroxide	De-sloughing agent while effervescing. Can harm healthy granulation tissue and may form air emboli if packed in deep sinuses.
Mercuric chloride, crystal violet, Proflavine	Bacteriostatic agents active against Gram-positive species only. May be mutagens and can have systemic toxicity.
Cetrimide (quaternary ammonium)	Good detergent, active against Gram-positive and -negative organisms, but high toxicity to tissue.
Chlorhexidine	Active against Gram-positive and -negative organisms, with small effect on tissue.
Acetic acid (0.5% to 5%)	Low pH, effective against *Pseudomonas* species, may select out *S. aureus*.
Povidone iodine	Broad spectrum of activity, although decreased in the presence of pus or exudate. Toxic with prolonged use or over large areas.

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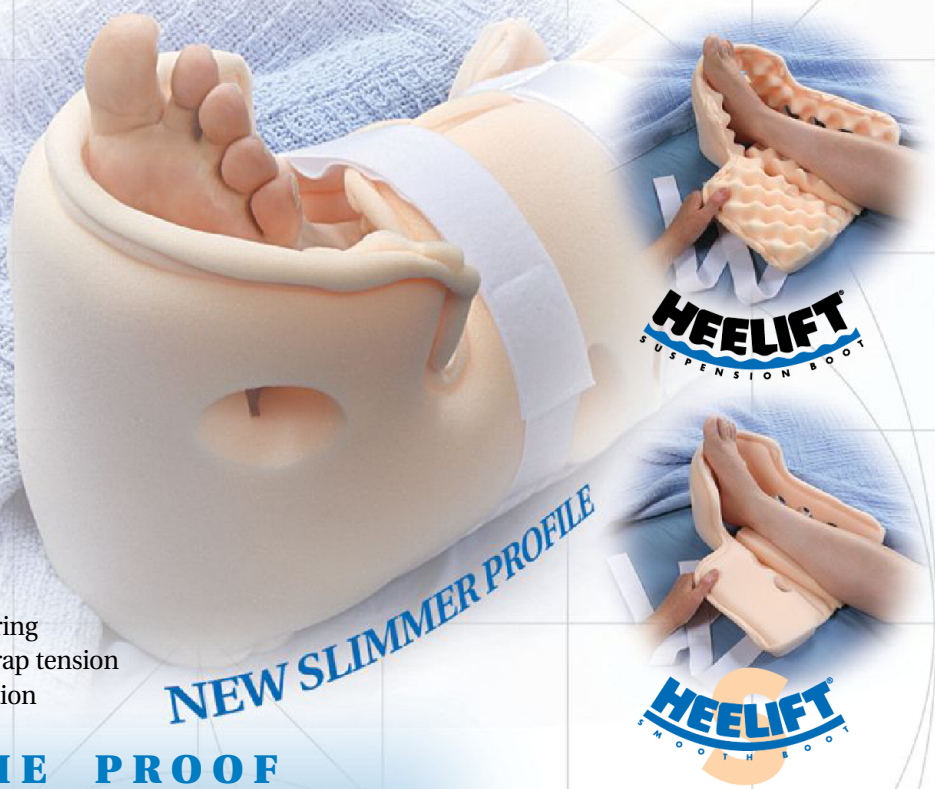

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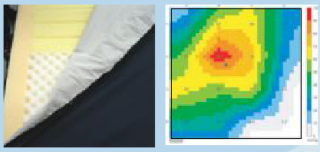
Average pressure	2.3
Maximum pressure	5.9
Center of pressure	2.7, 2.5

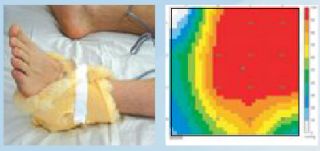
Pressure Reduction Mattress

Sensors included	16
Variation coefficient	59.7%
Standard deviation	26.8
Average pressure	44.8
Maximum pressure	100
Center of pressure	2.2, 2.2



