Skin and Wound Care for Health Care Professionals

R.GARY SIBBALD

Contents

CHAPTER 3

CHAPTER 4

CHAPTER 5

CHAPTER 6

This is where you can write your introduction.

Acknowledgements

Acknowledgements

This open textbook was developed by Sault College.

The development of this OER and course have been funded by the Province of Ontario and eCampusOntario (OOLC).

CHAPTER 1

Chapter 1: Introduction and Statement 1

WOUND BED PREPARATION

Authors:

- Reneeka Jaimangal
- Laurie Goodman
- R.Gary Sibbald

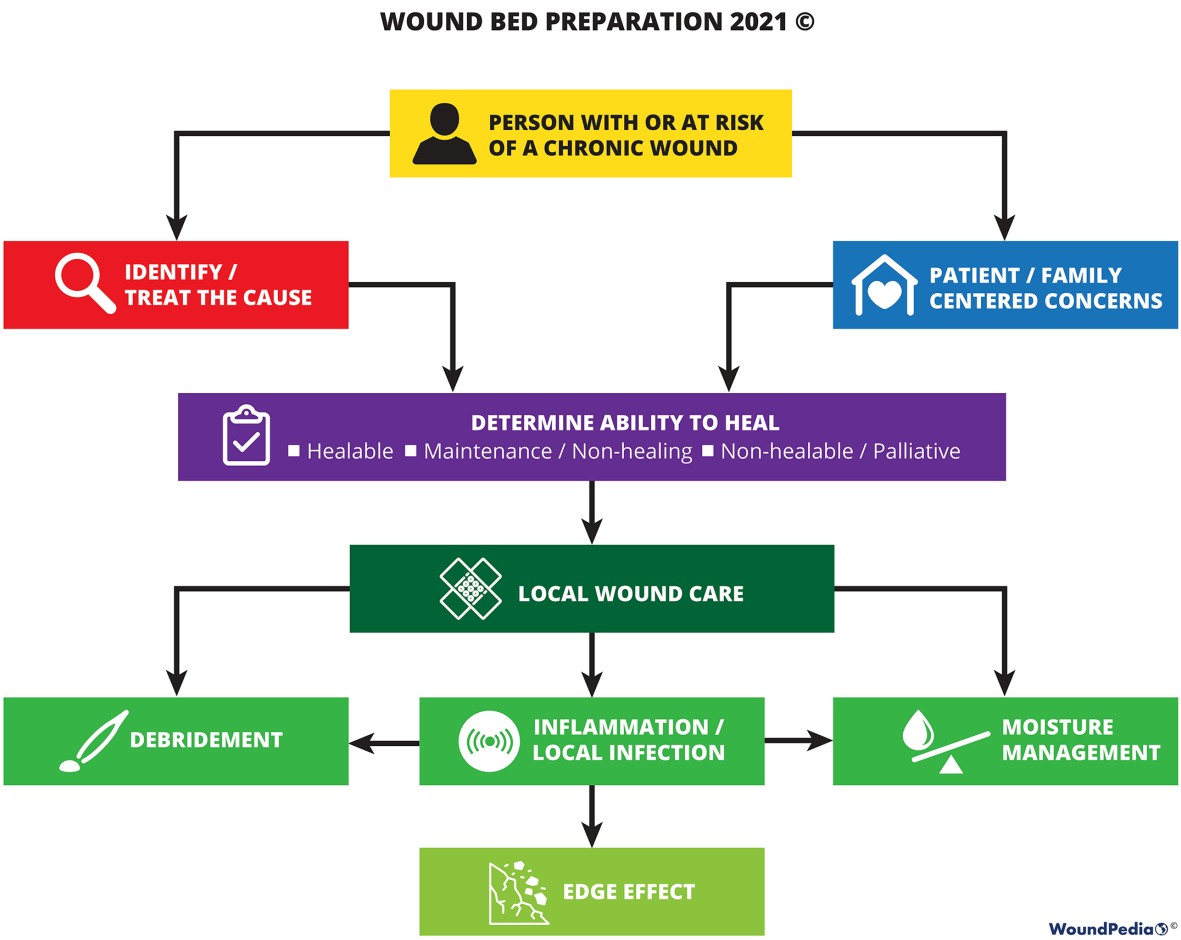
Wound healing is a dynamic and complex process that involves four phases: hemostasis, inflammation, proliferation, and remodeling (Guo & DiPietro, 2010). All four phases need to follow a certain sequence and time interval to achieve optimal wound healing. Acute wound healing follows the normal healing trajectory and often heal in less than 30 days.

Chronic wounds are often present for more than 30 days although some authors site periods of up to 12 weeks before wounds are considered chronic. When the wound becomes "stuck" in one or more phases, most commonly the inflammatory stage, there is delayed healing that results in a chronic wound. Many factors including abnormal vascular supply, poorly controlled diabetes, malnutrition, infection and active autoimmune diseases may impair wound healing (Guo & DiPietro, 2010).

Chronic wound patients with prolonged wound healing that do not heal with conservative wound care interventions become a major healthcare burden (Cukjati et al., 2001; Schultz et al., 2003). A 2018 systematic chronic wound review concluded that these wounds incur extensive health care costs (Olsson et al., 2019). Patients with chronic wounds also have reduced activities of daily living as reflected in poor quality of life assessments (Olsson et al., 2019). As such, it is imperative to accurately identify causes for impaired wound healing and correct them accordingly (Frykberg & Banks, 2015).

Wound Bed Preparation (WBP) provides a structured and systematic approach to wound management that facilitates wound healing and the use of other therapeutic interventions (Schultz et al., 2003). WBP was first published in 2000 (Falanga, 2000; Sibbald et al., 2000) with continuing updates over the years, the most recent being in 2021 (Sibbald et al., 2021). WBP focuses on identification of the cause, prevention and management of various wound types along with addressing patient-centered concerns for a holistic approach (Sibbald et al., 2021). See Figure 1.

Figure 1. Wound Bed Preparation Algorithm 2021



Used with permission from WoundPedia 2021

Wound Bed Preparation 2021 is a revision of previous iterations along with literature updates, formalized by a consensus from wound care experts, that produced 10 statement recommendations for chronic wound care (Sibbald et al., 2021). The following 10 statements presented in this chapter 1 have been adapted from WBP 2021.

STATEMENT 1 – **TREAT THE CAUSE** (S) OF THE WOUND

Early and accurate identification of the cause(s) and appropriate treatment are crucial to wound care and entails three steps: 1a, 1b & 1c

1a) Determine if there is adequate blood supply to heal: Adequate tissue oxygenation is vital for cell metabolism and many wound healing mechanisms, especially collagen synthesis, prevention of infection, re-epithelialization and angiogenesis (Gottrup, 2004). Clinicians should examine the leg and foot for signs of poor vascular supply (pallor on elevation, dependent rubor, cool distal extremity) and palpate for the pedal pulses (dorsalis pedis or posterior tibial), recorded as absent or present (Sibbald et al., 2011, 2021). About 8% of the

general population have an aberrant dorsalis pedis artery and the posterior tibial artery should be alternatively palpated. A palpable pedal pulse (either of the two, not necessarily both) implies that the arterial pressure in the foot is at least 80mmHg or more.

The ankle brachial pressure index (ABI) is a standard test used to determine the degree of arterial blood supply to the extremity and is calculated by dividing the ankle systolic pressure by the brachial (arm) systolic pressure (Al-Qaisi et al., 2009). A normal ABI is equal to or greater than 0.9 and less than 1.4 (Beaumier et al., 2020; Gerhard-Herman et al., 2017). Less than 0.9 indicates some degree of arterial comprise, while an ABI of more than 1.4 is an incorrect value that indicates calcification of the vessels in the foot (Beaumier et al., 2020; Gerhard-Herman et al., 2017). Calcification of the vessels is present in 80% of patients with diabetes and in approximately 20% of older adults (Sibbald et al., 2021); in these cases toe pressure measurements are useful.

The audible hand-held Doppler (AHHD) test is an alternative method, where based on the audible Doppler waveforms, the degree of arterial compromise can be determined. A monophasic sound indicates arterial compromise and the need for non-invasive sequential lower leg Duplex Doppler studies to identify bypassable or dilatable vessels A multiphasic sound (triphasic or biphasic) indicates an audible ABPI equal or greater than 0.9 with adequate arterial supply for healing and the use of high compression bandaging (Sibbald et al., 2011). A 2015 study on 379 legs on 200 patients, concluded that the "AHHD proved to be a reliable, simple, rapid, and inexpensive bedside exclusion test of peripheral arterial disease in diabetic and nondiabetic patients" (Nabavizadeh et al., 2015). This test is quicker to perform than the traditional ABPI; it is not falsely elevated with calcified vessels, does not require the patient to be recumbent for 20 minutes ant there is no need to inflate a blood pressure cuff over the calf that is often painful! (Sibbald & Ayello, 2021). See Table 1

Table 1 Vascular Assessment Methods

Method	Indication for Healability
Palpable pulse – dorsalis pedis, posterior tibial	>80 mmHg
Ankle-brachial pressure index (ABPI)	>0.6 and <1.4
Transcutaneous oxygen tension	>30 mmHg
Toe pressure	>30-45 mmHg
Audible handheld Doppler	Triphasic or biphasic sound(represents ABPI >0.9)

1b) Identify the cause(s) as precisely as possible or make appropriate referrals: Wound etiologies can often be unclear and misleading, resulting in inappropriate management strategies. The cause of the wound should be accurately identified taking into consideration different wound types including, vascular leg ulcers (venous is most common but also arterial, mixed, lymphatic or a combination), pressure injuries, and foot ulcers often in persons with Diabetes. See Table 2. Other wounds include inflammatory ulcers (pyoderma gangrenosum, vasculitis) malignant ulcers, post-surgical, traumatic wounds, and other factors that contribute to skin breakdown (moisture, fragile skin, additional comorbidities, etc.) (Sibbald et al., 2021).

Table 2: Treating the cause of three main wound types

Wound Type	Treatment of the Cause
All wounds	Adequate pain control, management of moisture, optimized nutritional status
Venous ulcers  *Used with permission from WoundPedia 2021*	• Compression bandages for healing • Compression stockings for maintenance and prevention of recurrence • No arterial disease – High compression • [Ankle Brachial Pressure Index (ABPI) > 0.9/ AHHD] • Mixed venous/arterial disease – Modified compression • [Ankle Brachial Pressure Index (ABPI 0.6-0.9]
Pressure injuries  *Used with permission from WoundPedia 2021*	• Pressure redistribution over bony prominences • Reduction of shear forces • Enhancing physical activity and mobility • Management of incontinence and moisture

Diabetic foot ulcers(V.I.P.S.)

Used with permission from WoundPedia 2021

- V= Vascular – Determine adequate vascular supply
- I= Infection – Treat superficial critical colonization / deep
- + surrounding infection
- P= Pressure – Redistribute Plantar Pressure
- S= Sharp – Surgical serial debridement

1c) Evaluate comorbidities and other factors that may delay/suppress healing: All modifiable cofactors and comorbidities should be focused on to expedite the wound healing process. These factors include systemic disease (especially uncontrolled diabetes, immunocompromised state, obesity, active autoimmune diseases), malnutrition, previous wound related surgical interventions, prescribed medication (immunosuppressants, oral corticosteroids over 20 mg daily, non-steroidal anti-inflammatory agents (some are over the counter), chemotherapy), and substance use including smoking, alcoholism, street/illicit drug use (Guo & DiPietro, 2010).
All medications and chronic diseases need to be optimized (may require follow up with the family doctor and other specialists). Relevant laboratory investigations, especially complete blood count, hemoglobin, Hemoglobin A1c (HbA1c), albumin, C reactive protein, X-ray, ultrasound, etc., should be ordered where necessary. The Canadian Nutritional Taskforce validated a 2 question screening tool to perform a quick nutritional assessment without requiring laboratory tests (Laporte et al., 2015; Screening – CMTF – Canadian Malnutrition Task Force, n.d.).

1. Have you lost weight in the past 6 months without trying?
2. Have you been eating less than usual for more than a week?

If the patient answers “yes” to both questions, a referral to a registered dietitian to perform a detailed nutritional assessment is required (Screening – CMTF – Canadian Malnutrition Task Force, n.d.).

Statements 2 to 4

STATEMENT 2 – PATIENT CENTERED CONCERNS

The patient should be at the center of their care. Management plans should be prepared, modified, and adapted to the individual patient, taking into consideration their specific, unique needs and concerns. Sackett et al. (1996) stated that the practice of evidence based medicine includes scientific evidence, expert opinion and patient preference that should consider the patients' rights and opinions. (Sackett et al., 1996).

2a) Optimal pain management: Wound associated pain is a frequent source of distress for patients with chronic wounds. The intensity of wound pain can be high with any chronic wound but may be more evident depending on the wound etiology and aggravating factors (e.g., ischemic arterial ulcers or inflammatory ulcers including pyoderma gangrenosum).

Pain is derived from two physiological pathways that require different and focused therapeutic management. Nociceptive pain occurs from tissue damage caused by trauma or injury (Mudge & Orsted, 2010). It is often acute and described as aching, throbbing, tender, gnawing (Sibbald et al., 2021). Neuropathic pain occurs as a result of damage to the nervous system, usually spontaneous and described as shooting, burning stinging or stabbing (Sibbald et al.,2021). There are various causes of wound pain that are usually interrelated including, pain (from the wound itself), external stimuli, due to dressing changes, compression, and other local causes including, edema, ischemia, skin disease (Mudge & Orsted, 2010). It is essential to perform consistent and regular pain assessments for effective therapeutic interventions. These should be documented at every assessment. There are many validated tools that either qualitatively or quantitatively assess pain. They range from simple, (the visual analog scale, numerical rating scale and pain faces scale), to more complex tools (including questionnaires and pain diaries) (Mudge & Orsted, 2010).

2b) Evaluate activities of daily living, exercise/mobility, psychological well-being, mental health, support system (circle of care, access to care, financial constraints). A patient centered approach addresses the patient as whole and their circle of care. Many patients lack the social and financial support necessary to facilitate the chronic wound journey. Wound pain has many debilitating effects and has been shown to reduce activities of daily living, often measured indirectly with quality of life assessment tools (Woo & Sibbald, 2008). Mental health and psychosocial well-being should be addressed. Many patients have difficulty coping with the chronicity of some wounds and other factors including copious exudate, excessive odour, negative body image and social isolation. Healthcare system factors including accessibility to care need to be assessed as they impact directly on clinical outcomes. Clinicians should therefore advocate for their patients and tailor treatment plans that are accommodating to the patient and their unique situation

2c) Evaluate habits – smoking, alcohol, substance use, hygiene. Cigarette smoke affects arterial endothelial

function and decreases vascular supply by as much as 40% thus producing ischemia and subsequently, affecting wound healing (Weller et al., 2021). Mechanisms to deal with smoking cessation and control of alcohol and substance abuse will facilitate wound healing but this often takes time and clinician patience as relapses are common.

2d) Empower patients with education and support to increase treatment adherence (coherence). Chronic wound care management is a collaborative effort that requires negotiation with the patient to include their perspective. This will increase subsequent adherence to the plan of care. These actions can include, but not limited to, using compression therapy, offloading devices, mobility/turning schedules, smoking cessation, and adequate nutritional intake. It is important to explore the reasons why patients are non-adherent and plan strategies that align with both clinician and patient needs (Weller et al., 2021).

STATEMENT 3 – DETERMINE ABILITY TO HEAL

Wounds are classified into three categories based on their ability to heal: healable, maintenance and nonhealable (Sibbald et al., 2021).

3a) Healable wounds constitute approximately two-thirds of wounds seen in the community. For these wounds, the cause can be identified and corrected, and they follow the healing trajectory. Healing can take a variable period depending on the correct diagnosis and treatment, comorbidities and the patient's adherence to the standard of care.

3b) Maintenance wounds occur in cases where the patient refuses to adhere to the treatment plan or there are health care system barriers, or both, that prevent the cause from being corrected. For example, a patient may refuse to use the recommended compression therapy that is vital for venous insufficiency ulcer to heal. Another example is when a patient refuses to wear appropriate footwear for the high-risk diabetic foot. For system barriers, chiropody services and offloading footwear are not covered by health care systems including universal Ontario health care. Patients often cannot financially afford to pay for these much needed services necessary for neuropathic or ischemic ulcers often in persons with diabetes (Sibbald et al., 2011, 2021). The main approach for maintenance wounds is based on the fact that the wound is healable, but the appropriate treatment is either not attainable for system reasons or adhered to due to individual patient choices.

3c) Nonhealable wounds. Wounds that have inadequate blood supply or an underlying cause that cannot be corrected are classified as nonhealable wounds (e.g., due to unresponsive malignancy, critical ischemia) and account for 5-10% of all wounds. The priorities of care for these patients are not aimed at wound healing, but instead at maintaining quality of life, minimizing pain, exudate, odour, infection and facilitate continuation of activities of daily living (Sibbald et al., 2021). If the cause of the wound is corrected, the wound may change to healable or maintenance healing classification.

STATEMENT 4 – LOCAL WOUND CARE: WOUND HISTORY AND CLINICAL EXAMINATION

4a) A comprehensive wound history and assessment is a pivotal aspect of wound care, thereby defining the status of the wound and establishing a baseline for subsequent assessments.

Local wound care interventions are then based on the ability to heal classification of the wound (healable, maintenance or nonhealable). Wound assessments and documentation should follow a standardized approach with consistent measurement units and parameters (Hess, 2019). The MEASURE mnemonic is a common tool used for wound assessments that describes specific wound parameters (Keast et al., 2004).

- **Measure** (length, width, depth, and area): Wound measurement techniques can vary The most common method is using the longest length by the widest width perpendicular to each other with a wound ruler (some institutions also use the head-to-toe configuration). Another simple method includes wound tracing on calibrated acetate or transparent film. More technical methods include computer imagery, wound photography with digital tracing on mobile apps, etc. (Flanagan, 2003)
- **Exudate** (quantity and quality): amount (none, scant, moderate, heavy) and characteristics should be documented (serous, sanguineous, pustular or combinations with the most predominant component stated first)
- **Appearance**: wound bed, including tissue type: (black necrotic tissue, healthy firm pink granulation tissue , soft yellow to brown slough, new purple re-epithelialization) and their relative proportion of the wound surface
- **Suffering**: wound pain score, pain type(s), and characteristics
- **Undermining**: presence or absence; if present, assessed for using the hands of the clock to document (where the patient's head direction signifies 12 o'clock and their feet being 6 o'clock)
- Reevaluate: monitoring all parameters at regular intervals
- **Edge**: condition of the edge and surrounding skin (rolled edges, maceration, thick callus, dryness, erythema, edema).