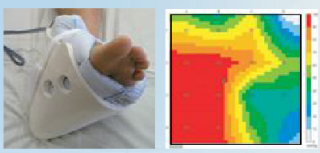
Heel Protector

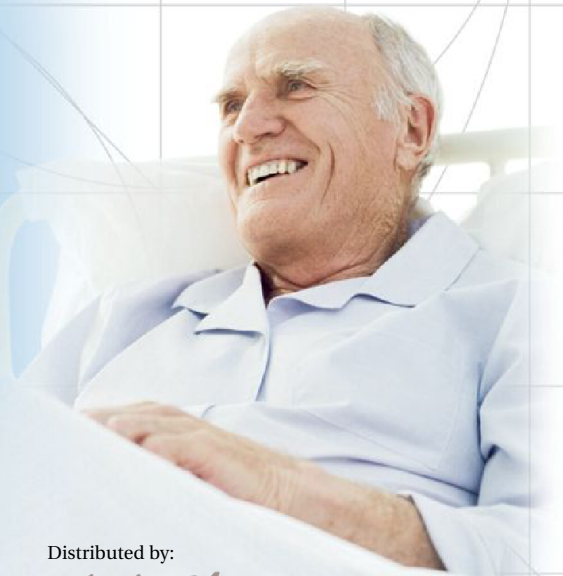
Sensors included	16
Variation coefficient	36.4%
Standard deviation	28.2
Average pressure	77.5
Maximum pressure	100
Center of pressure	2.8, 2.4



Heel Pillow

Sensors included	16
Variation coefficient	40.5%
Standard deviation	28.1
Average pressure	69.4
Maximum pressure	100
Center of pressure	2.1, 2.5





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Recommendation 8: (Level of Evidence: IIa)
Assess and treat the wound for increased bacterial burden or infection (distinguish from persistent inflammation of non-bacterial origin).

Discussion

The diagnosis of infection is based on clinical criteria, with bacterial swabs or deep cultures, laboratory and radiological tests used as adjuncts for diagnosis and treatment. All wounds contain bacteria at levels ranging from contamination through colonization and critical colonization (also known as increased bacterial burden, occult or covert infection) to infection. Increased bacterial burden may be confined to the superficial wound bed or may be present in the deep compartment and surrounding tissue of the wound margin. Therefore, it becomes important to diagnose both the bacterial imbalance and the level of invasion in order to diagnose and treat infection properly (Table 8). Increased bacterial burden in pressure ulcers has been demonstrated to delay healing in patients with chronic ulceration.[29,30]

Contamination is the presence of bacteria in the wound surface, and *colonization* is the presence of replicating bacteria attached to the wound tissue, but not causing injury to the host. *Critical colonization* occurs when bacteria delay or stop healing of the wound without the presence of classical symptoms and signs of infection. *Infection* is the presence of replicating micro-organisms in a wound associated with host injury. The borders between these concepts are not clearly established. The clinician must assess the patient's symptoms and signs present in the wound to distinguish contamination, colonization and healing from critically colonized or infected wounds that are not healing or that even may be endangering the life of the patient.

The classical signs of infections are pain, erythema, edema, purulent discharge and increased warmth. In chronic wounds, other signs of infection should be added. These include delayed healing or new areas of breakdown, increased discharge (often initially serous or clear and watery before it becomes pustular), bright red discolouration of granulation tissue, friable and exuberant granulation, new areas of slough on the wound surface, undermining and a foul odour.[31] Serous exudate may be increased in a chronic wound with increasing bacterial burden before purulence is noted, with the clinical signs usually recognized in infections. It has been suggested that chronic wounds should show some evidence of healing within four weeks to progress to healing by week 12.[13] If this time limit is exceeded, then increased bacterial burden or infection should be suspected as one of the causes of delayed healing.[32] Discolouration of granulation tissue arises from loose, poorly formed granulation tissue, while friable granulation tissue that bleeds easily occurs from excessive angiogenesis stimulated by bacterial pathogens. Healthy granulation tissue is pink-red and moist with a translucent appearance. When infected, it will appear dull and may have patches of greenish or yellow discolouration. Certain anaerobic species, such as *Bacteroides fragilis* and *Streptococci* produce a dullish, dark red hue, while *Pseudomonas* may produce green or blue patches that may fluoresce at 365 nm (Wood's) light. Undermining results from atrophic granulation tissue inhibited or digested by bacteria. Foul odour is usually produced by Gram-negative bacilli, especially *Pseudomonas* species or anaerobes, digesting granulation tissue.[33]