Figure 2 Wound Bed Appearance: Courtesy of Sharon Baranoski

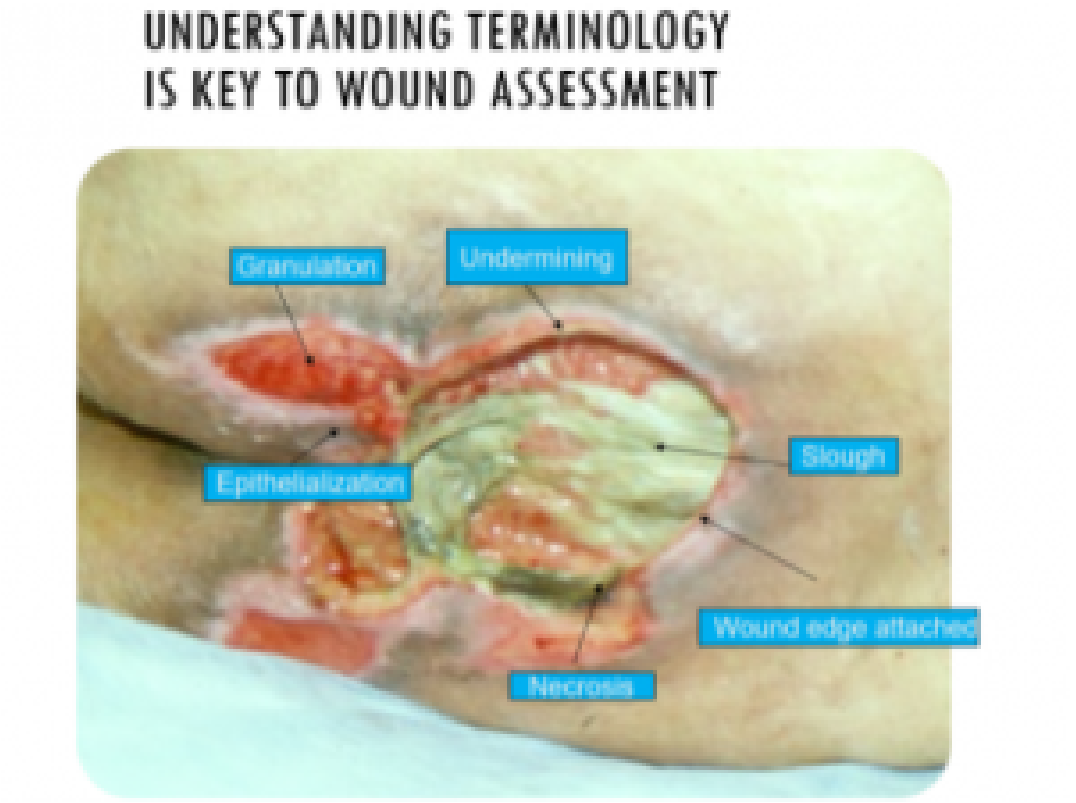


Figure 2 Wound Bed Appearance: Courtesy of Sharon Baranoski

Precise and standardized wound assessments are vital for monitoring the progress of wound healing and early

identification of wounds that are stalled or deteriorating with interventions. This is necessary to correct factors that are impeding wound healing and avoid unnecessary use of advanced modalities (Flanagan, 2003). Wounds that are nonhealable are ideally identified early. Various studies in reduction of surface area of different wound etiologies concur that a surface area reduction of 20-30% at week 4 is a good predictor for healing at week 12 (Chronic Wounds and Delayed Healing Risk, 2010; Flanagan, 2003; Sheehan et al., 2003). Wound assessments and individualized care plans should be accurately documented and communicated to the patient and their circle of care.

4b) Gently cleanse the wound with low toxicity solutions (water, saline, antiseptic agents). The cleansing solution used depends on the characteristics of the wound and availability in practice. There is poor consensus in the literature on wound cleansing recommendations. An updated 2021 Cochrane review on cleansing solutions of venous leg ulcers concluded that there is "lack of RCT evidence to guide decision making about the effectiveness of wound cleansing compared with no cleansing and the optimal approaches to cleansing of venous leg ulcers" (McLain et al., 2021). However, general wound care principles recommend using low toxicity solutions such as water, saline, and other skin friendly antiseptic agents (Sibbald et al., 2011). This avoids cytotoxic effects and damage to healthy granulation tissue. Acetic acid (diluted to 0.5-1.0%) or hypochlorous acid can also be used in some cases where an acidic environment is preferred (e.g., used to topically treat species of Pseudomonas) (Block & Rowan, 2020). Based on the healing classification of the wound, antiseptic agents with some tissue cytotoxicity may be used with a benefit vs. risk scenario (low concentrations chlorhexidine or it's derivative polyhexamethylene biguanide (PHMB) or povidone iodine). This may be in the cases of maintenance and nonhealable wounds that have a high potential for infection where these agents can be used to manage odour, exudate, and control bioburden. See Table 3. Wound irrigation is also a controversial topic. However, expert opinion recommends that wounds should not be irrigated if the base of the wound is not visible, to avoid accumulation of the irrigation solution in closed spaces (Sibbald et al., 2011).

Table 3. Common antiseptic agents for use in nonhealable wounds. Cytotoxicity is less important than antimicrobial action.

AGENT	TOXICITY	EFFECTS
Chlorhexidine (PHMB). GR	• Low GR	• Neutral, non-release • Does not treat wound surface • Kills bacterial cell wall – no bacteria left for resistance GR
Povidone Iodine GR	• Low • Less toxic with slow-release formulations GR	• Pro-inflammatory • Treats wound surface • Broad spectrum • Good penetration of biofilm glycocalyx GR
Acetic Acid (diluted to 0.5-1.0%) Hypochlorous Acid GR	• Moderate GR	• Lowers pH of wounds (bacteria thrives in alkaline environment) • Pseudomonas • Disinfectants GR
Saline YL	• Neutral YL	YL
Dyes-Scarlet red, Proflavine PK	• Toxic PK	• Select out Gm neg. **PK**
Na Hypochlorite-Dakins, Eusol PK	• Toxic = bleach PK	PK
Hydrogen Peroxide PK	• Action = Fizz PK	PK
Quaternary Ammonia- Cetrimide PK	• Very high toxicity PK	PK

Adapted from Wound Bed Preparation 2021

Statements 5 to 10

STATEMENT 5 – DEBRIDEMENT OF WOUNDS WITH ADEQUATE PAIN CONTROL WHEN APPROPRIATE.

Debridement is one of the elements of the DIME [debridement of devitalized tissue, infection or inflammation control, moisture management and (wound) edge effect] principles of local wound care (Snyder et al., 2016). Debridement is the removal of dead tissue. It can also remove senescent cells, slough, debris, or any other extraneous materials, thereby promoting re-epithelization (Manna et al., 2021) . There are different types of debridement (*Wound Debridement Options*, 2018). Sharp surgical debridement for healable wounds is the most aggressive, using surgical instruments to remove dead or devitalized tissue to bleeding or viable wound base (creating an acute wound in a chronic wound). It requires adequate blood supply to ensure healing post debridement. The ability to perform acute sharp debridement is based on various factors including, each practitioner's skill and scope of practice, availability of instruments, need for anesthesia, location and back up personnel.

Conservative surgical debridement consists of removing non-viable slough or dead tissue. This may be performed by removing surface slough but not cutting into live viable tissue of the wound base or edges (Sibbald et al., 2021). This type of debridement is often performed in maintenance or non-healable wounds. Other types of debridement are primarily performed on healable wounds and include enzymatic (enzymes chemically liquefy dead tissue), biological (e.g., maggot therapy), autolytic (using various dressings) and mechanical (hydrotherapy, wet-to-dry dressings that may cause more tissue damage more than the clinical benefit). See Figure 3.

Figure 3. Debridement methods for healable wounds

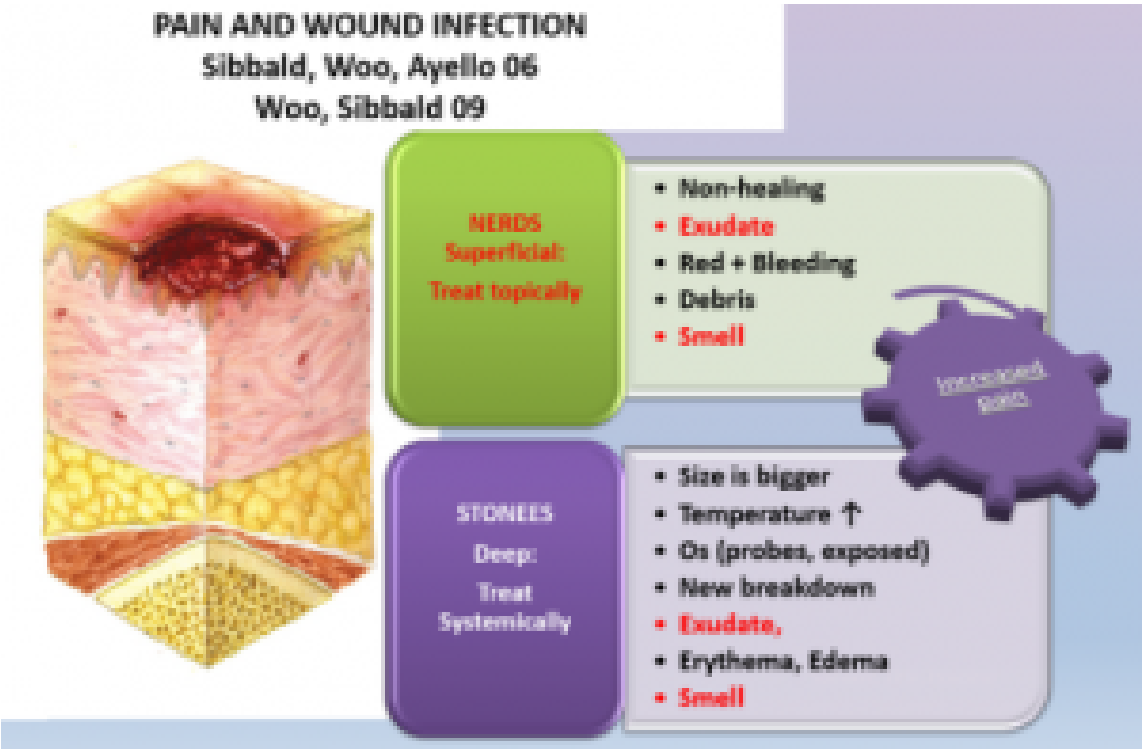
For Wounds That Can Heal			
Debridement			
Surgical	Autolytic	Biological	Mechanical
• Sharp • Conservative	• Hydrogeis • Hydrocolloids • Alginates	• Sterile Maggots • Accidental Larvae	• Went to dry • Ultrasonic • Hydrojet

STATEMENT 6 – ASSESS AND TREAT WOUNDS FOR INFECTION OR INFLAMMATION.

Wound infection and inflammation comprise the "I" in the DIME (Debridement, Infection/Inflammation, Moisture Management, Edge Effect) approach. Wound infections can be superficial where there is critical colonization/local infection or be present in deep and surrounding compartment (Sibbald et al., 2006, 2017). Sibbald et al. uses an analogy of the wound as a soup bowl with a thin layer of soup to explain this concept. The superficial compartment that can be treated with topical antimicrobials, with the soup bowl representing the deep and surrounding tissue compartments requiring systemic antimicrobial treatment (Sibbald et al., 2017).

6a) Treat local infection topically. The NERDS and STONEES tool is a validated clinical tool to differentiate superficial from deep and surrounding infection (Woo & Sibbald, 2009). Any three or more NERDS criteria (Nonhealing, Exudate, Red friable tissue, Debris, Smell) indicate local infection and would need to be treated topically with appropriate antiseptics and antimicrobial dressings e.g., silver, iodine, polyhexamethylenebiguanide (PHMB)/chlorhexidine, Methylene Blue/ Crystal Violet.

6b) Treat deep and surrounding infection with systemic antimicrobials. Any three or more STONEES criteria (Size increase, Temperature differential of >30F on mirror image part of body, Os (probe to bone, New areas of breakdown, Exudate, Edema, Smell) indicate presence of deep and surrounding infection. Pain may be an additional third sign.



Used with permission from Woo and Sibbald 2009

6c) Assess for presence of inflammation and using anti-inflammatory agents where necessary. Chronic wounds can also have an extensive and lengthy inflammatory response that impedes wound healing. There are various methods to diagnose wound Inflammation including measuring proteases [particularly matrix metalloproteinases (MMPs) and other biomarkers] however, they are not easily accessible in everyday practice

(Saleh et al., 2019). It is necessary to consider the inflammatory properties of agents according to the wound status e.g., iodine is a proinflammatory antimicrobial, while silver is anti-inflammatory (Sibbald et al., 2021)

STATEMENT 7 – MOISTURE MANAGEMENT.

When selecting dressings, clinicians should aim for a comprehensive approach and consider patient satisfaction, improved wound outcome and cost of care (Brindle & Farmer, 2019).

7a) For healable wounds where the aim is to achieve moisture balance and facilitate autolytic debridement, dressings such as calcium alginates, hydrogels, acrylics, hydrocolloids, and films are recommended for use.

7b) When only moisture balance is required, super absorbents, foams, calcium alginates, hydrocolloids, and hydrogels are used.

7c) Moisture reduction is needed for maintenance and nonhealable wounds. The goal of care is to decrease moisture and bacterial load. Constant reevaluation of the state of the wound and patient would determine the choices of dressings and topical treatments that are appropriate at any given time. It is important to assess patient preference and not induce pain or discomfort. Dressings with PHMB/chlorhexidine and those with iodine can be active with decreased moisture and reduce bacterial load at the same time. Silver needs to be ionized for antibacterial action and this requires a moist wound interphase that is contraindicated in non-healable or maintenance wounds.

7d. Wound packing can also be done with wet (saline) packing (healable wounds) where tunnelling is involved.

Table 4. Four ribbon gauze choices for wound packing

Type ribbon gauze	Action	Comment
Saline soaked	Donate moisture to wound	Not antibacterial
Plain – dry	Absorb exudate from the wound	Not antibacterial
PHMB (AMD Gauze) PolyHexaMethyleneBiquanide Povidone Iodine-soaked gauze	Kills bacteria entering the gauze Releases iodine to kill bacterial on the wound surface including biofilms	Non-release = neutral to wound surface -Use with caution with thyroid disease -Pro-inflammatory to the wound surface

STATEMENT 8 – EVALUATE THE RATE OF HEALING.

8a) Reassess wounds that are stalled (healable) for other causes and diagnosis. A comprehensive assessment is necessary to further investigate other wound diagnoses. One way to identify a wound that needs to be reassessed is to calculate the reduction in wound volume between week 0 and week 4. If a wound is not 20-40% smaller by week 4, the wound is unlikely to heal by week 12. Often, a wound biopsy and a referral to an interprofessional assessment team would revise the diagnosis and treatment to try and establish an enhanced wound trajectory.

STATEMENT 9 – EDGE EFFECT

Adjunctive therapies are used for wounds that are stalled but healable. These modalities include: ultrasound, negative pressure wound therapy (NPWT), electrical stimulation, hyperbaric oxygen (HBO), dermal substitutes/skin grafts, platelet-enriched plasma and reconstructive surgery (Boersema et al., 2021).

9a) These modalities should be chosen based on evidence for their use and applicability to the individual patient, after a comprehensive, interprofessional assessment has been completed (Sibbald et al., 2021).

9b) Skin grafts have been successfully used in some cases, especially for deep and extensive thermal burns with recent studies detailing the use of natural skin substitutes that are bioengineered including acellular in vitro cultured skin cells (Łabuś et al., 2021).

STATEMENT 10 – ORGANIZATIONAL SUPPORT.

Organizations, their governing principles and current practices should enable evidence-informed practices interprofessional education and team work, multidirectional communication, quality improvement programs and patient-centered care (Engle et al., 2021; Sibbald et al., 2021). The Porter Model of health care that connects 6 other P's but most importantly starts with the patient and includes the (healthcare) professional, provider, payer, policy maker and politician. This model provides value for the health care dollar (adamkasi, 2017; Sibbald et al., 2021).

Conclusion & References

CONCLUSION

Wound Bed Preparation (WBP) is a model to treat the "whole patient" and not just the "hole in the patient." Treatment of the cause and addressing patient concerns are often best accomplished with an interprofessional approach. The ability of a wound to heal is based on adequate blood supply and treatment of the cause. Maintenance or nonhealable wounds require attention to patient centered care including pain control and optimizing activities of daily living.

Local wound care should include accurate documentation and consideration of the four main local components of topical treatment: debridement, infection/inflammation control, moisture management for all wounds. The edge effect is for healable wounds that are stalled and includes skin grafts and adjunctive therapies. The health care system needs to establish interprofessional wound care teams to optimize patient outcomes and deliver cost effective wound care.

REFERENCES

Adamkasi. (2017, June 2). Porter Five Forces Model of Health Care Industry. Porter Analysis. https://www.porteranalysis.com/porter-five-forces-model-of-health-care-industry

Al-Qaisi, M., Nott, D. M., King, D. H., & Kaddoura, S. (2009). Ankle Brachial Pressure Index (ABPI): An update for practitioners. Vascular Health and Risk Management, 5, 833–841.

Beaumier, M., Murray, B., Despatis, M.-A., Patry, J., Murphy, C., Jin, S., & Drombolis, D. (2020). Best Practice Recommendations for the Prevention and Management of Peripheral Arterial Ulcers.

Block, M. S., & Rowan, B. G. (2020). Hypochlorous Acid: A Review. Journal of Oral and Maxillofacial Surgery, 78(9), 1461–1466. https://doi.org/10.1016/j.joms.2020.06.029

Boersema, G. C., Smart, H., Giaquinto-Cilliers, M. G. C., Mulder, M., Weir, G. R., Bruwer, F. A., Idensohn, P. J., Sander, J. E., Stavast, A., Swart, M., Thiart, S., & Van der Merwe, Z. (2021). Management of Nonhealable and Maintenance Wounds: A Systematic Integrative Review and Referral Pathway. Advances in Skin & Wound Care, 34(1), 11–22. https://doi.org/10.1097/01.ASW.0000722740.93179.9f

Brindle, T., & Farmer, P. (2019). Undisturbed wound healing: A narrative review of the literature and clinical considerations. 10(2), 9.

Chronic Wounds and Delayed Healing Risk. (2010, June 1). HMP Global Learning Network. https://www.hmpgloballearningnetwork.com/site/wounds/content/chronic-wounds-and-delayed-healing-risk

Cukjati, D., Reberšek, S., & Miklavčič, D. (2001). A reliable method of determining wound healing rate. Medical & Biological Engineering & Computing, 39(2), 263–271. https://doi.org/10.1007/BF02344811

Engle, R. L., Mohr, D. C., Holmes, S. K., Seibert, M. N., Afable, M., Leyson, J., & Meterko, M. (2021). Evidence-based practice and patient-centered care: Doing both well. Health Care Management Review, 46(3), 174–184. https://doi.org/10.1097/HMR.0000000000000254

Falanga, V. (2000). Classifications for wound bed preparation and stimulation of chronic wounds. Wound Repair and Regeneration: Official Publication of the Wound Healing Society [and] the European Tissue Repair Society, 8(5), 347–352.

Flanagan, M. (2003). Improving accuracy of wound measurement in clinical practice. Ostomy/Wound Management, 49(10), 28–40.

Frykberg, R. G., & Banks, J. (2015). Challenges in the Treatment of Chronic Wounds. Advances in Wound Care, 4(9), 560–582. https://doi.org/10.1089/wound.2015.0635

Gerhard-Herman, M. D., Gornik, H. L., Barrett, C., Barshes, N. R., Corriere, M. A., Drachman, D. E., Fleisher, L. A., Fowkes, F. G. R., Hamburg, N. M., Kinlay, S., Lookstein, R., Misra, S., Mureebe, L., Olin, J. W., Patel, R. A. G., Regensteiner, J. G., Schanzer, A., Shishehbor, M. H., Stewart, K. J., … Walsh, M. E. (2017). 2016 AHA/ACC Guideline on the Management of Patients With Lower Extremity Peripheral Artery Disease: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Circulation. https://doi.org/10.1161/CIR.0000000000000470

Gottrup, F. (2004). Oxygen in Wound Healing and Infection. World Journal of Surgery, 28(3), 312–315. https://doi.org/10.1007/s00268-003-7398-5

Guo, S., & DiPietro, L. A. (2010). Factors Affecting Wound Healing. Journal of Dental Research, 89(3), 219–229. https://doi.org/10.1177/0022034509359125

Hess, C. T. (2019). Comprehensive Patient and Wound Assessments. Advances in Skin & Wound Care, 32(6), 287–288. https://doi.org/10.1097/01.ASW.0000558514.64758.7f

Keast, D. H., Bowering, C. K., Evans, A. W., Mackean, G. L., Burrows, C., & D'Souza, L. (2004). MEASURE: A proposed assessment framework for developing best practice recommendations for wound assessment. Wound Repair and Regeneration: Official Publication of the Wound Healing Society [and] the European Tissue Repair Society, 12(3 Suppl), S1-17. https://doi.org/10.1111/j.1067-1927.2004.0123S1.x

Łabuś, W., Kitala, D., Szapski, M., Klama-Baryła, A., Kraut, M., & Smętek, W. (2021). Tissue Engineering in Skin Substitute. Advances in Experimental Medicine and Biology, 1345, 193–208. https://doi.org/10.1007/978-3-030-82735-9_16

Laporte, M., Keller, H. H., Payette, H., Allard, J. P., Duerksen, D. R., Bernier, P., Jeejeebhoy, K., Gramlich, L., Davidson, B., Vesnaver, E., & Teterina, A. (2015). Validity and reliability of the new Canadian Nutrition Screening Tool in the "real-world" hospital setting. European Journal of Clinical Nutrition, 69(5), 558–564. https://doi.org/10.1038/ejcn.2014.270

Manna, B., Nahirniak, P., & Morrison, C. A. (2021). Wound Debridement. In StatPearls. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK507882/

McLain, N. E., Moore, Z. E., & Avsar, P. (2021). Wound cleansing for treating venous leg ulcers. Cochrane Database of Systematic Reviews, 3. https://doi.org/10.1002/14651858.CD011675.pub2

Mudge, E., & Orsted, H. (2010). Wound Infection and Pain management. Made Easy. Wounds International, 1, 1–6.