Deep infection will often cause erythema and warmth extending 2 cm or more beyond the wound margin when the surrounding skin becomes involved. The bacterially stimulated increased inflammatory response is painful and will cause the wound to increase in size or lead to satellite areas of tissue breakdown resulting in adjacent tissue ulceration. Deep infections, especially in ulcers of long duration, can often lead to underlying osteomyelitis. Probing to bone is a simple clinical test that may indicate osteomyelitis, especially in patients with neuropathic foot ulcers often associated with diabetes.[34]

Gardner et al.[35,36] examined the reliability and validity of clinical signs of infection in two recent papers. These studies identified various symptoms and signs of infection and compared diagnoses made using these signs with results of quantitative cultures from tissue biopsies to correlate each sign or symptom with the stated criteria of infection. Increasing pain, friable granulation tissue, foul odour and

TABLE 8

Clinical Signs and Symptoms of Wound Infection

Superficial, Increased Bacterial Burden (Critically Colonized)	Deep Wound Infection	Systemic Infection
Non-healing	Pain	Fever
Bright red granulation tissue	Swelling, induration	Rigors
Friable and exuberant granulation	Erythema	Chills
New areas of breakdown or necrosis on the wound surface (slough)	Increased temperature	Hypotension
Increased exudate that may be translucent or clear before becoming purulent	Wound breakdown	Multiple organ failure
Foul odour	Increased size or satellite areas	
	Undermining	
	Probing to bone	

Adapted from Sibbald RG, Browne AC, Coutts P, et al.[38]

TABLE 9

Topical Antimicrobials Useful in Wounds with Overt and Covert Infection

Agent	*S. aureus*	*MRSA*	*Streptococcus*	*Pseudomonas*	Anaerobes	Comments	Summary
Cadexomer iodine	+	+	+	+	+	Also debrides. Low potential for resistance. Caution with thyroid disease.	Low risk and effective
Silver	+	+	+	+	+	Do not use with saline. Low potential for resistance.	
Silver sulfadiazine	+	+	+	+	+	Caution with sulphonamide sensitivity.	
Polymyxin B sulphate/ Bacitracin zinc	+	+	+	+	+	Bacitracin in the ointment is an allergen; the cream formulation contains the less-sensitizing gramicidin.	Use selectively
Mupirocin		+				Reserve for MRSA and other resistant Gram+ species	
Metronidazole					+	Reserve for anaerobes and odour control. Low or no resistance of anaerobes despite systemic use.	
Benzoyl peroxide	Weak	Weak	Weak		Weak	Large wounds. Can cause irritation and allergy.	
Gentamicin	+		+	+		Reserve for oral/IV use—topical use may encourage resistance.	Use with caution
Fusidin ointment	+		+			Contains lanolin (except in the cream).	
Polymyxin B sulphate/ Bacitracin zinc neomycin	+	+	+	+	+	Neomycin component causes allergies, and possibly cross-sensitizes to aminoglycosides.	

Adapted from Sibbald RG, Orsted HL, Schultz GS, et al.[18]

wound breakdown all demonstrate the validity for the diagnosis of infection based on discriminatory power and positive predictive value. Those symptoms that rated most highly, with the positive predictive value in brackets, are

- Increasing pain (1.0)
- Edema (0.93)
- Wound breakdown (0.89)
- Delayed healing (0.87)
- Friable granulation (0.8)
- Purulent exudate (0.78)
- Serous exudate (0.74)

Many clinicians use a number of signs or symptoms to make a diagnosis of infection. Non-healing is often the first criterion. When managing bacterial colonization or infection, the modified recommendations made in the Agency for Health Care Policy and Research pressure ulcer treatment guidelines remain helpful and are described as follows:[37]

- Do not use swab cultures to *diagnose* infection.
- Consider a two-week trial of topical antimicrobials/antimicrobial dressings if the wound isn't healing despite optimal care (increased bacterial burden, covert infection, critical colonization suspected).
- Perform bacterial cultures and evaluate for osteomyelitis if the wound fails to improve.
- Use systemic antibiotics for overt infection.

If topical antimicrobials are used, it is important to use non-sensitizing antibiotics with low tissue toxicity. Agents used systemically should be avoided to prevent breeding resistant organisms on the surface of a wound (Table 9). Common sensitizers frequently misused in patients with chronic wounds, particularly leg ulcers, are antibiotics such as neomycin and bacitracin or agents containing lanolin or perfumes.[39]

For systemic antibiotics, it is often wise to base choices on culture once a diagnosis is made. In chronic wounds of less than one month in duration, the causative pathogens are often Gram-positive organisms. For wounds of greater than one month in duration or in patients who are immune-compromised, broad spectrum coverage for Gram-positives, Gram-negatives and anaerobic species is usually required (see Table 10).

Recommendation 9: (Level of Evidence: IV)
Select a dressing that is appropriate for the needs of the wound, the patient and the caregiver or clinical setting.

TABLE 10

Treatment of Wound Infection in Diabetic Foot Ulcer Management

Non-limb-threatening Infection	Limb-threatening Infection	
Superficial Infection	**Deep Wound Infection**	**Systemic infection**
• Support host defences • Requires a team approach • Cleanse and debride wound • May be monomicrobial • Topical antimicrobials • May require oral/IV antibiotics (based on host risk) • Offloading • Ongoing evaluation based on clinical findings • Patient education	• As in superficial infection • Polymicrobial • Will require oral or IV antibiotics • May require surgical debridement • Non weight-bearing • Consider hospitalization • Consider Infectious Disease consultation • Ongoing evaluation based on clinical findings	• As in deep wound infection • Will require hospitalization • Will require IV antibiotics • Ongoing evaluation based on clinical findings • Bedrest

Adapted from the Registered Nurses' Association of Ontario, Guideline Development Panel.[3]

Discussion

Clinicians should base the choice of dressing selection on the patient history and assessment, the cause of the wound, and the evaluation of the wound bed and peri-wound skin. Each wound must be treated individually as there is no "recipe" for a particular wound type. The selected dressing should provide the appropriate moisture for the wound environment, prevent infection, not cause pain, and not cause damage to the wound or peri-wound area. The clinician needs to consider what the function of the dressing is in order to maximize the preparation of the wound bed. The form chosen needs to conform to the area where it is applied to facilitate moisture balance and prevent infection. Ongoing reassessment of the dressing choice needs to occur along with the regular assessment of the wound.

The clinician should become familiar with the different categories of dressings and their construction (Table 12). They should have an understanding of the mode of action of the dressing within the wound, as well as the indications and contraindications to use. The selection of the dressing should balance the goal of care with the cost to payer in order to attain optimal, cost-effective care.

Recommendation 10: (Level of Evidence: III–IV)
Evaluate expected rate of wound healing to determine if treatment is optimal. If sub-optimal healing is noted, reassess the cause and patient-centred concerns.

Discussion

Flanagan[41] states that a 20 per cent to 40 per cent reduction of wound area in two and four weeks is likely to be a reliable predictive indicator of healing. A clinical study demonstrated that a 50 per cent reduction in ulcer area at 12 weeks of treatment is a good predictor of healing.[42] If the edge is not migrating, and the wound is not getting smaller, a full reassessment of cause and corrective therapies needs to occur. If patient and wound factors are optimized and the edge is still not migrating, then a wound may need advanced therapies to kick-start the healing process. A biopsy to rule out other causes, such as unrecognized malignancy, needs to occur if healing does not progress.

Falanga[2] designed a classification system (Table 11) to monitor the outcomes of bioengineered skin that is helpful in assessing the movement of the wound edge as a parameter for monitoring healing outcomes.

Clinicians need to remember that the edge of the wound is only one outcome parameter, and wound closure is not always the expected outcome. Maintenance wounds, that is wounds that are unlikely to

TABLE 11

Clinical Classification of the Early Effect of the Wound Edge

Class	Effect	Edge Description
A	Full	Thin but widespread epidermal coverage, the edges have been activated.
B	Edge effect only	Stimulation of the wound's edges, translucent epidermal outgrowth visible.
C	Wound bed stimulation only	Stimulation of granulation tissue, wound bed is even with surrounding skin.
D	No benefit	There is no stimulation of the wound edges or bed.