Nabavizadeh, R., Alavi, A., Sibbald, R., Valaei, F., Coutts, P., & Mayer, D. (2015). Audible handheld Doppler ultrasound determines reliable and inexpensive exclusion of significant peripheral arterial disease. Vascular, 23, 622–629.

Olsson, M., Järbrink, K., Divakar, U., Bajpai, R., Upton, Z., Schmidtchen, A., & Car, J. (2019). The humanistic and economic burden of chronic wounds: A systematic review. Wound Repair and Regeneration: Official Publication of the Wound Healing Society [and] the European Tissue Repair Society, 27(1), 114–125. https://doi.org/10.1111/wrr.12683

Sackett, D. L., Rosenberg, W. M., Gray, J. A., Haynes, R. B., & Richardson, W. S. (1996). Evidence based medicine: What it is and what it isn't. BMJ : British Medical Journal, 312(7023), 71–72.

Saleh, K., Strömdahl, A.-C., Riesbeck, K., & Schmidtchen, A. (2019). Inflammation Biomarkers and Correlation

to Wound Status After Full-Thickness Skin Grafting. Frontiers in Medicine, 6, 159. https://doi.org/10.3389/fmed.2019.00159

Schultz, G. S., Sibbald, R. G., Falanga, V., Ayello, E. A., Dowsett, C., Harding, K., Romanelli, M., Stacey, M. C., Teot, L., & Vanscheidt, W. (2003). Wound bed preparation: A systematic approach to wound management. Wound Repair and Regeneration: Official Publication of the Wound Healing Society [and] the European Tissue Repair Society, 11 Suppl 1, S1-28. https://doi.org/10.1046/j.1524-475x.11.s2.1.x

Screening—CMTF – Canadian Malnutrition Task Force. (n.d.). Retrieved October 4, 2021, from https://nutritioncareincanada.ca/resources-and-tools/hospital-care-inpac/screening

Sheehan, P., Jones, P., Caselli, A., Giurini, J. M., & Veves, A. (2003). Percent Change in Wound Area of Diabetic Foot Ulcers Over a 4-Week Period Is a Robust Predictor of Complete Healing in a 12-Week Prospective Trial. Diabetes Care, 26(6), 1879–1882. https://doi.org/10.2337/diacare.26.6.1879

Sibbald, R. G., & Ayello, E. A. (2021). The Audible Handheld Doppler Facilitates Virtual and Blended Care Models During COVID-19. Advances in Skin & Wound Care, 34(4), 175. https://doi.org/10.1097/01.ASW.0000735716.33518.87

Sibbald, R. G., Elliott, J. A., Persaud-Jaimangal, R., Goodman, L., Armstrong, D. G., Harley, C., Coelho, S., Xi, N., Evans, R., Mayer, D. O., Zhao, X., Heil, J., Kotru, B., Delmore, B., LeBlanc, K., Ayello, E. A., Smart, H., Tariq, G., Alavi, A., & Somayaji, R. (2021). Wound Bed Preparation 2021. Advances in Skin & Wound Care, 34(4), 183–195. https://doi.org/10.1097/01.ASW.0000733724.87630.d6

Sibbald, R. G., Elliott, J. A., Verma, L., Brandon, A., Persaud, R., & Ayello, E. A. (2017). Update: Topical Antimicrobial Agents for Chronic Wounds. Advances in Skin & Wound Care, 30(10), 438–450. https://doi.org/10.1097/01.ASW.0000524471.28441.b9

Sibbald, R. G., Goodman, L., Woo, K. Y., Krasner, D. L., Smart, H., Tariq, G., Ayello, E. A., Burrell, R. E., Keast, D. H., Mayer, D., Norton, L., & Salcido, R. S. (2011). Special considerations in wound bed preparation 2011: An update©. Advances in Skin & Wound Care, 24(9), 415–436; quiz 437–438. https://doi.org/10.1097/01.ASW.0000405216.27050.97

Sibbald, R. G., Williamson, D., Orsted, H. L., Campbell, K., Keast, D., Krasner, D., & Sibbald, D. (2000). Preparing the wound bed—Debridement, bacterial balance, and moisture balance. Ostomy/Wound Management, 46(11), 14–22, 24–28, 30–35; quiz 36–37.

Sibbald, R. G., Woo, K., & Ayello, E. A. (2006). Increased bacterial burden and infection: The story of NERDS and STONES. Advances in Skin & Wound Care, 19(8), 447–461; quiz 461–463. https://doi.org/10.1097/00129334-200610000-00012

Snyder, R. J., Fife, C., & Moore, Z. (2016). Components and Quality Measures of DIME (Devitalized Tissue, Infection/Inflammation, Moisture Balance, and Edge Preparation) in Wound Care. Advances in Skin & Wound Care, 29(5), 205–215. https://doi.org/10.1097/01.ASW.0000482354.01988.b4

Weller, C. D., Richards, C., Turnour, L., & Team, V. (2021). Patient Explanation of Adherence and Non-Adherence to Venous Leg Ulcer Treatment: A Qualitative Study. Frontiers in Pharmacology, 12, 1382. https://doi.org/10.3389/fphar.2021.663570

Woo, K. Y., & Sibbald, R. G. (2008). Chronic wound pain: A conceptual model. Advances in Skin & Wound Care, 21(4), 175–188; quiz 189–190. https://doi.org/10.1097/01.ASW.0000305430.01413.2e

Woo, K. Y., & Sibbald, R. G. (2009). A cross-sectional validation study of using NERDS and STONEES to assess bacterial burden. Ostomy/Wound Management, 55(8), 40–48.

Wound Debridement Options: The 5 Major Methods. (2018, April 19). WoundSource. http://www.woundsource.com/blog/wound-debridement-options-5-major-methods

Self-Check

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://ecampusontario.pressbooks.pub/skinandwoundcare/?p=165#h5p-1

CHAPTER 2

Chapter 2: Patient Centered Concerns

Authors:

- Linda Norton MSc.CH, PhD, IIWCC (CAN), OT Reg. (Ont.)
- Patricia Coutts RN, IIWCC (CAN)

Learning Objectives

Type your learning objectives here.

- Identify the impact chronic wounds have on the client's quality of life
- Describe the interplay between chronic wounds and lifestyle factors
- Demonstrate adapting best practices to the client's situation

Case Study

Mary is a 74-year-old woman who is well known to you. She has had several neuropathic foot ulcers over the years, that have always progressed to closure. You have been seeing her for the past 6 weeks for a neuropathic foot ulcer on the plantar aspect of the first metatarsal head. Despite Mary telling you that she is following the treatment plan and offloading her foot, you notice that once again she has a significant callus build up around the wound. As you work on debriding the callus, Mary tells you how excited she is now that her daughter and grandchildren have moved back to town. Mary is looking forward to babysitting her grandchildren once per week, and baking cookies with them. She tells you about all the fun she is having scurrying around the kitchen with them. As you listen to her talk, you recognize that baking cookies with her grandchildren is likely contributing to the increased callus and may contribute to difficulty closing the wound. How would you address this situation with Mary?

The treatment and management of chronic wounds is multifaceted, complex and requires the client to change many aspects of the way they live their life to adhere to the treatment plan. For example, a recommendation to offload a neuropathic foot ulcer may mean a warehouse worker cannot perform their job, a family caregiver cannot look after their loved one, or a person cannot go for a walk-in nature that they have previously found helpful for their mental health. Given the far-reaching impacts of treatment plans, health care providers have a responsibility to address patient centred concerns to help to foster adherence to the treatment plan.

It is important to recognize that chronic wounds affect the client's quality of life and may potentially influence what the client is able to do; but the client's lifestyle – the way they live their life – can influence the heal-ability of

the wound. By examining both quality of life and lifestyle factors, clinicians can determine the specific factors that are relevant for each client and address them as part of the treatment plan.

Client-Centred Concerns: Quality of Life

Quality of life, when discussed in the medical literature, is restricted to health-related quality of life (Price & Krasner, 2012) i.e. related to the individual or group's perceived physical and mental health over time (Centers for Disease Control and Prevention, 2022). Quality of life is an all-encompassing term and includes both "health-related quality of life" and all factors that impact on an individual's life (Price & Krasner, 2012). In Mary's case, the impact of the chronic wound is not just on her perception of her health but has a meaningful impact on the way she interacts with her grandchildren, and her hobby of baking cookies.

This idea of quality of life is far reaching and requires an assessment in many domains of the client's life including loss of sense of self, influence on relationships, coping, treatment plans, relationships with caregivers, mobility, pain, depression, and lifestyle factors. Each of these will be discussed in turn.

Loss of sense of self (Kinmond, Mcgee, Gough, & Ashford, 2003)

The wound or the injury takes over—they become the wound rather than the person. The individual's schedule and choices they make are influenced by the wound rather than their own desires.

Influence on relationships (Gorecki C, Brown JM, Nelson EA, Briggs M, Schoonhoven L, Dealey C, Defloor T, 2009; Gorecki, Nixon, Madill, Firth, & Brown, 2012)

The wound may prevent the person from maintaining intimate relationships with their spouse or impact the relationship with their families and friends. The wound may prevent the person from engaging in their usual social activities. The odor and exudate may make the individual hesitate to interact with others and make others uncomfortable to interact with them.

Coping (Gorecki et al., 2012)

Individuals react differently to stress and may have difficulty coping with the health impacts. Sleep patterns can also be disrupted, resulting in a lack of restful sleep. The length of time the individual has had the wound also impacts their ability to cope. One coping strategy that an individual might normally employ includes increasing their activity, however activity can be limited by the chronic wound. Education may play a role here to help empower the client and improve their coping abilities. (Gorecki C, Brown JM, Nelson EA, Briggs M, Schoonhoven L, Dealey C, Defloor T, 2009). The circle of care, including friends and family can contribute to the individual's ability to cope.

Treatments (Price & Krasner, 2012)

The individual needs to schedule their activities of everyday living around dressing changes, and the schedule of the health care provider. Inconsistencies in care providers, timing of dressings, approach to completing the dressing etc., can all have an impact on the individual's quality of life. Scheduling around dressing changes may make it difficult for the individual to maintain their employment and could have a financial impact.

Relationships with Care Provider (Gorecki C, Brown JM, Nelson EA, Briggs M, Schoonhoven L, Dealey C, Defloor

T, 2009)

Expectations around treatments and goals may be different between the individual and the health care provider. The health care provider's expectation may be that the individual will follow the set treatment plan, the individual's may be that the care provider will heal the wound, regardless of whether the treatment plan is followed. In Mary's case, her wounds have always progressed to healing. She may not recognize that the goal of spending time baking and standing on her feet for indefinite periods of time with the grandchildren is negatively impacting the goal of wound healing.

Mobility (Price & Krasner, 2012)

Mobility has a major influence on every aspect of the client's life including their independence with activities of daily living, their ability to grocery shop, their ability to continue working and participation in family activities etc.

Pain (Price & Krasner, 2012)

Recognizing that pain is an important factor influencing quality of life, and has been studied in relationship to chronic wounds, it is not the sole factor contributing to the individual's perceived quality of life. Even if the client is not in pain, the wound could still have a detrimental impact on the individual's quality of life. Listening to the client's reported pain levels and in particularly, increases in pain levels, can provide early indications of deterioration or the need for analgesics.

Depression needs to be considered in relationship to individuals with chronic wounds. All of the factors listed – decreased mobility, pain, potential for isolation, treatment regimes, coping, loss of sense of self can all contribute to feelings of depression. Feelings of depression can further negatively impact quality of life. (Price & Krasner, 2012)

CLIENT CENTERED CONCERNS: LIFESTYLE FACTORS

Clinicians believe lifestyle factors are important to address, but there isn't a common definition of lifestyle factors nor how to address them (Norton, 2018). Lifestyle factors can be defined as the habits and choices the individual makes throughout their day.

Performing simple activities of daily living (ADL) can be difficult for clients with chronic wounds and can result in client's needing to reorganize these activities (Joaquim, Silva, Garcia-Caro, Cruz-Quintana, & Pereira, 2018). Conversely, the way a client currently performs their ADLs may impact wound healing. Consider a client with a spinal cord injury dressing independently in bed; the area of the wound may be subject to increased pressure or shear forces during this activity.

Treatment plans, especially those that require time, or a change in the client's lifestyle can be difficult to implement.

"Many people with spinal cord injury perceive a trade-off between performing pressure- redistributing activities and participating in life. Everything takes longer to accomplish for a person with spinal cord injury, and many feel they simply do not have time for both. Participating in life is the choice they often make." (Houghton, Campbell, & Panel, 2013)

Recognizing the impact that the wound, and treatment plans have on the client and their lifestyle, enables the clinicians to move beyond how to "fix" the wound, and move alongside the client to jointly determine the best course of action for that specific client given their goals, their abilities and lifestyle.

Consider a person with a neuropathic foot wound, like Mary described in the case study. Offloading, might be

part of the treatment plan, however barriers to accessing devices such as funding, delivery systems etc. make access to this equipment difficult (Mattison, Wilson, Wang, & Waddell, 2020). Having the client limit the time on their feet may be another strategy, however this strategy may have unintended outcomes. For example, if the client is working, they may need to have accommodations made at work, or it may limit their ability to work. In Mary's case, making a recommendation of reducing the time on her feet, would result in her not being able to enjoy baking cookies with her grandchildren.

Addressing Client Centered Concerns

Addressing client centered concerns requires the clinician to establish a collaborative relationship where the client is ultimately in control. Implementing a self-management treatment plan, utilizing the 5 A approach; Assess, Advise, Agree, Assist and Arrange can be helpful (Registered Nurses' Association of Ontario, 2010, pp. 25–44).

Assess involves establishing a good rapport with the client, screening for depression, as well as assessing for the readiness for change (Registered Nurses' Association of Ontario, 2010, pp. 27–32). A client's readiness for change has been conceptualized as stages:

- Precontemplation (not thinking about changing)
- Contemplating (considering the benefits and costs of change)
- Preparation (making small changes)
- Action (taking a definitive action)
- Maintenance (sustaining the change), and
- Relapse (a normal part of the change process)
  (Registered Nurses' Association of Ontario, 2010, p. 30).

By understanding the client's readiness to change, the clinician can intervene appropriately. For clients in the contemplating stage, the clinician can help the client weigh the advantages and disadvantages of the change.

In the second step, the clinician advises the client, providing specific information on the client's condition, treatment possibilities and expected outcomes. Key to this step is providing information directly relevant to the client's situation and context (Registered Nurses' Association of Ontario, 2010, pp. 33–39).

In the next step the clinician and client collaboratively set goals (Registered Nurses' Association of Ontario, 2010, p. 40). Goals are set both on the client's interest and their confidence in changing a specific behaviour. Jointly developing an action plan that the client can follow empowers the client to take charge of their health and make informed lifestyle choices.

Once the goals and action plans have been established, the role of the clinician is to assist the client by helping them identify and overcome any barriers (Registered Nurses' Association of Ontario, 2010, pp. 41–43). Lastly, the clinician arranges any follow up appointments required. Regular follow up has been shown to help individuals maintain lifestyle changes (Registered Nurses' Association of Ontario, 2010, p. 44)

Ultimately through examining the factors contributing to the client's quality of life, as well as their lifestyle helps the clinician empower the client to move towards best practices to manage their chronic wound.

Conclusion and References

What about Mary?

Mary's case study was drawn from research examining how health care professionals identify and address lifestyle factors (Norton, 2018). Two different health care providers, in two different geographical locations identified a similar patient (Mary). Both health care providers identified baking cookies with the grandchildren as a potential lifestyle factor impacting the trajectory of wound closure, because the client was spending too much time on their feet during this activity. Both clinicians reported that they had addressed the lifestyle factor. The first clinician reported that they told the client to stop baking cookies with their grandchildren. The second clinician worked with the client, ensuring appropriate footwear during the baking activity, developing strategies of how the grandchildren could participate in different ways to help reduce the amount of standing required etc.

Both health care providers identified and addressed the lifestyle factors, but who's patient would you like to be if you were in Mary's situation?

REFERENCES

Centers for Disease Control and Prevention. (2022, February 19). Health-Related Quality of Life (HRQOL).

Gorecki C, Brown JM, Nelson EA, Briggs M, Schoonhoven L, Dealey C, Defloor T, N. J. (2009). Impact of Pressure Ulcers on Quality of Life in Older patients: A Systemic Review. *Journal of American Geriatric Society*, *57*(7), 1175–1183. https://doi.org/10.1111/j.1532-5415.2009.02307.x

Gorecki, C., Nixon, J., Madill, A., Firth, J., & Brown, J. M. (2012). What influences the impact of pressure ulcers on health-related quality of life? A qualitative patient-focused exploration of contributory factors. *Journal of Tissue Viability*, *21*(1), 3–12. https://doi.org/10.1016/j.jtv.2011.11.001

Houghton, P. E., Campbell, K. E., & Panel, C. (2013). *Canadian Best Practice Guidelines for the Prevention and Management of Pressure Ulcers in People with Spinal Cord Injury, A Resource Handbook for Clinicians*.

Joaquim, F. L., Silva, R. M. C. R. A., Garcia-Caro, M. P., Cruz-Quintana, F., & Pereira, E. R. (2018). Impact of venous ulcers on patients' quality of life: an integrative review. *Revista Brasileira de Enfermagem*, *71*(4), 2021–2029. https://doi.org/10.1590/0034-7167-2017-0516

Kinmond, K., Mcgee, P., Gough, S., & Ashford, R. (2003). "Loss of self": a psychosocial study of the quality of life of adults with diabetic foot ulceration. *Journal of Tissue Viability*, *13*(1), 6–16.

Mattison, C. A., Wilson, M. G., Wang, R. H., & Waddell, K. (2020). Enhancing Equitable Access to Assistive Technologies in Canada: Insights from Citizens and Stakeholders. *Canadian Journal on Aging*, *39*(1), 69–88. https://doi.org/10.1017/S0714980819000187

Norton, L. (2018). *Scholarship @ Western How Do Health Care Providers Identify and Address Lifestyle Factors with Community Dwelling Adults Who Have Chronic Wounds?* Western University. Retrieved from https://ir.lib.uwo.ca/cgi/viewcontent.cgi?article=7648&context=etd

Price, P., & Krasner, D. (2012). Health-Related Quality of Life and Chronic Wounds: Evidence and Implications for Practice. *Chronic Wound Care: A Clinical Source Book for Healthcare Professionals.*, *1*, 77–84.

Registered Nurses' Association of Ontario. (2010). *Strategies to Support Self-Management in Chronic Conditions: Collaboration with Clients*. Toronto ON: Registered Nurses Association of Ontario. Retrieved from http://rnao.ca/sites/rnao-ca/files/storage/related/6711_SMS_Summary.pdf

Self-Check

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://ecampusontario.pressbooks.pub/skinandwoundcare/?p=1121#h5p-7

CHAPTER 3

Chapter 3: Chronic Wound Pain: An Undermanaged Patient Concern

Authors:

- Douglas Queen,
- Laurie Goodman,
- Reneeka Jaimangal
- Ramesh Zacharrias
- Gary Sibbald

SUMMARY

Chronic wound pain is distressing and influences the patient's ability to function (Ren et al, 2021). One of the failures of modern medicine is the inadequate assessment and treatment of pain. The clinician's approach to chronic wound pain combines the 'preparing the wound bed' paradigm with chronic wound care pain management (Sibbald et al, 2021). A holistic approach must include the diagnosis and treatment of the underlying cause, identification, and correction of patient centred concerns, and the four components of local wound care (DIME: Debridement, Infection / Inflammation, Moisture management, Edge effect).

Securing a thorough pain history focusing on pain patterns will facilitate healthcare professionals develop specific pain relief initiatives (Leren et al, 2020). Pain is a component of quality of life (a tool to measure general disabilities) that is reflected in activities of daily living. Patient-centred concerns need to address pain control measures until the cause of the pain can be identified. Controlling pain, however, may not always improve activities of daily living. Each of the components of local wound care may also be responsible for pain; strategies need to be implemented to ensure adequate patient comfort.

Key Learning Points

1. Chronic wound pain is distressing and influences patients' health-related quality of life.
2. Noncyclic acute wound pain occurs as single episode, acute wound pain. It is best described as the type associated with sharp debridement of a wound.
3. Cyclic acute wound pain is periodic acute wound pain that recurs. It is best described as the type associated with routine dressing changes.

4. Chronic wound pain is the persistent pain that occurs without an event or trigger. It is best described as a throbbing pain with an untreated cause.
5. It is paramount that healthcare professionals help the patient recognize the pain patterns to assist with specific pain relief strategies.

Introduction

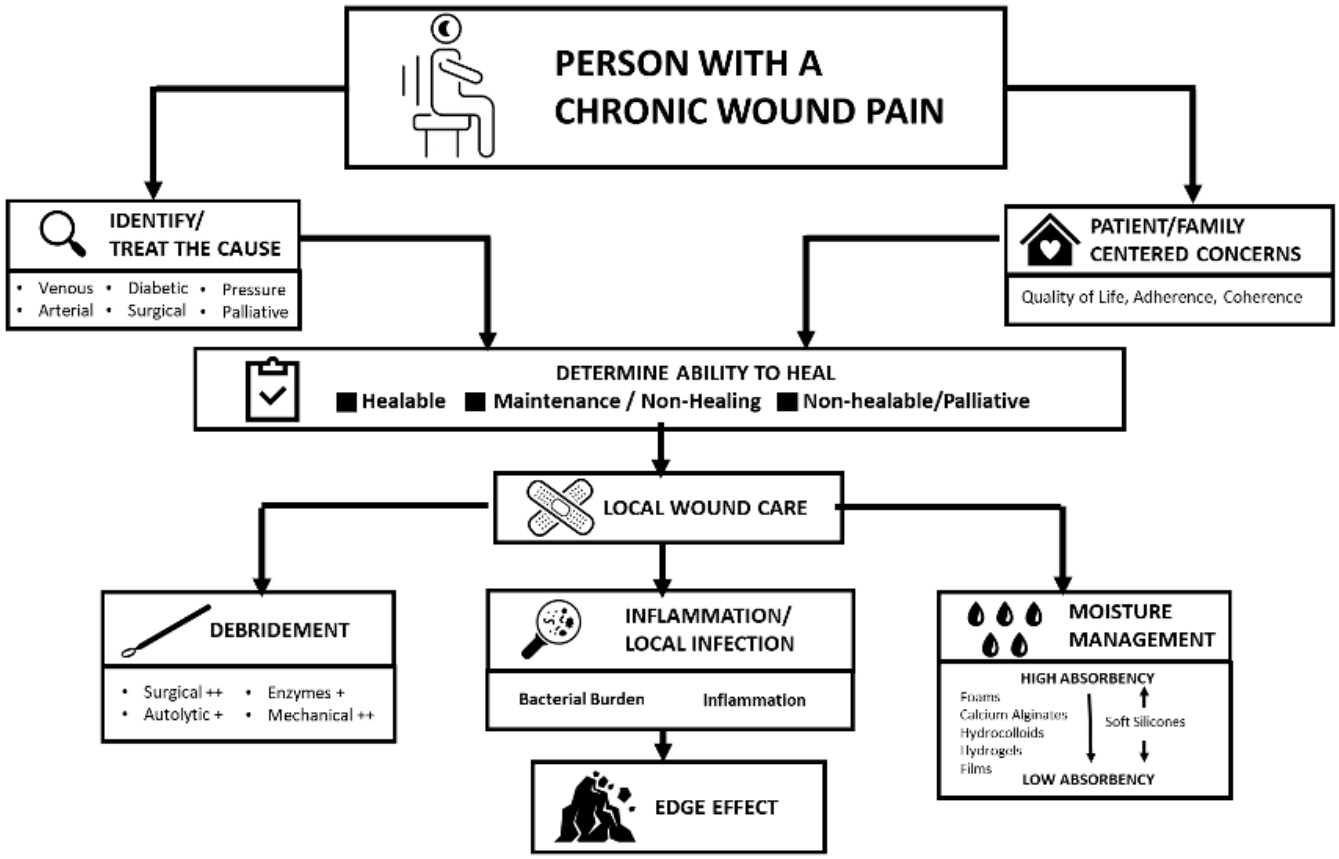
Margo McCaffery summarized her view of pain as "It's whatever the experiencing person says it is, existing whenever and wherever the person says it does" (McCaffery, 1968). Pain is often neglected because no simple diagnostic test exists to measure it.

Wound-related pain is an important component of patient-centered concerns that is often undervalued by healthcare professionals. When patients are asked to identify their priorities for a healthcare visit, they often reported pain management as their number one priority. In the late 90s, the European Wound Management Association (EWMA) drove a change in the management of wound related pain with its pivotal position document (Moffatt et al, 2002). This document recognized and focused on chronic wound pain and its influence on patients' quality of life. It stated that one of the failures of modern medicine is the inadequate assessment and treatment of pain.

In the several decades since the publication of this document, the management of wound pain has been integrated into the wound bed paradigm originally discussed in Sibbald et al (2000, 2003, 2006, 2011, 2015 and 2021). The three main pain components are (Figure 1)

- **Treating the cause** involves the correct diagnosis of the wound pain.
- **Patient-centered concerns** must focus on what the patient sees as the primary reasons and resolutions for the pain.
- **Local wound care** needs to revolve around the three pillars of practice: debridement, bacterial balance, and moisture management, including the impact of pain.

Figure 1 – Chronic Wound Pain Paradigm (Adapted from, Reddy et al, 2003 and Sibbald et al, 2021)



THE MECHANISM OF PAIN

The process of pain involves a stimulus, detection of the stimulus by receptors, transmission of the stimulus via nerves, and interpretation of the stimulus in the brain. Pain can be described through two main types, nociceptive and neuropathic.

Nociceptive pain is an inflammatory response to direct tissue damage with an identified trigger or stimulus. Usually, relatively acute, nociceptive pain resolves when the tissue damage stops and resulting inflammation subsides (Wulf and Baron, 2002).

Neuropathic pain is independent of acute stimuli or triggers. Often, it is described as spontaneous with burning, tingling or stinging and when more severe, as stabbing or shooting.

Trauma to the peripheral nerves (e.g., amputation and phantom limb pain) is often associated with abnormal sensory function and a relative increase in patients' response to pain (Colloca et al, 2017).

The term 'chronic pain' has been overused and has an unfortunate inference as a negative term often associated with drug misuse. The term 'persistent pain' may encourage a more positive attitude by patients and health professionals (AGS Panel, 2002).

Some Negative Outcomes of Unrelieved Pain

- Uncontrolled pain can cause stress and activation of the sympathetic nervous system. This can result in endocrine system releasing excessive hormones, inflammatory process activation, tachycardia, increased respiration rate and eventually weight loss (Wells, Pasero, McCaffery, 2008). Involuntary movements prepare the body for fight or flight.

- Sub-optimally managed pain is harmful for patients with metastatic cancers by reducing natural cells needed to prevent further tumor growth and spread (Wells, Pasero, McCaffery, 2008.
- Unrelieved acute pain may increase likelihood of chronic pain in future. One example is when acute pain from shingles is not managed aggressively and early, there is increased risk for ongoing post herpetic neuralgia (a painful chronic condition following shingles).
- Sub-optimally managed pain can lead to mistrust between the patient and care provider resulting in decreased patient satisfaction and delayed recoveries. This can lead to depression, anxiety and unscheduled emergency visits, all translating to largely preventable costs to the healthcare system.

There are many barriers to effective pain management from both the clinician and patient's side. Fear of Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) or negative attitudes and misconceptions toward opioid use may adversely overshadow both patient and clinician perspectives. The lack of pain assessment education and treatment is also a common factor for appropriate clinical use of both product classes. From the patient's perspective, there may be a history of opioid tolerance or overuse that can negatively impact optimal pain management. These are a few of the complex challenges. There is a need to overcome pain related barriers and myths.

WOUND ASSOCIATED PAIN

Tissue injury associated pain signals have an essential function and are clinically important symptoms (Khammissa et al, 2020; Bechert and Abraham, 2009). For example, local pain as a symptom or any increase in pain without another etiology is a key predictor of wound infection. It is one of the four cardinal indicators for inflammation (Gardner et al, 2001; Cutting et al, 2013). Pain or the fear of pain can also influence the healing process by interfering with the immune response (Matsuzaki and Upton, 2013). Unresolved pain is often associated with delayed wound closure (Stechmiller et al, 2019). Krasner proposed a conceptual model for wound pain (Table 1).

Table 1 – Krasner Model for Chronic Wound Pain
(Modified from Krasner, 1995; Krasner, 2001)

1. Noncyclic acute wound pain occurs during intermittent manipulation of the wound, including debridement. Use of local anesthesia, adequate preparation of the patient, and premedication can help reduce this pain.
2. Cyclic acute wound pain accompanies regular procedures, including dressing changes and patient repositioning. In addition to the previous strategies, use of nontraumatic dressings, soaking adherent dressings before removal, and allowing patient control can minimize this type of pain.
3. Chronic wound pain is the persistent pain, including between dressing changes, that the patient feels all the time, even when the wound is not being manipulated. Both non-pharmacologic and pharmacologic treatments can be used.

The clinical acceptance of wound-related pain is the first component but of equal importance is an understanding of the mechanism of pain, its impact clinically (Table 2) and its management from a patient's perspective (Bechert and Abraham, 2009).

Table 2 – Important Facts Regarding Management of Wound Related Pain
(Modified from Purcell et al, 2020).

• Analgesics may have a negative impact on healing
• Anti-inflammatory agents (NSAIDS) may reduce pain but may affect wound healing
• Antidepressant or antiepileptic agents raise questions regarding the tissue repair processes. Before clinicians consider treatment with analgesics or other treatment r that will alleviate the real or potential injury to tissue.

Professionals often define and assess a patient's wound pain based on their clinical assumptions (Woo et al, 2008; Woo and Sibbald, 2009).

Pain Assessment & Management

PAIN ASSESSMENT

A thorough pain history is essential to wound pain management (Price et al, 2007). The nature, onset, duration, and exacerbating and relieving factors will help determine the cause of the pain and direct strategies for relief. Pain intensity can be reliably measured using validated pain scales. Several pain scales (Figure 2) have been widely accepted for use among older adults, including people with mild to moderate cognitive impairment (Herr and Garand, 2001). A verbally administered 0 to 10 numeric rating scale is a good first choice for measuring pain intensity. Anchors for pain may have more meaning by stating 0 is no pain, 5 is equivalent to a bee sting and 10 represents slamming the car door on your thumb! If the patient has difficulty with the scale, other verbal descriptor scales, pain thermometers, and faces pain scales (Hicks et al, 2001) also have accepted validity and reliability in this population (Bieri et al, 1990; AGS Panel, 2002). The scale of choice should be appropriate for the individual and used consistently with each assessment (Ferrell, 2002).

Figure 2 – Examples of Pain Assessment Tools

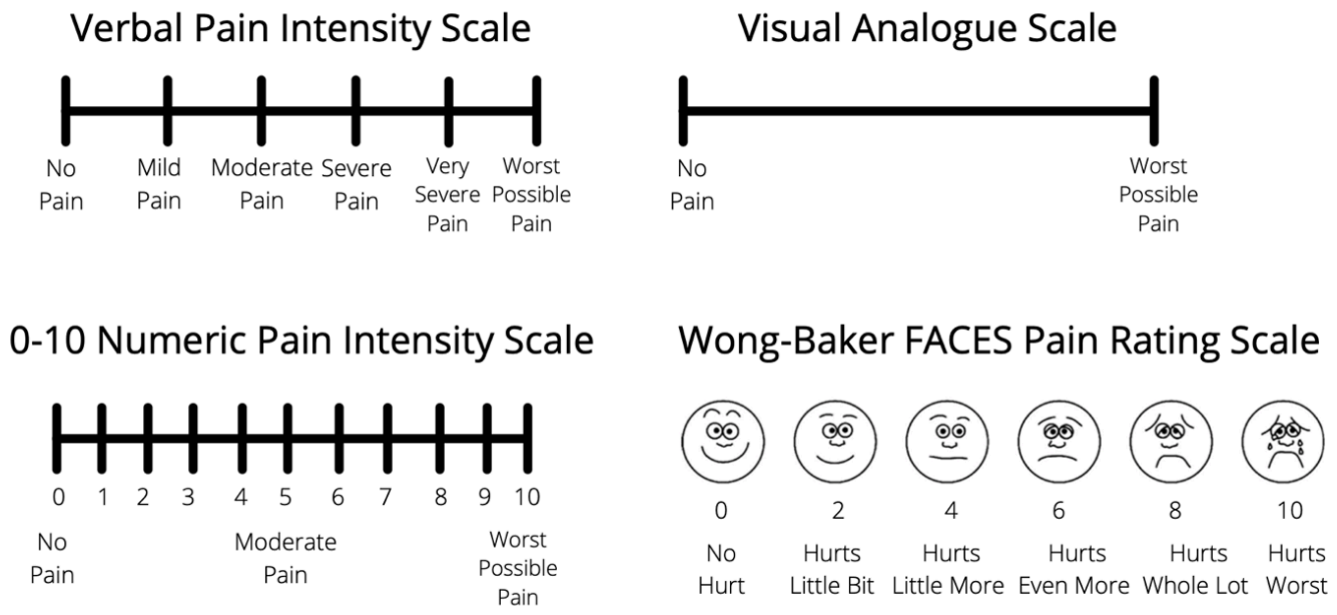


Figure 2 – Examples of Pain Assessment Tools

Although sensory and cognitive impairment may be present, pain can usually be assessed accurately using techniques adapted for the individual's disabilities (Herr et al, 1995; Gagliese and Melzack, 1997). Older patients

may be challenged with pain assessment tools (Ferrell et al, 1990; Grossberg et al, 2000). Many patients and their families accept pain as an inevitable consequence of aging, do not believe pain can be treated, may fear diagnostic tests, and/or assign too much importance to hypothetical medication side-effects or addiction (AGS Panel, 2002). A patient with severe dementia who suffers from pain presents a greater challenge. In this case (or in the case of a nonverbal patient) pain can be assessed by directly observing the patient for grimacing, other body withdrawal movements or obtaining a history from caregivers.

Patients should be observed for evidence of pain-related behaviors during movement or dressing changes. Deteriorating cognitive status or agitation also should elicit assessment for pain as a potential cause (AGS Panel, 2002).

Clinicians should have a high index of suspicion regarding sub-optimally treated pain when people with cognitive impairment have comorbid diseases that may include chronic wounds, arthritis, ischemia or cancer. Patients with persistent pain should be reassessed regularly for improvement, deterioration, or adherence to medication regimens. A good management strategy is using a pain diary. This could include logging pain intensity, medications used, mood and response to treatment (AGS Panel, 2002). Many barriers exist to optimal pain management (see Table 3).

PAIN MANAGEMENT

The management of wound pain should be integrated into the Wound Bed Preparation paradigm (Sibbald et al, 2000; Reddy et al, 2003; Sibbald et al, 2021): treat the cause, address patient-centred concerns and optimize local wound factors (see Figure 2). Treating the cause should determine the correct diagnosis and initiate treatment of the wound pain.

Patient-centred concerns must focus on what the patient perceives as the primary cause for the pain. To accomplish this, open discussions with the patient and family are needed, with the patient's expectations being central. Care planning and education at regular intervals is also required, recognizing that this takes time. Patient anticipatory pain and suffering can be just as disruptive to activities of daily living as the actual experience of pain.

Local wound care needs to revolve around the four pillars of local wound care practice: DIME: Debridement, Infection / Inflammation, Moisture management, Edge effect. The Krasner model (Table 1) emphasizes the association of wound pain to identify the appropriate trigger and treatment (Krasner, 1995).

1. Treat the cause.

Treating the cause of chronic wound pain involves identifying and removing the source of the causative factor(s). For example, surfaces should be assessed to minimize excess pressure in the case of pressure injuries.

Wound infection and inflammation can cause wound pain. Treating the surface bacterial load and inflammatory stimulus can minimize the chance of deep and surrounding infection. Surface infection can be treated topically (ionized silver, iodine, PHMB / chlorhexidine, methylene blue / crystal violet). Deep and surrounding infections require systemic agents.

Pharmacological pain-reducing interventions are most effective when coupled with non-pharmacologic interventions that acknowledge patient-centred concerns (Jacox et al, 1994; Ferrell, 1996). By the gate control theory of Melzack and Wall (Katz and Rosenbloom, 2015), the nervous system only transmits one predominant signal. The non-pharmacological management strategies could include music, diaphragmatic breathing, meditation, yoga, TENS (Transcutaneous Electrical Nerve Stimulation), ultrasound, heat, cold, etc.

2. Patient-Centred Concerns in Wound Care

Pain in the context of wound care often has been described as the patient's subjective experience. However, it is the caregiver who often interprets the patient's pain according to his/her own cultural/environmental perspective.

Wound pain management can remain an inaccurate science if it is not tailored to the patient's situation. Although "pain management experts" are available, patients in pain are frequently at the mercy of less well-informed members of the healthcare team whose approach can range from feast (the more pain medication the

better) to famine (limiting pain medication because of fears of addictive or drug-seeking behaviors). In addition, the pain experience of the elderly is often neglected and poorly controlled. The more experienced healthcare professional carefully integrates pain management into the wound management process.

Consider each of the following steps (Sibbald et al, 2021):

A) Identify barriers to effective pain management
B) Activate a patient-centred approach to wound care
C) Address anxiety, depression and pain
D) Consider non-pharmacological management of pain
E) Debride wounds appropriately
F) Manage infection/inflammation
G) Initiate appropriate topical treatment
H) Optimize moisture management

Wound Pain Fundamentals

Assume that every wound is painful and that every patient who has a wound is in pain (Briggs et al, 2004). Patients frequently experience pain during dressing changes (e.g., strong adhesives, debridement), especially around wound edges and in infected or inflamed wounds (Collier and Hollingworth, 2000; World Union, 2004; Tegegne et al, 2020).

Wound pain can serve as an important indicator of inadequate wound management, untreated underlying cause and/or infection (Sibbald et al, 2003).

Debridement and wound cleansing are often main sources of pain or discomfort (Rodeheaver, 2001). Both procedures are necessary to facilitate wound healing (O'Brien, 2002).

Moist wound healing results in faster healing, (Winter, 1963; Hinman and Maibach, 1963) less scarring and less pain. The pain reduction is attributed to the nerve endings being covered in fluid that prevents dehydration (Kannon and Garrett, 1995).