Adapted from Falanga.[2]

TABLE 12

Modern Classes of Dressing

Generic Categories		Local Wound Care			Care Considerations
Class	Description	Tissue Debridement	Infection	Moisture Balance	Indications / Contraindications
1 Films/membranes	Semi-permeable adhesive sheet. Impermeable to H_2O molecules and bacteria.	+	–	–	Moisture vapour transmission rate varies from film to film. Should not be used on draining or infected wounds.* Create occlusive barrier against infection.
2 Non-adherent	Sheets of low adherence to tissue. Non-medicated tulles.	–	–	–	Allow drainage to seep through pores to secondary dressing. Facilitate application of topicals.
3 Hydrogels	Polymers with high H_2O content. Available in gels, solid sheets or impregnated gauze.	++	–	+	Should not be used on draining wounds. Solid sheets should not be used on infected wounds.
4 Hydrocolloids	May contain gelatin, sodium carboxymethylcellulose, polysaccharides and/or pectin. Sheet dressings are occlusive with polyurethane film outer layer.	+++	– / +	++	Should be used with care on fragile skin. Should not be used on heavily draining or infected wounds.* Create occlusive barrier to protect the wound from outside contamination. Characteristic odour may accompany dressing change and should not be confused with infection.
5 Calcium alginates	Sheets or fibrous ropes of calcium sodium alginate (seaweed derivative). Have hemostatic capabilities.	++	+	+++	Should not be used on dry wounds. Low tensile strength—avoid packing into narrow deep sinuses. Bioreabsorbable.
6 Composite dressings	Multilayered, combination dressings to increase absorbency and autolysis.	+	–	+++	Use on wounds where dressing may stay in place for several days.*
7 Foams	Non-adhesive or adhesive polyurethane foam. May have occlusive backing. Sheets or cavity packing. Some have fluid lock.	–	–	+++	Use on moderate to heavily draining wounds. Occlusive foams should not be used on heavily draining or infected wounds.*
8 Charcoal	Contains odour-adsorbent charcoal within product.	–	–	+	Some charcoal products are inactivated by moisture. Ensure that dressing edges are sealed.
9 Hypertonic	Sheet, ribbon or gel impregnated with sodium concentrate.	+	+	++	Gauze ribbon should not be used on dry wounds. May be painful on sensitive tissue. Gel may be used on dry wounds.
10 Hydrophilic fibres	Sheet or packing strip of sodium carboxymethylcellulose. Converts to a solid gel when activated by moisture (fluid lock).	+	–	+++	Best for moderate amount of exudate. Should not be used on dry wounds. Low tensile strength—avoid packing into narrow deep sinuses.
11 Antimicrobials	Silver or cadexomer iodine with vehicle for delivery: sheets, gels, alginates, foams or paste.	+	+++	+	Broad spectrum against bacteria. Not to be used on patients with known hypersensitivities to any product components.
12 Other devices	Negative pressure wound therapy (NPWT) applies localized negative pressure to the surface and margins of the wound. Dressings consist of polyurethane or polyvinyl alcohol materials.	–	+	+++	This pressure-distributing wound dressing actively removes fluid from the wound and promotes wound edge approximation. Advanced skill required for patient selection for this therapy.
13 Biologics	Living human fibroblasts provided in sheets at ambient or frozen temperatures. Extracellular matrix. Collagen-containing preparations. Hyaluronic acid. Platelet derived growth factor.	–	–	–	Should not be used on wounds with infection, sinus tracts, 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.

* Use with caution if critical colonization is suspected. Adapted from Canadian Association of Wound Care[40]

heal, need to have alternative endpoints, such as wound stabilization, reduced pain, reduced bacterial load or decreased frequency of dressing changes.[8]

Recommendation 11: (Level of Evidence: Ia–IV)
Use active wound therapies (biological agents, skin grafts, adjunctive therapies) when other factors have been corrected and healing still does not progress.

Discussion

Adjunctive therapies should be considered as options for wound management when healing is recalcitrant. Adjunctive therapies such as Negative Pressure Wound Therapy (NPWT), also referred to as Topical Negative Pressure (TNP) therapy, biologically active dressings, living skin tissue (grafts) or living skin equivalents, electrical stimulation, hyperbaric oxygen and therapeutic ultrasound may offer alternatives to stimulating healing when malignancy is ruled out. Some of these therapies are discussed in more detail under the appropriate ulcer etiology in other papers in this issue of *Wound Care Canada*. The level of evidence for each therapy is dependent on the etiology of the ulcer.