Table 3: Dressing and Treatment Approaches

Clinical Nuggets: Sometimes Forgotten Pain-Relieving Strategies

- Clinician & patient (+ family) should have a planning discussion for dressing changes, debridement or procedures with patient consent and input prior to starting. This helps the patient to positively anticipate the steps involved shifting some sense of control to them. Debriefing patients by reflecting on the procedure is beneficial to improve the next planned intervention
- Ask the patient what has previously worked or not worked to include the feedback into the planning of the next procedure
- Be organized and have all anticipated equipment ready prior to starting a dressing change or procedure. Minimizing the time the wound is exposed to air reduces irritation, cooling of the wound bed and pain
- Handle all wounds gently (Moffatt et al, 2002)
- Avoid unnecessary stimulus to the wound, including unnecessary prodding or poking
- Avoid drafts from an open window, fan or vent
- Protect wound edges with barrier products (film forming liquid acrylates, petrolatum, zinc oxide, windowed dressings)
- Allow patients to change their own dressing if possible (Reddy et al, 2003)

- Allow patients to call "time out" verbally or by some nonverbal cue like raising their hand (Krasner et al, 2006).
- Encourage slow, rhythmic breathing and other relaxation techniques.
- Let patients know that there are "no points for bravery" and that blood flow may be decreased during episodes of pain.
- Topical anesthesia prior to debridement / medical procedures: Apply approximately 20 to 30 (or up to 60 – depending on the region) minutes prior to the procedure, under occlusive plastic wrap (Evans and Gray, 2005)
- A systematic review of topical analgesic & anesthetic agents determined that lidocaine / prilocaine cream (EMLA – Eutectic Mixture of Local Anesthetics) and ibuprofen foam are effective agents for reducing wound-related pain associated with chronic leg ulcers (Purcell et al. 2020). These products need to make direct contact with the wound surface and surrounding skin to be effective
- Use dressings least likely to adhere and to cause pain including hydrogels, hydrofibers, alginates, soft silicones (Alvarez et al, 2006) and cellulose (Hollingsworth, 2000). Gauze can reduce moisture but may cause tremendous pain, especially when adherent to the wound surface and is subsequently removed (Puntillo et al, 2001)
- Avoid the pain associated with gauze for healable wounds (Moffatt et al, 2002). Novel alternatives to gauze include calcium alginates, hydrogels, hydrocolloids & polyacrylate dressings. These promote efficient moisture management and debridement without pain (Percival et al, 2005)
- Fill but avoid overpacking wound cavities ("Fluff, don't stuff")
- Match absorbency with exudate levels (Moffatt et al, 2002)
- Choose advanced wound care dressings for longer wear times.

Dressing removal is often associated with increased pain (Moffatt et al, 2002). Dry dressing and adherent products are most likely to cause pain and trauma at dressing changes. Products designed to be non-traumatic should be used to prevent pain. Gauze is most likely to cause pain and should be avoided, including wet-to-dry regimens (Ovington, 2001).

One of the most important dressing selection considerations involves choosing a dressing that minimizes pain (Briggs et al, 2004; Woo et al, 2009).

Be sure to select dressings with absorbency that matches exudate levels (Queen et al, 2004; Briggs et al, 2004). Choose dressings with longer wear times to minimize wound manipulation and aggravation of the wound healing cycle. Contact layers or dressings that remain in close proximity to the wound bed prior to dressing changes also have proven beneficial for pain reduction (Reddy et al, 2003). Do not neglect pain management during wound cleansing. Appropriate noncytotoxic wound cleansing (potable water, normal saline) used at body temperature are best to reduce discomfort (Van Rijswijk and Braden, 1999).

When removing a dressing, avoid unnecessarily manipulating the wound, thus preventing further damage to the delicate granulation and healing tissue within the wound bed and periwound skin. If the dressing has become dried out, moisten it with an isotonic solution before removal (Queen et al, 2003). Choose dressings that allow less frequent and therefore less painful dressing changes (Sibbald et al, 2021). An exception to the moisture balance rules are persons with maintenance or nonhealable wounds (bacterial and moisture reduction is more important than tissue toxicity). These individuals should have bacterial and moisture reduction using topical antiseptics and superabsorbent dressings. This avoids the use of more expensive dressings, including foams with moisture exchange. If the dressing becomes dried onto the wound surface, the wound dressing can be hydrated with saline or water for easy removal.

Too often clinicians ignore pain because it is not easy to measure, yet unrelieved pain may seriously hamper efforts to heal chronic wounds. A paradigm that integrates pain management into an approach to wound bed management provides the clinician with a framework for improved care. An approach to chronic wound pain

management that treats the cause and addresses local wound factors may lead to improved outcomes as patients may be more adherent to optimal care plans. Patient-centred wound care management strategies requires further interprofessional education and training to create an environment where pain and trauma are minimized. A patient-centered regimen ensures appropriate care in a reduced pain environment (see Table 4).

Table 4 – MANAGEMENT OF WOUND-RELATED PAIN (Sibbald et al, 2021)

Simplified Pain Component	Therapeutic Action
Use a measurement tool	• Numeric Rating Scale, 0–10 (11-point scale; 0 = no pain, 5 = bee sting, 10 = slam the car door on your thumb; most people can live with a 3 or 4 out of 10) • Faces scale: cognitively challenged, young children, older persons
Differentiate neuropathic pain	• Burning, stinging, shooting, stabbing • Gabapentin/pregabulin, tricyclics, medical marijuana, selective serotonin reuptake inhibitors
Differentiate nociceptive pain	• Gnawing, aching, tender, throbbing • Acetaminophen, aspirin, nonsteroidal anti-inflammatory drugs, narcotics (short/long acting)
Dressing removal	• Pull laterally to release adhesive bond and rotate like the hands of a clock before lifting up • Avoid strong adhesives (acrylates, etc) and use silicone adhesives or nonadhesive dressings
Wound cleansing (sterile only required with immune compromise, deep postsurgical wounds)	• Use saline or (potable) water solutions at room temperature • Gentle compresses or soaks are less traumatic than irrigation (make sure all solution is retrieved and you can visualize the base of the wound with no procedure-induced bleeding or unnecessary trauma)
Debridement Healable wounds – sharp surgical, autolytic, enzymatic, mechanical, biological Maintenance or nonhealable wounds – conservative surgical	• Topical eutectic mixture of local anesthetics is superior to other topical pain modalities • Use a thick layer and occlude with film type dressing for 10–30 min (shorter period for genitalia, face, folds; longer times on back or thick skin) • Can supplement topical agents with intralesional xylocaine with adrenaline (if not end artery and no other contraindication)
Document and re-evaluate at regular intervals	• Assess changes in pain and wound characteristics at each wound re-assessment visit • Evaluate effectiveness of previous and current wound intervention and need for further procedures / treatment changes
©WoundPedia 2021.	

Conclusion and References

CONCLUSION

Persistent pain dominates patients' lives and has often not been a major concern for health care professionals. Many patients, particularly the elderly, are reticent to report their pain for fear of being seen as 'difficult.' Each health professional has an obligation to ask about their patient's pain and accurately document their responses. Holistic management must integrate patient-centred concerns and should consider the patient's wishes, desires, goals, for minimizing local wound pain. Interprofessional health care teams can select from a range of options to help patients effectively manage wound pain. Increased awareness of these options must be raised through coordinated, relevant educational initiatives. Ideally, the aim for wound care practitioners should be to develop treatment and monitoring strategies to improve the lives of persons with chronic wounds. Unless wound pain is optimally managed, patient suffering and the associated costs to the health care system will continue to increase.

REFERENCES

AGS Panel on Persistent Pain in Older Persons. The management of persistent pain in older persons. American Geriatrics Society. J Am Geriatr Soc. 2002;50:S205-S224.

Alvarez O. Ease the pain of wound care: Better choices in debridement and dressing options. Oral presentation at the Symposium on Advances in Skin and Wound Care in San Antonio, TX, April 29, 2006.

Bechert, K., & Abraham, S. E. (2009). Pain management and wound care. *The journal of the American College of Certified Wound Specialists*, *1*(2), 65–71.

Bieri D, Reeve RA, Champion GD, Addicoat L, Ziegler JB. The faces pain scale for the assessment of the severity of pain experienced by children: development, initial validation, and preliminary investigation for ratio scale properties. Pain. 1990;41(2):139-150.

Boulton AJ. Treatment of symptomatic diabetic neuropathy. Diabetes Metab Res Rev. 2003;19(Suppl 1):S16-S21.

Briggs M, et al. Minimising pain at wound dressing-related procedures: A consensus document (A World Union of Wound Healing Societies' Initiative). London, U.K.: Medical Education Partnership Ltd. 2004.

Colloca, L., Ludman, T., Bouhassira, D., Baron, R., Dickenson, A. H., Yarnitsky, D., Freeman, R., Truini, A., Attal, N., Finnerup, N. B., Eccleston, C., Kalso, E., Bennett, D. L., Dworkin, R. H., & Raja, S. N. (2017). Neuropathic pain. *Nature reviews. Disease primers*, *3*, 17002.

Collier M, Hollingworth H. Pain and tissue trauma during dressing change. Nurs Stand. 2000;July;21-27;14(40):71-73.

Cutting, K., White, R. and Mahoney, P. (2013), Wound infection, dressings and pain, is there a relationship in the chronic wound?. International Wound Journal, 10: 79-86.

Dalton JA, Youngblood R. Clinical application of the World Health Organization analgesic ladder. Journal of Intravenous Nursing. 2000;23(2):118-124.

Evans E, Gray M. Do topical analgesics reduce pain associated with wound-dressing changes? Journal of WOCN. 2005;32(5):287.

Ferrel BA. Pain. In: Osterweil D, Brummel-Smith K, Beck JC, eds. Comprehensive Geriatric Assessment. New York, NY: McGraw Hill; 2000:381-397.

Ferrell BA, Ferrell BR, Osterweil D. Pain in the nursing home. J Am Geriatr Soc. 1990;38:409-414.

Ferrell BR. Patient education and non-drug interventions. In: Ferrell BR, Ferrell BA, eds. Pain in the Elderly. Seattle, Wash: IASP Press; 1996:35-44.

Frescos N, Copnell B. Podiatrists' views of assessment and management of pain in diabetes-related foot ulcers: a focus group study. J Foot Ankle Res. 2020 Jun 3;13(1):29.

Gagliese L, Melzack R. Age differences in the quality of chronic pain: a preliminary study. Pain Research and Management. 1997;2:157-162.

Gardner SE, Frantz RA, Troia C, Eastman S, MacDonal M, Buresh K, Healy D. A tool to assess clinical sign and symptoms of localized infection in chronic wounds: development and reliability. Ostomy/Wound Management. 2001;47(1):40-47.

Geba GP, Weaver AL, Polis AB, et al. Efficacy of rofecoxib, celecoxib, and acetaminophen in osteoarthritis of the knee: a randomized trial. The VACT Group (Vioxx, Acetaminophen, Celecoxib Trial). JAMA. 2002;287:64-71.

Graham DY, White RH, Moreland LW, et al. Duodenal and gastric ulcer prevention with misoprostol in arthritis patients taking NSAIDs. Misoprostol Study Group. Ann Intern Med. 1993;119:257-262.

Grossberg GT, Sherman LK, Fine PG. Pain and behavioral disturbances in the cognitively impaired older adult: assessment and treatment issues. Annals of Long Term Care. 2000;8:22-24.

Herr KA, Mobily PR, Kohout FJ, et al. Evaluation of the faces pain scale for use with the elderly. Clin J Pain. 1998;14:29-38.

Herr, K. A., & Garand, L. (2001). Assessment and measurement of pain in older adults. *Clinics in geriatric medicine*, *17*(3), 457–vi.

Hicks CL, von Baeyer CL, Spafford PA, van Korlaar I, Goodenough B. The faces pain scale revised: toward a common metric in pediatric pain measurement. Pain. 2001;93(2):173-183.

Hollinworth H, Collier M. Nurses' views about pain and trauma at dressing changes: results of a national survey. Journal of Wound Care. 2000;9(8):369-373.

Jacox A, Carr DB, Payne R, et al. Clinical Practice Guideline Number 9: Management of Cancer Pain. Rockville, Md. Agency for Health Care Policy and Research, US Department of Health and Human Services, Public Health Service. Agency for Health Care Policy and Research; 1994: AHCPR Publication No. 94-0592.

Kannon GA, Garrett AB. Moist wound healing with occlusive dressings. A clinical review. Dermatol Surg. 1995;21(7):583-590.

Katz, J., & Rosenbloom, B. N. (2015). The golden anniversary of Melzack and Wall's gate control theory of pain: Celebrating 50 years of pain research and management. *Pain research & management*, *20*(6), 285–286.

Khammissa RAG, Ballyram R, Fourie J, Bouckaert M, Lemmer J, Feller L. Selected pathobiological features and principles of pharmacological pain management. J Int Med Res. 2020 May;48(5):300060520903653.

Krasner D. Caring for the person experiencing chronic wound pain. In: Krasner D, Rodeheaver GT, Sibbald RG, eds. Chronic Wound Care, 3rd ed. Wayne, Pa.: HMP Publications;2001.

Krasner D. The chronic wound pain experience: a conceptual model. Ostomy Wound Manage. 1995 Apr;41(3):20-5.

Krasner D, Sibbald RG. Local aspects of diabetic foot ulcer care: assessment, dressings and topical agents. In: Levin ME, O'Neal DN, Bowker JH, eds. The Diabetic Foot, 6th ed. St. Louis, Mo.: Mosby-Yearbook;1999.

Krasner DL, Shapshak D, Hopf HW. Managing wound pain. In Bryant RA, Nix DP, (eds.). Acute and Chronic Wounds: Current Management Concepts, Third Edition. St. Louis: Mosby Elsevier. 2006;542.

Leren, L, Johansen, E, Eide, H, Falk, RS, Juvet, LK, Ljoså, TM. Pain in persons with chronic venous leg ulcers: A systematic review and meta-analysis. *Int Wound J*. 2020; 17: 466– 484

MacLean CH. Quality indicators for the management of osteoarthritis in vulnerable elders. Ann Intern Med. 2001;135:711-721.

Matsuzaki, K. and Upton, D. (2013), Wound treatment and pain management: a stressful time. International Wound Journal, 10: 638-644.

McCaffery, M. (1968) Nursing Practice Theories Related to Cognition, Bodily Pain, and Man-Environment Interactions. Los Angeles: University of California at LA Students Store.

Moffatt CJ, Franks PJ, Hollinworth H. Understanding wound pain and trauma: an international perspective. In: European Wound Management Association. Pain at Wound Dressing Changes: A Position Document. 2002:2-7.

O'Brien M. Exploring methods of wound debridement. Br J Community Nurs. 2002;Dec:10-18.

Price, P., Fogh, K., Glynn, C., Krasner, D.L., Osterbrink, J. and Sibbald, R.G. (2007), Managing painful chronic wounds: the Wound Pain Management Model. International Wound Journal, 4: 4-15.

Puntillo KA, White C, Morris AB, et al. Patients' perceptions and responses to procedural pain: Results from Thunder Project II. Am J Crit Care. 2001;10(4):238-251.

Purcell A, Buckley T, King J, Moyle W, Marshall AP. Topical Analgesic and Local Anesthetic Agents for Pain Associated with Chronic Leg Ulcers: A Systematic Review. Adv Skin Wound Care. 2020 May;33(5):240-251.

Queen D, Woo K, Shulz VN, Sibbald RG. Chronic wound pain and palliative cancer care. Ostomy/Wound Management. 2003;49(10):16-18.

Queen, D., Orsted, H., Sanada, H. and Sussman, G. (2004), A dressing history. International Wound Journal, 1: 59-77.

Reddy M, Kohr R, Queen D, Keast D, Sibbald RG. Practical treatment of wound pain and trauma: A patient-centered approach. An overview. Ostomy/Wound Management. 2003;49(4A):2-15.

Ren H, Wang D, Ding Y, Hu H, Qin Z, Fu X, Hu Y, Cao R, Liang L, Li C, Mei S. Does Social Support Moderate Wound Pain and Health-Related Quality of Life in Patients With Chronic Wounds? A Multicenter Descriptive Cross-sectional Study. J Wound Ostomy Continence Nurs. 2021 Jul-Aug 01;48(4):300-305.

Rodeheaver GT. Wound cleansing, wound irrigation, wound disinfection. In Krasner DL, Rodeheaver GT, Sibbald RG, (eds.). Chronic Wound Care: A Clinical Sourcebook for Healthcare Professionals, Third Edition. Wayne, PA: HMP Communications. 2001:369-83.

Sibbald RG, Campbell K, Coutts P, Queen D. Intact skin: An integrity not to be lost. Ostomy/Wound Management. 2003;49(6):27-33.

Sibbald RG, Elliott JA, Persaud-Jaimangal R, Goodman L, Armstrong DG, Harley C, Coelho S, Xi N, Evans R, Mayer DO, Zhao X, Heil J, Kotru B, Delmore B, LeBlanc K, Ayello EA, Smart H, Tariq G, Alavi A, Somayaji R. Wound Bed Preparation 2021. Adv Skin Wound Care. 2021 Apr 1;34(4):183-195.

Sibbald, R. G., Elliott, J.A., Ayello, E.A., & Somayaji, R, (2015). Optimizing the moisture management tightrope with wound bed preparation 2014. Advances in Skin & Wound Care, 28(10), 466-476.

Sibbald, R. G., Goodman, L., Woo, K., Krasner, D., Smart, H., Tariq, G. et al. (2011). Special considerations in wound bed preparation 2011: An update. Advances in Skin and Wound Care, 24(9), 415-436.

Sibbald, R.G., Orsted, H.L., Coutts P. M., & Keast, D.H. (2006). Best practice recommendations for preparing the wound bed, Update 2006.Wound Care Canada, 4(1), 15-29.

Sibbald, R.G., Orsted, H.L., Schultz, G.S., Coutts P., & Keast, D.H. (2003). Preparing the wound bed: Focus on infection and inflammation. Ostomy/Wound Management, 49(11), 24-51.

Sibbald RG, Williamson D, Orsted HL, Campbell K, Keast D, Krasner D, Sibbald D. Preparing the wound bed – debridement, bacterial balance and moisture balance. Ostomy/Wound Management. 2000;46(11):14-35.

Sindrup SH, Jensen TS. Efficacy of pharmacological treatments of neuropathic pain: an update and effect related to mechanism of drug action. Pain. 1999;83(3):389-400.

Stechmiller JK, Lyon D, Schultz G, Gibson DJ, Weaver MT, Wilkie D, Ferrell AV, Whitney J, Kim J, Millan SB. Biobehavioral Mechanisms Associated With Nonhealing Wounds and Psychoneurologic Symptoms (Pain, Cognitive

Dysfunction, Fatigue, Depression, and Anxiety) in Older Individuals With Chronic Venous Leg Ulcers. Biol Res Nurs. 2019 Jul;21(4):407-419.

TenderWet Annex IV White Paper, Clinical experience/case studies. Heidenheim, Germany: TenderWet, Hartmann. 1998. [On file at Medline Industries, Inc., in Mundelein, IL.]

Tegegne BA, Lema GF, Fentie DY, Bizuneh YB. Severity of Wound-Related Pain and Associated Factors Among Patients Who Underwent Wound Management at Teaching and Referral Hospital, Northwest Ethiopia. *J Pain Res*. 2020;13:2543-2551

van Rijswijk L, Braden BJ. Pressure ulcer patient and wound assessment: An AHCPR clinical-practice guideline update. Ostomy/Wound Management. 1999;45(Suppl 1A):56S.

Ventsfridda V, Saita L, Ripamonti C, De Conno F. WHO guidelines for the use of analgesics in cancer pain. Int J Tissue React. 1985;7(1):93-96.

Ref: Wells N, Pasero C, McCaffery M. Improving the Quality of Care Through Pain Assessment and Management. In: Hughes RG, editor. Patient Safety and Quality: An Evidence-Based Handbook for Nurses. Rockville (MD): Agency for Healthcare Research and Quality (US); 2008 Apr. Chapter 17. Available from: https://www.ncbi.nlm.nih.gov/books/NBK2658/

Woo KY, Harding K, Price P, Sibbald G (2008) Minimising wound-related pain at dressing change: evidence-informed practice. *Int Wound J* **5(2):** 144–57

Woo KY, Sibbald RG (2009) The improvement of wound-associated pain and healing trajectory with a comprehensive foot and leg ulcer care model. *J Wound Ostomy Continence Nurs* **36(2):** 184–91

World Union of Wound Healing Societies Consensus Panel. Minimizing pain at wound dressing-related procedures: A consensus document. London, U.K.: Medical Education Partnership Ltd. 2004.

Wulf H, Baron R. The theory of pain. In: European Wound Management Association. Pain at Wound Dressing Changes: A Position Document. 2002.

CHAPTER 4

Chapter 4: Healing Trajectories

Author:

- Douglas Queen BSc, PhD, MBA

OVERVIEW

Accurate and clinically practical methods for measuring the rate of wound healing are necessary before calculating healing rates and distinguishing wound progression, stalled wounds and a worsening wound status.

If a wound is not at least 20% to 40% smaller by week 4, it is unlikely to heal by week 12 (Sibbald et al, 2021). Stalled (healable) wounds should be reevaluated for alternate diagnoses; consider wound biopsy, further investigation, and/or referral to an interprofessional assessment team to optimize treatment. Healing trajectory can be assessed in the first 4 to 8 weeks to predict if a wound is likely to heal by week 12, provided there are no new complicating factors (Laporte et al, 2015). Changes in the wound, the individual or their environment, may necessitate the reclassification of a wound to the maintenance or nonhealable category.

Wound healing trajectories are a useful tool for evaluation of time to healing, especially with the utilization of clinical data. Wound healing trajectories are an important evaluation tool for acute wounds and chronic wounds including venous stasis ulcers, diabetic foot ulcers, pressure injuries and others.

Learning Objectives

1. **Describe chronic would healing trajectories**
2. **Compare the concepts of chronic wound healing trajectories, wound healability classifications and treatment interventions**
3. **Identify the benefits of early healing time predictions**

INTRODUCTION

Chronic wounds heal slowly and this contributes to the significant management cost (Han and Ceilley, 2017). Classification of wound healability is one of the first steps providers must take after an accurate diagnosis is established. In some cases, interprofessional input may be required to determine an accurate diagnosis, complicating factors and wound healing classification. These are holistic and fundamental first steps in the Wound Bed Preparation paradigm.

Generally, chronic wounds are classified into one of three categories: healable, maintenance, and nonhealable. Providers readily accept that the wound healability classification may change. Wound healing is impacted by many factors and can be complex. Changing health status, lifestyle choices and available resources also influence approaches to chronic wounds and healing outcomes.

As a patient with a chronic wound enters the health care system or moves between sectors, baseline wound assessments are performed. Wound measurements must be standardized (longest length × widest width at 90° or head-to-toe & side-to-side) as part of this initial assessment process. Subsequent wound assessments must utilize the same methodology so that comparisons can determine the healing trajectory.

Evaluate Chronic Wound Healing

If a wound is not at least 20% to 40% smaller by week 4, it is unlikely to heal by week 12.

Providers are required to calculate and communicate the rate of healing (healing trajectory) as outlined in Table 1. Note the healing trajectory over time can be either positive (smaller) or negative (larger).

Table 1. Evaluating the Rate of Healing of a Chronic Wound: zz

How to Calculate Wound Surface Area from Two Assessments 4 weeks apart Longest length (cm) × widest width (cm) = surface area (cm^2) (In any direction) (perpendicular to the length) Example: First visit, surface area is 4cm × 2cm = **$8cm^2$** Second visit, surface area is 4cm × 1cm = **$4cm^2$**
How to Calculate Percentage of Wound Healing (Wound Healing Trajectory) First visit area (cm^2) **MINUS** Second visit area (cm^2) **=** difference in surface area Example from above: 8cm2 – 4cm2 = $4cm^2$ Difference in Surface Area / First visit Surface area &#215 100 =4cm2 / $8cm^2$ × 100 = 50% wound surface area reduction between visits This wound is in a positive healing trajectory as it is getting smaller.
Reference: Sibbald, et al, Wound Bed Preparation, 2021

Stalled (healable) wounds should be re-evaluated, often requiring further investigations (e.g., wound biopsy, other tests) for possible alternate diagnosis along with treatment change. Referral to an interprofessional assessment team to optimize management may be necessary, that will often result in improved wound outcomes.

Healing trajectory can be assessed in the first 4 to 8 weeks to predict if a wound is likely to heal by week 12, provided there are no new complicating factors.

For the stalled non-healable and maintenance wounds, re-evaluating by means of assessments and measurements still play a role in ongoing monitoring. When the goal is to prevent further deterioration, maintaining a neutral healing trajectory may be confirmed. A negative healing trajectory may occur in the non-healable wound where efforts shift to patient centered concerns including pain management, exudate, smell and comfort strategies.

Providers can use the healing trajectory (positive, neutral or negative percentage of wound closure over time) to inform the treatment and intervention plans.

Local wound care strategies (Sibbald et al, 2021) will vary by the wound healing classification as illustrated below.

- **Healable Wounds:** have the potential to heal (Sibbald et al, 2012)
  These wounds have sufficient vascular supply, the underlying cause can be corrected & general health can be optimized (Sibbald et al, 2012).
  The **goal** is for closure of the wound in a timely fashion with ongoing functional integrity including prevention of recurrences.
- **Maintenance Wounds:** have healing potential, but various patient factors are compromising current

wound healing (Orsted et al, 2010).
The **goal** is not necessarily to heal the wound, but to reduce the risk of infection and further deterioration while promoting client self-management and independence of the wound care regime.

- **Nonhealable Wounds:** Lack the ability to heal due to untreatable causes such as terminal disease, end-of-life or other organ failures (Despatis, 2008).
  The **goal** is to promote comfort and reduce the risk of infection and possibly prevent further deterioration.

Both maintenance and non-healable wounds are the most challenging from both the clinician's and patient's perspective, in addition to being resource intensive to the healthcare system. A systematic review explored the evidence for nonhealable and maintenance wound management and proposed an interprofessional referral pathway for these wounds based on the findings (Boersema G.C. et al., 2021).

Table 2. Local wound care strategies are customized for each wound healing classification

Wound Healing Classification	Considerations	Sharp Surgical Debridement (All with adequate pain management strategies implemented)	Inflammation/Infection Management (when 3 or more NERDS or STONEES criteria confirmed)	Moisture Management
Healable	Provide moist environment Promote granulation	Active (within the scope of provider)	Treat inflammation/infection (topically or systemic)	Moisture balance
Maintenance	Decrease moisture and bacteria Prevent deterioration	Conservative (no bleeding)	Bacterial reduction Topical antisepsis/ systemic antimicrobial	Moisture reduction
Nonhealable	Decrease moisture and bacteria Prevent infection Enhance comfort	Contraindicated in some cases Gentle removal of non-viable necrotic tissue if needed	Bacterial reduction Topical antisepsis/ systemic antimicrobial	Moisture reduction

Adapted from Sibbald et al, 2015 and Sibbald et al, 2021.

Evolution of Dimensional Measurements versus Healing Trajectories

Clinicians and researchers have been measuring wounds in different ways for years, if not decades. More recently, technology has played a significant part in the evolution of the way in which we not only describe wounds but measure and document them (Wang et al, 2017; Queen, 2019). This technological evolution has taken the science of measurement beyond simple, single point dimensional measurements to the more dynamic measurement of wound healing trajectory (Feldman 2018). This is a better measure of success of any clinical approach including the assessment of therapies and treatment approaches (Bharara et al, 2010; McQuilling et al, 2021).

Tracking the healing process of open wounds follows an exponential curve. Wound-healing trajectories (percentage of wound closure versus time) have been used to describe chronic wound healing (Payne, et al 2011). Although wound healing trajectories were initially intended for acute wounds, they can also be used to evaluate the healing of chronic and complex wounds, including diabetic foot ulcers, pressure injuries and venous leg ulcers (European Wound Management Association, 2008; Phillips et al, 2000; Sheehan et al, 2003; Cardinal et al, 2009; Prince and Dodds, 2006).

Figure 1 – Wound Healing Curve (Norris and Chapman-Jones, 2015)

One potential inconsistency is actually measuring the wound size. Even when using digital photography, non-invasive measurements of wound area are subject to errors especially when defining the wound edge. This is most common when different operators are responsible for obtaining and analyzing the images (Wang et al, 2017). This is even more apparent when clinicians use a paper ruler. Furthermore, such methods only measure the area of the wound and provide no information about changes occurring in the wound depth (volume vs area).

Wound Healing Trajectory

Wound Healing Trajectory

Measurement of healing trajectory is useful for research and validating new clinical or therapeutic approaches. A variety of healing rate methods have been used with varying degrees of success and reproducibility (Carrel and Hartmann, 1916; Du Nouy, 1916; Snowden, 1984; Hokanson et al, 1991; Tranquillo and Murray, 1993).

The measurement of healing rate has evolved from a metric based and perimeter (Gilman, 1990) to a more predictive model by Margolis et al (1993) that included the initial venous ulcer healing rates over the first 4 weeks of therapy.

With tissue remodeling, chronic wound treatments are often associated with increased wound size in the first week of treatment. Several research groups observed (Margolis et al, 1993; Tallman et al, 1997; Cherry et al, 1998) that all patients with negative initial healing rates (weeks 2 to 4) failed to heal within 24 weeks. Patients failing to positively respond to a therapy after 1 month are unlikely to respond after longer periods of time and the management should be reconsidered.

In everyday practice healing trajectories may be more cumbersome with simpler metrics also working. Kantor and Margolis (2000) have proposed using the percent change in wound area over the first 4 weeks, whereas Margolis et al (2000) have proposed using an algorithm based on wound size and duration, that is commonly known before starting therapy. Both methodologies have become routine in everyday practice. The concept of healing trajectories remains important to future wound research and management (Cardinal et al, 2008).

The usefulness of wound-healing trajectories as predictors of validated treatment efficacy for diabetic foot ulcers and venous stasis ulcers (Steed et al, 2006). These trajectories are also useful as an outcome measure for pressure injury management (Payne et al, 2001).

Applicability of Healing Trajectory in Clinical Practice

Applicability of Healing Trajectory in Clinical Practice

Outcome measures or clinical endpoints are necessary, both to evaluate efficacy of potential new treatments undergoing investigation, as well as to determine effectiveness of currently used therapies. Presently, the only outcome acceptable for new treatments for venous stasis ulcers is total ulcer healing (100% closure – FDA Wound Healing Clinical Focus Group, 2001) and not surrogate endpoints.

Wound-healing trajectories provide more information about the entire continuum of the wound-healing process (Robson et al, 2000). Statistical analyses including a t-test performed on single point data (e.g., 100% closure) may not provide accurate guidance about the total effectiveness of new wound care agents over the entire wound healing process (Hokanson et al, 1991). Polansky and van Rijswijk (1994) stated that healing time curves (wound-healing trajectories) are a 'moving picture' of healing that provide more detail than the 'snapshot approach' indicate wound healing (100% closed) at the end of the study (Robson et al, 2000; Polansky and van Rijswijk, 1994).

Hill et al. (2004) compared these three methods in a single group of venous stasis ulcer patients and concluded that although initial healing rates have some general prognostic usefulness, but their poor predictive performance precludes their use as clinical trial surrogate endpoints.

The FDA Wound Healing Clinical Focus Group has stated that partial healing is not considered an acceptable wound healing claim, because the clinical benefit of statistically significant differences in wound size has not been established (FDA Wound Healing Clinical Focus Group, 2001). One surrogate endpoint could be 50% wound closure as a measure of partial healing. The predictive value of this surrogate endpoint (diabetic foot ulcers and pressure injuries) could result in shorter clinical trials, relying on specific shifts of the wound-healing trajectories from impaired healing towards an ideal endpoint (Robson et al, 2000; Hill et al, 1999; Robson et al, 2001).

The ability to predict healing time based on initial response to treatment has important benefits:

- The patient can see evidence of improvement, promoting adherence and future care
- A stalled ulcer can be identified earlier and the cause investigated with testing (e.g., biopsy or culture) and managed to maximize healing
- Preventing acute wounds evolving to chronic wounds
- Preventing wound deterioration by initiating timely interventions (e.g., compression treatment of venous ulcers)

Quantitating intermediate degrees of healing helps to decide if treatment is effective at each visit. Enabling the patient to have realistic expectations of healing time also would lead to higher patient satisfaction, adherence and planning for vacation or returning to work.

Wound healing trajectories (percent healing versus time) provide a dynamic picture of the decrease in wound burden over the entire continuum of the healing process. Improvement in healing can be determined by shifting the curve from "impaired" healing toward "ideal" healing (Figure 1). Compared to fixed endpoints (100% closure), these trajectories provide a more complete description of treatment efficacy.

Wound repair processes depend on the interaction of many time-dependent components (Robson et al, 2001). A wound healing trajectory allows one to evaluate the outcome of healing versus time. Knowing time for healing is vital, decreased healing corelates with greater rates of infection and scarring. The wound healing trajectory integrates the many time-dependent wound healing processes are affected by systemic and local deterrents to healing.

Conclusion and References

CONCLUSION

Healing trajectories are a useful tool for evaluating "time to healing", especially with the utilization of clinical data (Payne et al, 2011). Wound healing trajectories are useful for both acute wounds and chronic wounds, including venous stasis ulcers (Kantor and Margolis, 2000; Hill et al, 2004; Steed et al, 2006; Cardinal et al, 2009) and diabetic foot ulcers (Sheehan et al, 2003; Cardinal et al, 2008). The value of wound trajectory utilization for pressure injuries has also been proven (Hill et al, 1999; Payne et al, 2001; Payne et al, 2011). Efficient clinical trial protocol designs should include wound healing trajectories.

Key Learning Points

1. An accurate wound diagnosis is an important first step in determining the ability of the wound to heal
2. Chronic wounds fall into one of three categories: healable; maintenance and nonhealable
3. Wound status can change and should be regularly monitored
4. Healing trajectory is a more reliable wound tracker than single point wound area measurement

REFERENCES

Bharara, M., Schoess, J., Nouvong, A., & Armstrong, D. G. (2010). Wound inflammatory index: a "proof of concept" study to assess wound healing trajectory. *Journal of diabetes science and technology*, *4*(4), 773–779.

Cardinal, M., Eisenbud, D.E., Phillips, T. and Harding, K. (2008), Early healing rates and wound area measurements are reliable predictors of later complete wound closure. Wound Repair and Regeneration, 16: 19-22.

Cardinal, M., Phillips, T., Eisenbud, D.E. *et al.* Nonlinear modeling of venous leg ulcer healing rates. *BMC Dermatol* **9,** 2 (2009).

Carrel A, Hartmann A. The relation between the size of a wound and the rate of its cicatrization. J Exp Med 1916;24:429–450.

Cherry GW, Ryan TJ, Hoffman D. Tissue repair in patients with chronic venous leg ulcers treated with prezatide copper acetate gel and standard compression therapy [abstract]. Presented at the Symposium on Advanced Wound Care and Medical Research Forum on Wound Repair; April 18–22, 1998; Miami, FL. Abstract E7.

Despatis, M., Shapera, L., Parslow, N. Woo, K. (2008) Complex Wounds WCC 8(2):24-25.

Du Nouy PL. Mathematical expression of the curve representing cicatrization. J Exp Med 1916;24:451–460.

Feldman D (2018) Use of Imaging Techniques to Assess Skin Wound Healing for Tissue Engineering and Regenerative Medicine. Int J Biol Instrum 1:002.

FDA Wound Healing Clinical Focus Group. Guidance for industry: chronic cutaneous ulcer and burn wounds—developing products for treatment. Wound Rep Reg. 2001;9:258-68.

Gilman TH. Parameter for measurement of wound closure. Wounds 1990;2:95–101.

Han, G., & Ceilley, R. (2017). Chronic Wound Healing: A Review of Current Management and Treatments. *Advances in therapy*, *34*(3), 599–610.

Hill DP, Poore S, Wilson J, Robson MC, Cherry GW. Initial healing rates of venous ulcers: are they useful as predictive of healing? Am J Surg 2004;188(1A Suppl):22—5.

Hill DP, Payne WG, Robson MC. Wound trajectories to determine pressure ulcer treatment efficacy. Wound Rep Reg 1999;7:A256.

Hokanson JA, Hayward PG, Carney DH. A mathematical model for the analysis of experimental wound healing data. Wounds 1991;3:213–220.

Kantor J, Margolis DJ. A multicentre study of percentage change in venous leg ulcer area as a prognostic index of healing at 24 weeks. Br J Dermatol 2000;142:960–964.

Laporte M, Keller HH, Payette H, et al. Validity and reliability of the new Canadian Nutrition Screening Tool in the 'real-world' hospital setting. Eur J Clin Nutr 2015;69(5):558-64.

Margolis DJ, Gross EA, Wood CR, Lazurus GS. Planimetric rate of healing in venous ulcers of the leg treated with pressure bandage and hydrocolloid dressing. J Am Acad Dermatol 1993;28:418—21.

Margolis DJ, Berlin JA, Strom BL. Which venous leg ulcers will heal with limb compression bandages? Am J Med 2000;109:15–19.

Margolis DJ, Gross EA, Wood CR, Lazarus GS. Planimetric rate of healing in venous ulcers of the leg treated with pressure bandage and hydrocolloid dressing. J Am Acad Dermatol 1993;28:418–421.

McQuilling, JP, Carter, MJ, Fulton, JA, et al. A prospective clinical trial evaluating changes in the wound microenvironment in patients with chronic venous leg ulcers treated with a hypothermically stored amniotic membrane. *Int Wound J*. 2021; 1– 12.

Norris R and Chapman-Jones D (2015) Healing trajectories as an indicator of clinical outcomes in patients with venous leg ulcers. Wounds UK, Vol 11 (4): 68-73.

Payne WG, Ochs DE, Meltzer DD, et al. Long-term outcome study of growth-factor treated pressure ulcers. Am J Surg. 2001;181:81-6.

Payne WG, Bhalla R, Hill DP, Pierpont YN, Robson MC. Wound healing trajectories to determine pressure ulcer treatment efficacy. *Eplasty*. 2011;11:e1. Published 2011 Jan 10.

Phillips TJ, Machado F, Trout R, Porter J, Olin J, Falanga V. Prognostic indicators in venous ulcers. *J Am Acad Dermatol*2000;**43**:627–30.

Polansky M, Van Rijswijk L. Utilizing survival analysis techniques in chronic wound healing studies. Wounds 1994;6:150—8.

Prince S and Dodds SR. (2006). Use of ulcer size and initial responses to treatment to predict the healing time of leg ulcers, Journal of Wound Care. 15:7, 299-303

Orsted Heather L., Keast David H., Kuhnke Janet, Armstrong Pamela et al. (2010). Best Practice Recommendations for the Prevention and Management of Open Surgical Wounds. 1, s.l. : Wound Care Canada, Vol. 8.

Queen D. (2019). Artificial intelligence and machine learning in wound care-The wounded machine!. *International wound journal*, *16*(2), 311.

Robson MC, Steed DL, Franz MG. Wound healing: biologic features and approaches to maximize healing trajectories. Curr Prob Surg. 2001;38:61-140.

Robson MC, Hill DP,Woodske ME, Steed DL.Wound healing trajectories as predictors of effectiveness of therapeutic agents. Arch Surg. 2000;135:773-7.

Sheehan P, Jones P, Caselli A, Giurini JM, Veves A. Percent change in wound area of diabetic foot ulcers over a 4-week period is a robust predictor of complete healing in a 12-week prospective trial. Diabetes care. 2003 Jun1;**26**(6):1879–82

Sibbald RG, Elliott JA, Persaud-Jaimangal R, Goodman L, Armstrong DG, Harley C, Coelho S, Xi N, Evans R, Mayer DO, Zhao X, Heil J, Kotru B, Delmore B, LeBlanc K, Ayello EA, Smart H, Tariq G, Alavi A, Somayaji R. Wound Bed Preparation 2021. Adv Skin Wound Care. 2021 Apr 1;34(4):183-195.