The Canadian Consensus Group VAC Therapy (CCGVT) Report (2003)[43] and the Medical Advisory Secretariat (MAS) of the Ontario Ministry of Health and Long-Term Care for the Ontario Health Technology Advisory Committee Report (2004)[44] have reviewed the use of NPWT in the Canadian context. Both reports were unable to find significant evidence to support the use of NPWT but did conclude that there were clear clinical situations where the use of NPWT might be beneficial. These included such benefits as earlier hospital discharge, fewer dressing changes, savings in nursing costs and improved quality of life. The Canadian Consensus Group also suggested appropriate criteria for implementing NPWT. These included appropriate assessment of the patient, the absence of fistulas and malignancy, the ability of the patient to adhere to the plan of care and at least four weeks of prior first-line treatment without a reasonable decrease in wound size (<30%).

A 2004 Cochrane review by Kranke et al.[45] gave qualified support to the use of hyperbaric oxygen treatment (HBOT) for diabetic foot ulcers. HBOT significantly reduced the risk of major amputation and may improve the chance of healing at one year. The authors commented on the high cost of the therapy and its limited availability. The review could find no evidence to support the use of HBOT in other etiologies.

Cochrane reviews of the use of both electromagnetic therapy[46] and low-level laser[47] in the treatment of venous leg ulcers could find no evidence to support these modalities. This is consistent with the findings regarding pressure ulcers discussed in the pressure ulcer paper in this issue.

The discussion of the use of living skin equivalents and of platelet-derived growth factor from the original 2000 *Preparing the wound bed* article remains valid.[1] A recent meta-analysis of artificial skin grafts done for the Canadian Co-ordinating Office for Health Technology Assessment[48] concluded that artificial skin grafts promote wound closure, resulting in more frequent and rapid healing of diabetic foot ulcers when compared to standard therapy. The effect was seen 11 to 12 weeks after application of the graft. The same effect was not seen in venous leg ulcers. No significant increase in adverse outcomes such as infection was seen. The authors concluded that while cost may be increased in the short term, net cost savings might be seen at one year.

Provide Organizational Support

Recommendation 12: (Level of Evidence: IV)
For improved outcomes, education and evidence base must be tied to interprofessional teams with the co-operation of health-care systems.

Discussion

Wound healing can be a complex process once all the factors and co-factors that may affect healing are identified. Best practice care for persons with chronic ulcers demands a systematic, team approach from knowledgeable and skilled health-care professionals. These team members will vary based on the needs of the patients. The interdisciplinary team needs to work closely with patients and their families to address the complex lifestyle, self-care and multiple treatment demands of patients who have chronic wounds. Clinicians can facilitate and positively influence wound-healing outcomes by promoting, collaborating and participating in interdisciplinary care teams who follow best practice guidelines similar to those presented in this document and the other documents in this series. Armstrong et al.[49] demonstrated that a team approach to diabetic foot care resulted in significant savings to the health-care system. Implementation of best-practice, team-focused care in a study of 16,000 patients resulted in 66 per cent fewer hospital admissions, a 74 per cent decrease in hospital days and a 53 per cent decrease in nursing home admissions.

The development and implementation of a successful wound management program not only involve collaboration with practice leaders but, as the RNAO guidelines demonstrate, also benefit from collaboration with educators and administrators. Their support is required to ensure co-ordinated care with community and health-care agencies and the specialized, knowledgeable interdisciplinary team of health-care professionals striving for improved wound-care outcomes. All the RNAO wound-care-related clinical practice guidelines contain multiple recommendations related to the value of interprofessional teams and the need for organizational support.

Conclusion

The concept of the *Preparing the wound bed* algorithm as a systematic clinical decision-making framework, first published in the 2000 article, has stood the test of time.[1] The key components of wound assessment and management, i.e., identifying and treating the cause of the wound, addressing patient-centred concerns, establishing goals for wound healing, optimizing local wound care, and collaborating with interprofessional team members, remain valid five years later. To effect change and improve healing outcomes, clinicians need to move beyond the local to the global, learning to interact with, and effect change within, health-care systems.

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