Sibbald RG, Goodman L, Woo KY, Krasner DL, Smart H, Gulnaz T, Ayello EA, Burrell RE, Keast DH, Mayer D, Norton L. Special considerations in wound bed preparation 2011: An update. In: Krasner DL, Rodeheaver GT, Sibbald RG, Woo KY, eds. Chronic Wound Care: A Clinical Source Book for Healthcare Professionals. 5th ed. Vol 1. Malvern, PA: HMP Communications, 2012: 173-197.

Snowden JM. Wound closure: an analysis of the relative contributions of contraction and epithelialization. J Surg Res 1984;37:453–463.

Steed DL, Hill DP,Woodske ME, Payne WG, Robson MC.Wound-healing trajectories as outcome measures of venous stasis ulcer treatment. Int Wound J. 2006;3:40-47.

Tallman P, Muscare E, Carson P, Eaglstein WH, Falanga V. Initial rate of healing predicts complete healing of venous ulcers. Arch Dermatol 1997;133:1231–1234.

Tranquillo RT, Murray JD. Mechanistic model of wound contraction. J Surg Res 1993;55:233–247.

Wang, S. C., Anderson, J., Evans, R., Woo, K., Beland, B., Sasseville, D., & Moreau, L. (2017). Point-of-care wound visioning technology: Reproducibility and accuracy of a wound measurement app. *PloS one*, *12*(8), e0183139.

Self-Check

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://ecampusontario.pressbooks.pub/skinandwoundcare/?p=535#h5p-2

CHAPTER 5

Chapter 5: Local Wound Care & Documentation

Authors:

- Joshua Moralejo
- Patricia Coutts
- Laurie Goodman
- Reneeka Jaimangal
- R.Gary Sibbald

Learning Objectives

- Describe local wound care in supporting the wound environment
- Identify important wound parameters for documentation

This chapter will discuss the following statements from the Wound Bed Prep 2021:

- **Statement 4:** Local Wound Care – Monitor Wound History and Clinical Examination
- **Statement 7:** Moisture Management

LOCAL WOUND CARE

Case Study

A 59-year-old female with history of swelling of feet and ankles at the end of the day. Unremarkable medical history

Developed a left medical malleolus wound from shaking snow off her boot and subsequently hit her leg on a metal portion of the card. The wound is described as painful at times (up to 5/10 on the numerical 11 point scale), often and with increased drainage an occasional odour.

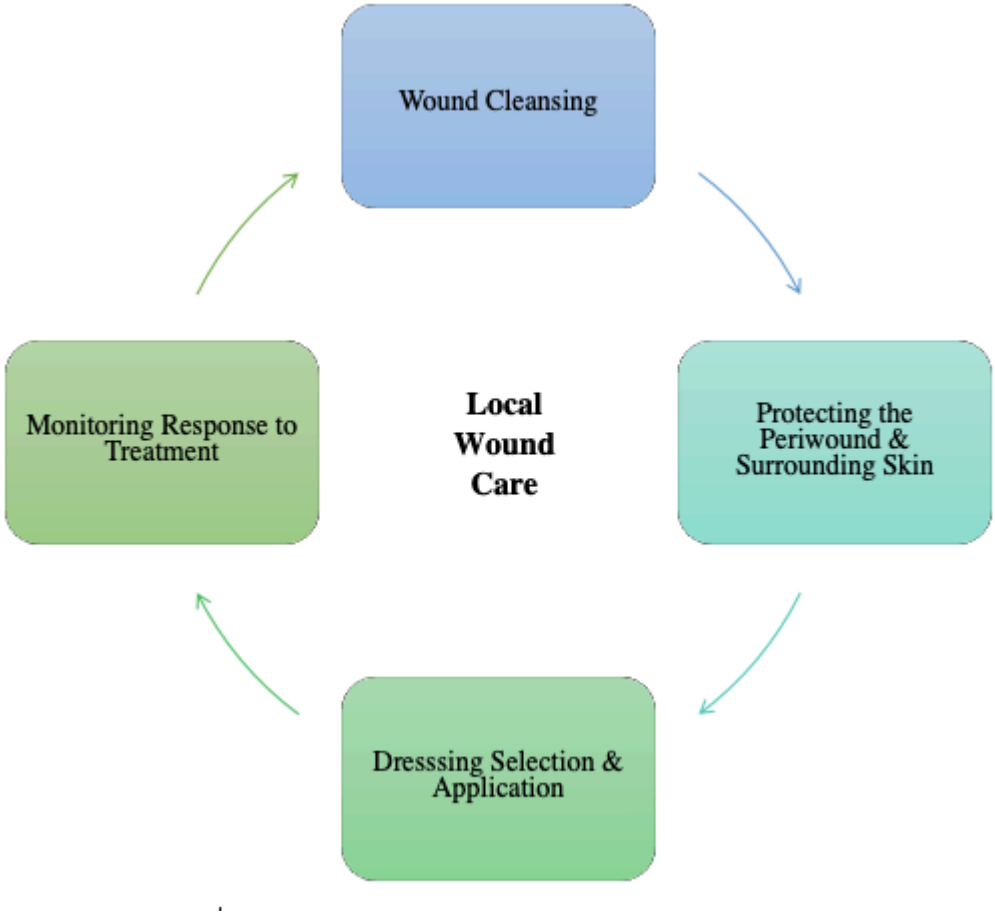
Vascular studies indicated mild incompetence of the left greater saphenous vein, and the ankle-branchial pressure index (ABPI) are 1.12 on the left and 1.00 on the right.

Her partner is very involved in her care assisting with dressing changes including applying compression bandages. Her greatest wish is to be able to walk her dog again without fear of falling.

***Question** – Describe local wound care consideration for this case.*

Local wound care is a practice that involves a series of procedures including cleansing, protection, dressing selection and monitoring (See Local Wound Care Figure 9.1). Local wound care depends on your patient, a detailed wound assessment, and what is available within the environment and the system. Wound care should also be driven by the wound's ability to heal. For healable wounds, local wound care interventions can range anywhere along the spectrum from maintaining a moist environment to sharp debridement (Sibbald et al., 2021). On the other hand, treatment of maintenance and non-healable wounds is focused on selective debridement, managing infection, and keeping the wound dry (Sibbald et al., 2021).

Figure 9.1 – Local Wound Care © Joshua Moralejo & Patricia Coutts



WOUND CLEANSING

Cleansing wounds are kept simple with gentle techniques using normal saline or potable tap water. Upon dressing removal and disposal, wound odour may be present, and this should disappear after appropriate cleansing. If the wound odour persists after cleansing, the cause should be explored for possible infection. When antiseptics are considered to manage bacteria or infection, then the use of low-toxicity cleansers are encouraged (Sibbald et al., 2015). Antiseptics should only be used when their benefit (antimicrobial action) outweigh the risk (potential cytotoxicity).

PROTECTING THE PERIWOUND AND SURROUNDING SKIN

Wound care not only involves cleansing the wound bed, but also the periwound (4cm beyond the wound borders) and surrounding skin. Build-up of debris, dry or dead skin, previous dressing residue or dried, crusted blood along the edges of the wound require gentle cleansing to prevent bacterial growth. After cleansing, the intact skin surrounding the wound should be protected. Skin protectants such as creams or liquid film barriers can be used to prevent potential breakdown such as exposure to wound exudate resulting in maceration (Sibbald et al., 2012).

DRESSING SELECTION AND APPLICATION

Dressings do not heal wounds; however, they do promote an optimal environment that supports wound healing. It is important to recognize that the wound is on a patient, the patient is in an environment and the environment is within a system. Therefore, a holistic approach in the wound plan of care is essential in optimizing dressing selection.

Dressings are meant for various purposes and are selected based on their function (what they do) and form (how they are designed). Some are made to protect the wound from the external environment, while others are used to promote debridement (e.g. autolytic), manage local infection or inflammation, and reduce or maintain moisture (Sibbald et al., 2021). Wound healing classification will direct dressing selection choices to optimize the desired moisture levels for the wound. Multipurpose dressings also exist e.g. moisture balance, autolytic debridement and antibacterial or a silver alginate.

The traditional categories of dressings include films, hydrogels, hydrocolloids, acrylics, calcium alginates, gelling fibers, foams and super absorbents. Dressings designed to manage exudate have the capacity to absorb scant to very large volumes of exudate. The appropriate size of the dressing should be selected when trying to manage the exudate. These dressings used to manage exudate are further expanded in Wound Bed Preparation 2015 (Sibbald et al 2015). Dressings used to manage local infection have an antimicrobial agent (such as iodine, silver, polyhexamethylenebiguanide [PHMB], chlorhexidine etc.) added to these traditional dressing categories.

There are other tools available to help with the selection of the appropriate local wound care products (See Wounds Canada's Wound Dressing Selection Guide and Product Picker).

MONITORING AND EVALUATION

Local wound care interventions should be re-evaluated periodically to ensure that the appropriate wound cleanser and dressings are used to optimize the wound environment. Patient factors such as patient preference, pain, previous products used and response to treatment should also be included in the care planning.

Documentation

WOUND DOCUMENTATION

Wound documentation is a valuable process that helps clinicians to monitor the progress of a wound. Newer technology and point of care innovations have paved the way for documentation using wound photography, digital measurements, and electronic health records. Electronic wound documentation platforms also allow for real-time reporting. (See Image 9.1). Wound assessment parameters should be documented in a consistent format to facilitate comparison and communication to team members. This begins with a comprehensive patient and wound history, along with a detailed wound assessment.

Image 9.1 – Sample of a Wound Electronic Documentation (Humber River Hospital, 2021). Used with Permission.

Wound Drainage	
Drainage Amount	None Small (Scant) Moderate Large
Drainage Description	Serous Sanguinneous Serosanquinneous Purulent (yellow, green or brown) Seropurulent Other – if selected, specify
Other (Specified)	
Periwound / Edge Assessment	
Periwound/Edge	Intact Excoriated Rolled Bleeding Induration Undermining/Tunneling Dry Macerated
Signs of Infection	
Signs of Superficial Infection	Non-healing Debris Exudate Increased Smell Red & Bleeding (Friable)
	*** 3 or More, Use Topical Antimicrobial***
Signs of deep and Surrounding Tissue	Size is Larger Exudate Increased Temperature Increased Erydate and Edema Exposed or Probe to Bone Smell New Breakdown
Wound Measurement	
Length (cm)	
Width (cm)	
Area (cm)	
Depth (cm)	

When assessing a wound, the specific location should be identified and documented e.g. left heel, coccyx, right

gluteal fold or lower leg. Often, multiple wounds may also be present in one location at a time. Wound cleansing should be preformed prior to wound assessment for improved visualization of the wound bed in its natural state. When wound debridement occurs, wound measurements should be recorded both pre and post debridement.

The MEASURE mnemonic is a well accepted framework for detailed wound assessment (Keast et al, 2004). Other validated assessment tools include the Bates-Jensen Wound Assessment Tool or Pressure Ulcer Scale for Healing.

Figure 9.2 – Additional factors to consider for wound assessment

Measurement

MEASURE

Wound measurement is often a good indicator of wound healing (Keast et al., 2004). Appropriate equipment such as a cotton tip applicator and measurement ruler should be used in the determination of wound measurements (Goldman & Salcido, 2002). Wound measurement (surface area in cm2) is calculated using the "longest length" on the surface in any direction, followed by the "widest width" that runs perpendicular (right angle) to the length (Sibbald et al., 2021). Depth is measured at the deepest portion of the wound (Keast et al., 2004) (*See Illustration 9.1*).

INSERT WOUND PICTURE WITH ARROWS

Illustration 9.1 – Wound Measurement

Wound measurement is obtained on the first assessment and should be reassessed at least weekly or as institutional policies require. Unlike chronic wounds, acute wounds follow a normal healing process, closing within 21 days (Keast & Orsted, 1998). In chronic wounds, wound size is expected to decrease by 20-40% within 4 weeks to ensure that wounds close by week 12 (Woo & Sibbald, 2009). Therefore, by measuring wounds at least on a weekly basis will help determine if wounds are progressing.

EXUDATE

Wound exudate may vary in amount and type. For example, a patient with a venous leg ulcer with edema, may have copious drainage while a patient with an intact eschar may have no exudate. Frequency of dressing changes, size of the products selected and wound characteristics are some examples that influence product selection for management of exudate (See Figure 9.3).

It is also important to describe the type of exudate on the wound surface as being serous (clear), serosanguineous (clear + bloody), sanguineous (bloody) or purulent (green or tan) (Keast et al., 2004). The type and volume of exudate should also be described. The most predominant feature of the exudate should be described first e.g. serosanguineous has more clear serum and small amounts of blood.

APPEARANCE

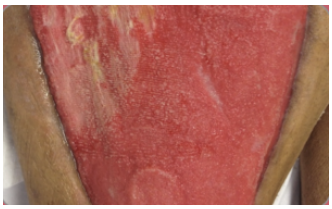
The appearance of the wound bed is a good indicator of the progression of wound closure. Other useful observations may include presence of bone (osteomyelitis), ligament, tendon or foreign body. There are four main tissue types of the wound bed (Figure 9.4):

- healthy granulation (pink, firm, moist)
- epithelialization (new, natural, thin protective layer, often a light purple colour)
- necrotic tissue (black or brown, firm or hard)

- slough (yellow, soft, wet, loose)

Wound appearance assessment is documented by percentages of tissue type observed relative to the entire wound bed size.

Figure 9.4 – Four tissue types. Photos: Courtesy ©L.Goodman

	**Granulation (light red to pink)** • New healthy, firm, moist, granulation tissue • Unhealthy granulation is dark red, friable bleeds easily with touch) and may indicate the presence of infection
	**Epiteliazation (light purple)** • New epithelial layer of tightly packed cells (one or more Layers) • Forms a thin protective layer over the new granulation tissue • Protect – physical disruption (e.g. dressing changes) and too much or too little moisture can cause breakdown
	**Slough (yellow or grey)** • Non-viable, stringy, loose, moist tissue that is separating from the body/would site • Removal is dependent on healability classification and goals of care
	**Necrotic (black or brown)** • Non-viable, dead, dry, firm tissue • Removal is dependent on healability classification and the goals of care e.g. if wound is healable, removal of the eschar may be considered but now always • Keep dry and stable until adequate vascular status is confirmed

SUFFERING

The wound pain score, type of pain and characteristics should be captured as part of the documentation.

UNDERMINING

Undermining or tunneling may also be seen underneath the borders of a wound. Undermining covers large areas or quadrants, while tunnels are narrow caverns that burrow towards a single direction (Wound Ostomy & Continence Nurses Society, 2010) (See Illustration 9.2).

INSERT WOUND PICTURE WITH AREAS OF UNDERMING & TUNNELING

Illustration 9.2 – Areas of Undermining & Tunneling

To appropriately locate the position of a tunnel or undermined area, imagine the wound as a clock with the 12 o'clock edge pointing towards the head of the patient and 6 o'clock to the feet (Keast et al., 2004; Sibbald

et al., 2021) (See Illustration 9.3). Use a sterile cotton-tip applicator to gently probe and measure the extent of undermining and tunneling e.g. a tunnel is 3cm deep at 4 o'clock. Identifying such areas can help ensure that they are packed appropriately to facilitate healing and communicates where dressing material needs to be removed from.

INSERT WOUND PICTURE WITH CLOCK

Illustration 9.3 – Locating Undermining and Tunneling (Clock Method)

It is important to obtain a wound measurement (including areas of undermining or tunneling) using a consistent method to ensure accuracy and reliability.

RE-EVALUATE

Comprehensive wound assessment and patient progress should be re-evaluated as necessary and according to institutional policies.

EDGE

Wound assessment goes beyond the surface of the wound and should also include an assessment of the wound edges and the periwound skin (4 cm beyond the wound). To support wound closure, wound edges should be like "the shore of a sandy beach" where the new epithelial tissue advances smoothly along the wound surface. Some wounds have a "cliff-like edge" or rolled edges (epibole), usually indicating chronicity because the epithelium falsely believes healing is complete. This type of wound edge inhibits epithelial tissue advancement resulting in delayed wound healing (Fletcher & Probst, 2020).

Maintaining a healthy periwound is a vital component of local wound care. Periwound skin should be assessed for:

- maceration (indicative of excessive moisture, white over hydrated skin)
- erythema (red, indurated)
- excoriation (linear erosion or ulcer)
- edema (swelling)
- thick callus (thickened epidermis)
- new areas of breakdown (possible sign of infection)

Early recognition and intervention are necessary to prevent overall wound deterioration but not treating the cause or trauma may also be responsible.

Infection

Wound infection results in impaired wound healing. The validated NERDS and STONEES tool may be used to assess and document potential superficial and deep and surrounding tissue infection.

Treatment

Documentation should also include local wound care plans and response to treatment. This process will help other clinicians to determine what preventative strategies, local dressings or cleansers were used and how it may have influenced the wound parameters being monitored.

V – Vascular: ABPI confirms adequate arterial blood supply for healing
I – Infection: NERDS and STONEES criteria (odour, pain, exudate) – consider topical antimicrobial treatment; possibly systemic antibiotic therapy based on other factors
P – Pressure: High compression therapy indicated due to absence of arterial disease once pain is under control and patient tolerates
S – Sharp surgical debridement: Depending on the wound bed appearance

Other – Normal saline appropriate for cleansing
– Periwound protection: liquid film acrylate or other available barrier
– Dressing selection: consider antimicrobial action, moisture balance (super absorbent) and pain control
– Support: Including patient and circle of care in treatment planzz
– Patient education on prevention of recurrence (compressions stockings for life)

Summary & References

SUMMARY

Local wound care provides an opportunity to promote a wound environment that will support wound healing. Selection of appropriate wound cleansers and dressings will depend on the wound healing classification, detailed wound assessment, patient preference and their environment. It is important that local treatment is re-assessed in a timely manner to ensure the overall goal of the patient and their wound is met.

REFERENCES

Caruana, M. F., Bradbury, A. W., & Adam, D. J. (2005). The validity, reliability, reproducibility and extended utility of ankle to brachial pressure index in current vascular surgical practice. European Journal of Vascular and Endovascular Surgery, 29(5), 443-51.

Dallam, L. E., Ayello, E. A. et al. (2016). Pain management and wounds. In Baronski, S., & Ayello, E. A., Wound care essentials: Practice principles (pp. 281-306). Philadelphia, PA: Wolters Kluwer.

Falanga, V. (2000). Classifications for wound bed preparation and stimulation of chronic wounds. Wound Repair and Regeneration, 8(5), 347-352.

Flanagan, M. (1997). A practical framework for wound assessment 2: methods. British Journal of Nursing, 6, 6-11.

Fletcher, J., & Probst, A. (2020). Managing dry wounds in clinical practice: challenges and solutions. Wounds Internationals, 11(2), 47-52.

Goldman, R. J., & Salcido, R. (2002). More than one way to measure a wound: an overview of tools and techniques. Advances in Skin and Wound Care, 15(5), 236-243.

Grey, J., Enoch, S., & Harding, K. (2006). ABC of wound healing: Venous and arterial leg ulcers. British Medical Journal, 332(2), 347-350.

Humber River Hospital. (2021). Wound/incision Assessment [Screenshot].

Keast, D. H., Bowering, C. K., Evans, A. W., MacKean, G. L., Burrows, C., & D'Souza, L. (2004). MEASURE: A proposed assessment framework for developing best practice recommendations for wound assessment. Wound Repair and Regeneration, 12, S1-17.

Keast, D. H., & Orsted, H. (1998). The basic principles of healing. Ostomy/Wound Management, 44(8), 24-28, 30-31.

Landes, S.J. (2008). Chronic wound infection and antimicrobial use. Advances in Skin and Wound Care, 21(11), 531-540.

Sibbald, R. G., Alavi, A., Sussman, G., Ayello, E., & Goodman, L. (2012). Dermatological aspects of wound care. In Krasner, D., Rodeheaver, G. T., Sibbald, R. G., & Woo, K.Y. (Eds.), Chronic wound care: A clinical source book for healthcare professionals (5th ed., pp. 207-222). Malvern, PA: HMP Communications.

Sibbald, G., Elliott, J. A., Ayello, E. A., & Somayaji, R. (2015). Optimizing the moisture management tightrope with wound bed preparation 2015. Advances in Skin and Wound Care, 28(10), 466-476.

Sibbald, R. G., Elliott, J. A., Persaud-Jaimangal, R., Goodman, L., Armstrong, D. G., Harley, C., Coelho, S., Xi, N., Evans, R., Mayer, D. O., Zhao, X., Heil, J., Kotru, B., Delmore, B., Leblanc, K., Ayello, E. A., Smart, H., Tariq, G., Alavi, A., & Somayaji, R. (2021). Wound Bed Preparation 2021. Advances in Skin & Wound Care, 34(4), 183-195.

Woo, K., & Sibbald, G. (2009). A cross-sectional validation study of using NERDS and STONEES to assess bacterial burden. Ostomy Wound Management, 55(8), 40-48.

Wound, Ostomy and Continence Nurses Society. (2010). Guidelines for prevention and management of pressure ulcers. Mount Laurel, NJ: Author.

CHAPTER 6

Chapter 6: Moisture Management

Author:

- Laurie Goodman

INTRODUCTION

This chapter is intended to guide health care clinicians and students through the important and dynamic skill of managing moisture for patients with chronic wounds. The classifications of healability will be applied to various desired moisture levels for optimal patient outcomes. Appropriate use of antibacterial and antiseptic products along with correct selection of dressings according to their form and function are expanded on. The Wound Bed Preparation paradigm (Sibbald, et al, 2021) in combination with relevant literature and expert opinion are presented in this chapter to assist the reader to apply clinically.

Learning Objectives

1. Review moisture management strategies in the context of wound healing classifications (healable, nonhealable & maintenance)
2. Examine the use of topical antimicrobials and antiseptics to facilitate appropriate moisture management
3. Apply wound assessment findings to dressing form and function features

MOISTURE MANAGEMENT

Moisture Management is a collective term where providers utilize their skilled clinical eye, astute assessment skills, a working knowledge of the accessible wound care product formulary while taking into account the patient's perspective. "Moisture management" has evolved along with evidence informed wound care practices and has now replaced the former term "moisture balance". Determination of the correct moisture level is now viewed as a dynamic and adaptable process as the wound moves through various appearances along the way. The former term, moisture balance, suggests an approach that balances all wounds at the similar level between moist and dry. This is still the case for a healable wound where that ideal level of moisture needs to be "balanced". The new term considers that the nonhealable / maintenance healability classifications need to be managed differently.

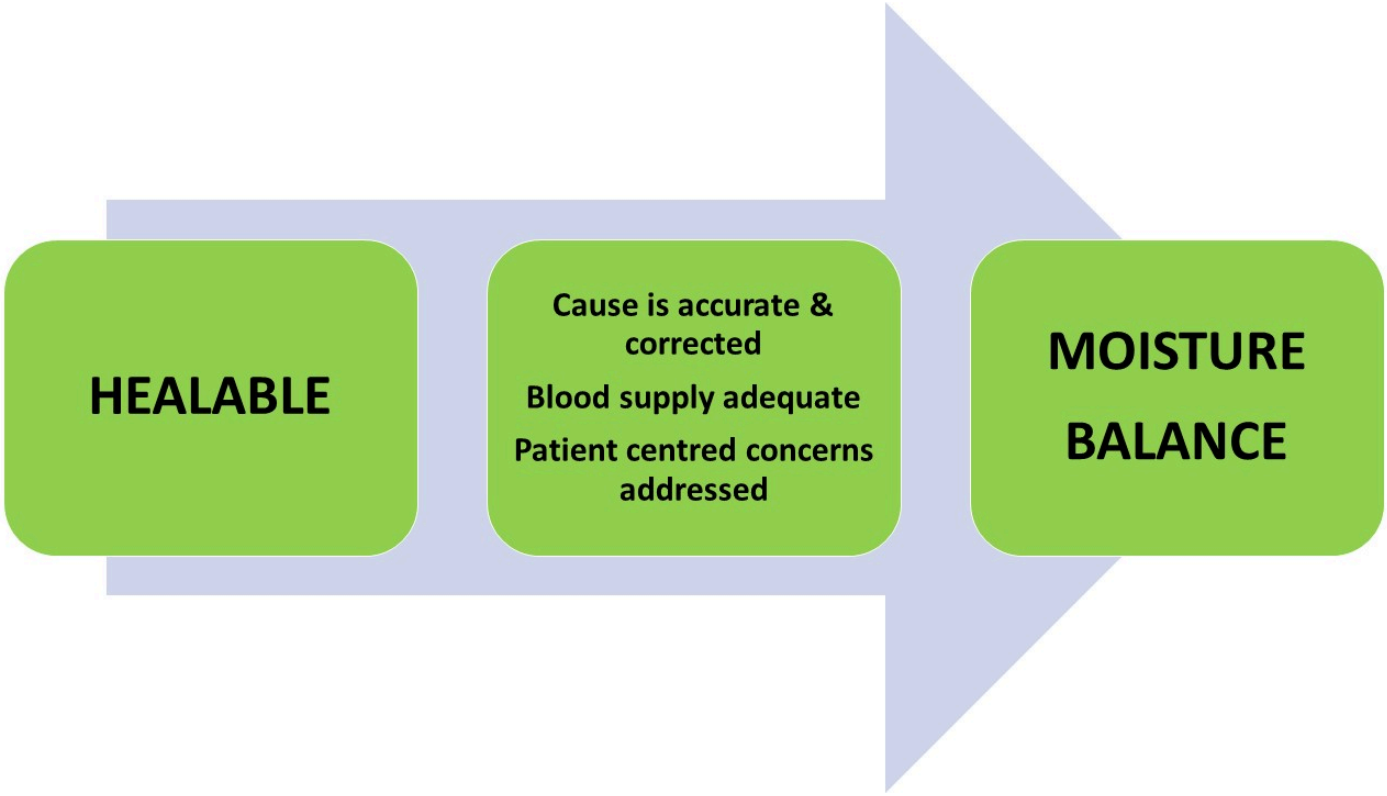
The Wound Bed Preparation framework (Sibbald et al, 2021) guides health care providers of individuals with a wound, through a holistic patient-centered assessment, diagnosis and treatment algorithm. This structured, evidence-based approach will direct the provider and patient to optimal wound care. The 2015 WBP (Sibbald et

al, 2015) added a crucial the step of determining the healability of the patient with a wound as either: healable, nonhealable or maintenance. Once the cause has accurately been confirmed and patient centered concerns have been accounted for, then the healability classification of the wound can be determined. A review of healable, nonhealable and maintenance healing classifications will be outlined in the context of moisture management.

Local wound care in the WBP algorithm includes the D, I, M, E approach (Debridement, Infection / Inflammation and Edge Effect) that will be covered in other chapters. This chapter focuses on the "M" for Moisture management in its application for chronic wounds along with various modifying factors. Moisture management means moisture balance for healable wounds and moisture reduction for nonhealable or maintenance wounds.

Moisture Balance for Healable Wounds

Figure 1. Moisture Balance for Healable Wounds (Goodman, 2021)



George D. Winter's research (1962) demonstrated that when wounds were maintained in a moist environment with a film covering, this resulted in: faster epithelization, decreased eschar formation, warmer wound surface temperature and double the healing rates. He demonstrated that for healable wounds, a moist environment optimized wound healing.

When the wound bed is kept moist, numerous other events occur that facilitate wound healing. These include:

- Growth factors and proteins are preserved on the wound surface (Tan and Dosan, 2019)
- Matrix destroying enzymes (proinflammatory cytokines and matrix metalloproteins) are sequestered and decreased (Tan and Dosan, 2019)
- Facilitating movement across the wound surface for keratinocytes, fibroblasts, growth factors and cytokines (Tan and Dosan, 2019)
- Fibroblasts that readily available to stimulate collagen synthesis (Tan and Dosan, 2019)

- Promotion of new tissue growth, to increase re-epithelization rate and overall faster wound healing (Dyson et al, 1998) (Beam, 2008)
- Reduced scarring (Hackl, 2014) (Powers, Morton, Phillips, 2013) (Attinger, et al, 2006)
- Reduced pain perception (Ousey, et al, 2016) (Coutts, Woo, Bourque, 2008)
- Facilitation of autolytic debridement (King, et al, 2014) (Gray, et al, 2010)

Allowing a healable wound to dry out will hamper wound healing. This leads to formation of slough, eschar and tissue necrosis, thereby reducing wound re-epithelization and closure. Preventing a healable wound (or portions of it) from drying out should be in the forefront of provider's goals. Unfortunately, once necrotic tissue forms, some form of debridement is then needed to regain to the eschar-free pink wound base. This is how many healable wounds exhibit delayed healing and may become chronic. These undesirable tissue changes increase the risk of bacterial damage from superficial critical colonization (local infection) and deep/surrounding wound infection. (Sibbald, Woo, Ayello, 2006) The presence of necrotic tissue increases the bacteria load and becomes an infection risk for the individual. By keeping the healable wound moist, delayed healing cascade and resultant chronic wound status may be prevented.

Every effort should be taken to keep healable wounds moist and in their expected healing trajectory. The quicker an individual's wound can heal, the less resources are required and outcomes are improved.

For the healable wound, potentially cytotoxic antiseptics are not indicated and should only be introduced for unique situations (e.g., local infection). If a healable wound is observed to suddenly produce some mild odour, green exudate and periwound erythema, this warrants a prompt intervention. One unique example would be if the wound base is observed to have any 3 of the 5 NERDS signs, this is indicative of local infection and would require use of antibacterial dressing (Sibbald, Woo, Ayello, 2006). Three to five-days of a short-term use of an antiseptic solution during wound cleansing would be a prudent treatment, then return to normal saline cleansing. This is an example where close assessment of a healable wound results in appropriate, timely treatment changes, and can keep the wound in a healing trajectory.

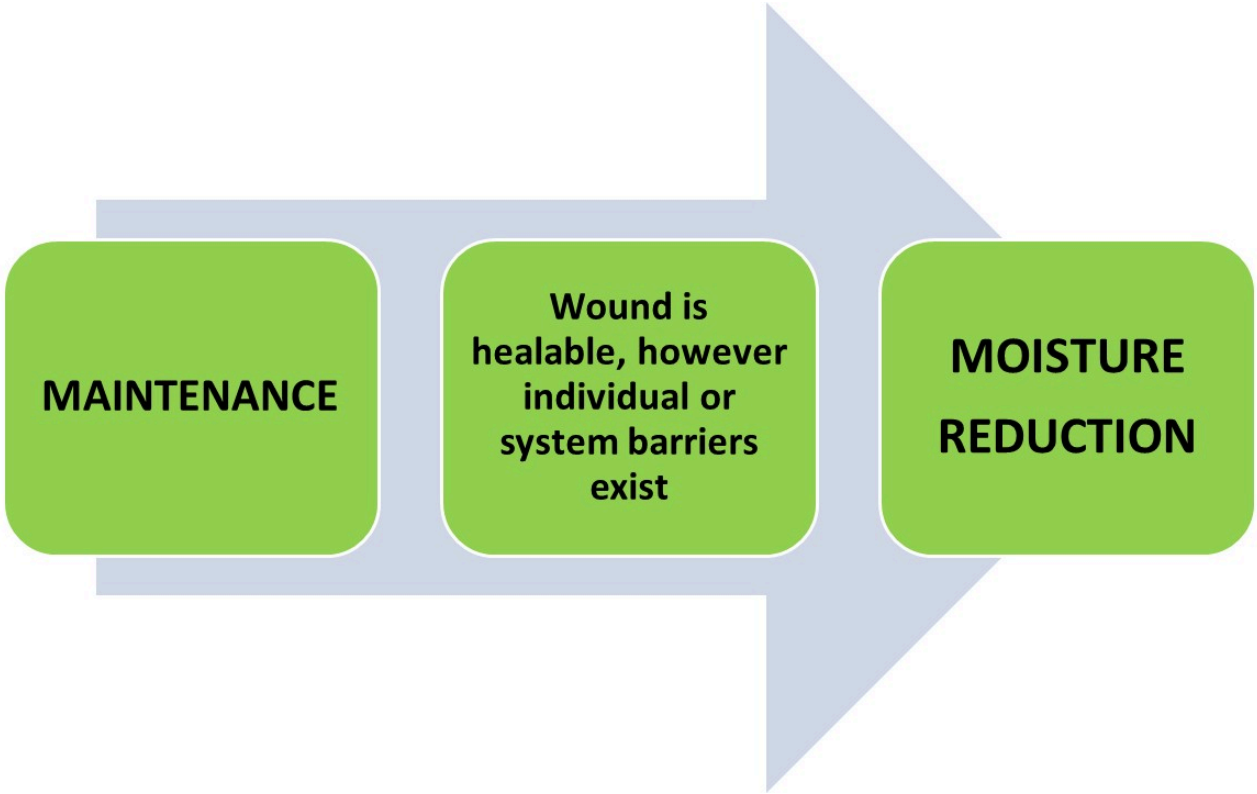
Foams and super absorbents are two different products that manage exudate differently. Reviewing the manufacturer's information on any wound product is recommended to facilitate appropriate use of resources. See Table 1 for a comparison of foams and super absorbents and their features.

Table 1. Comparison Between Foams and Super Absorbents

Dressing Category	Features	Average Wear time
Foams Moisture Balance (Moisture Exchange/ Moisture Balance)	Absorbs low to moderate amount of exudate Fluid exchange (dressing gives back some exudate to prevent wound surface from drying), observe for periwound maceration May be a method of delivery for antibacterial agent (silver) or containing a non-release antibacterial agent for antibacterial action above the wound surface (PHMB, Methylene blue/gentian violet) Optimal when infection is not an immediate concern and exudative levels are under control More expensive ($$$$ per dressing) – requires longer wear time for cost-effective use	2-7 days
Super absorbents Moisture Management (Fluid lock/diaper technology)	Absorbs a large to excessive amount of exudate Fluid lock technology within the product to keep wound surface at a lower moisture level (diaper technology) Do not cut (absorptive polymers will leak out on the wound surface) Antimicrobials may be used as contact layer under the superabsorbent Optimal when frequent dressing changes are needed or uncontrolled exudative situations E.g., superficial or deep and surrounding tissue infection Less expensive ($ per dressing)	1-3 days

Moisture Management for Maintenance Wounds

Figure 3. Moisture Management for Maintenance Wounds (Goodman, 2021)



The cautious and similar approach used for nonhealable wounds should be also taken for maintenance wounds. These wounds usually have adequate arterial blood supply, are free of malignancy and should ideally progress to healing however individual and/or system challenges prevent the healing. Some common examples to illustrate the maintenance wound include:

- An individual with longstanding chronic venous leg edema and subsequent lower leg ulcers, confirmed adequate arterial blood supply however refuses to wear compression therapy. Other individuals may have the compression bandages for treatment provided through Ontario home services. Lack of financial resources to purchase the compression stockings ongoing for years may result in maintenance wounds with frequent recurrences.
- An individual with neurotrophic foot ulcer has confirmed adequate arterial blood supply, requires plantar pressure redistribution, is willing to wear the offloading device however cannot afford the purchase of the specialized footwear. They have no extended benefits or financial resources. This is a

maintenance wound.

- A paraplegic individual with chronic pressure injuries to ischial tuberosities uses a wheelchair for mobility. The wounds have nearly closed on several occasions but the individual has a pattern of occasional excessive alcohol and tobacco use for a few weeks at time. During these binges the wounds deteriorate rapidly. The team has repeatedly educated the patient on the impact these binges have on wound healing, the risks of infection, sepsis and possibly death. This individual has repeatedly declined substance abuse counselling and therapy.

Once an individual with a maintenance wound is identified, using the correct approach for “moisture reduction” is key. It is by adequately reducing moisture that bacteria are thereby reduced, subsequentially decreasing the risk of potential infection, sepsis and death.

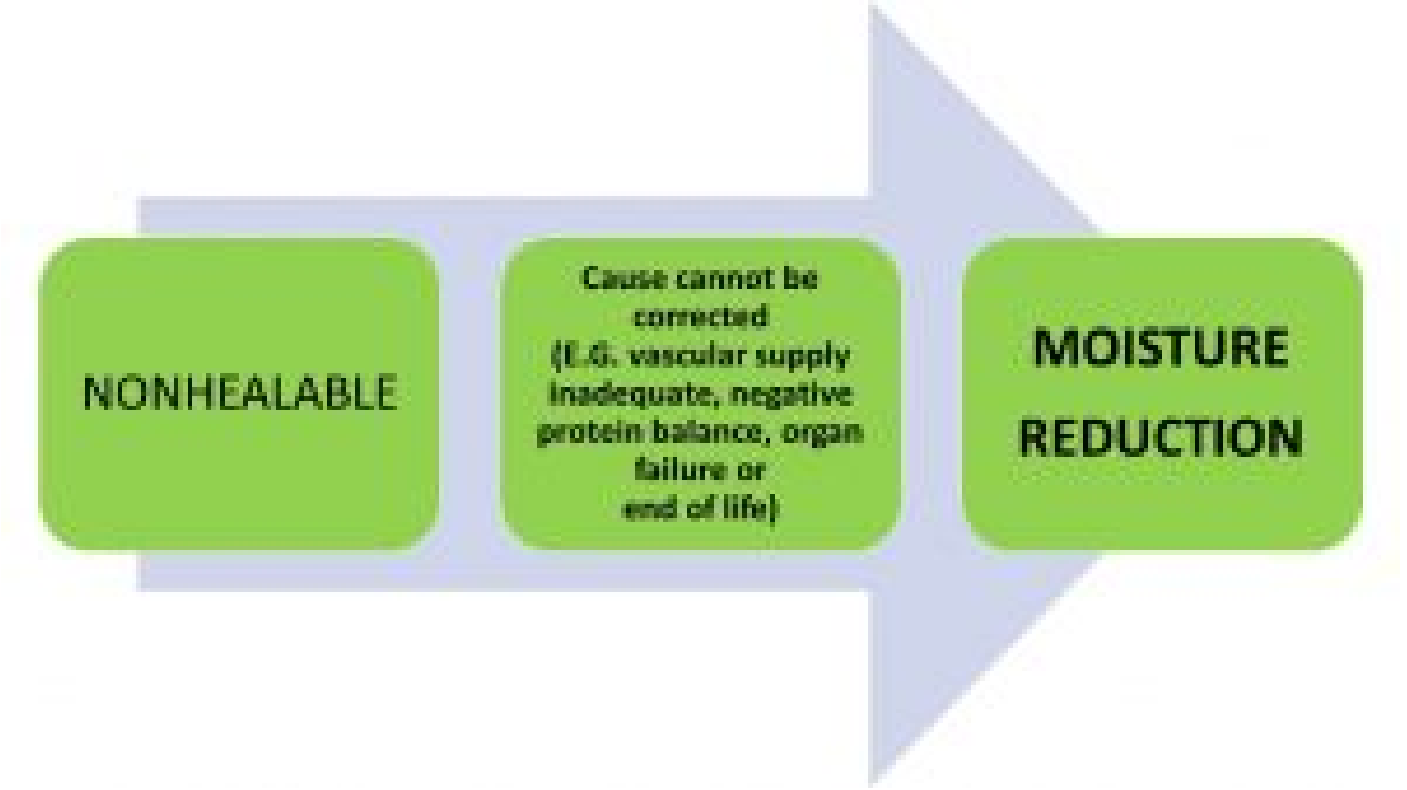
For a maintenance wound, the goal is to simply “maintain” a stable wound status and prevent infection (control edema, exudate). Goals are shifted to patient-centered concerns including the optimization of pain management and activities of daily living and healing is not the focus. Counselling the patient and / or their circle of care is needed as they accept that the wound may not heal. The inclusion of an interprofessional team is often advantageous to confirm that treatment elements are not overlooked.

Antiseptics are used for the purposes of moisture reduction and bacteria reduction for these individuals. Using these antiseptics, the benefit of reducing bacteria gains precedent over the potential risk of cytotoxicity to the wound bed.

As stated previously, healability classifications of wounds can change. Funding for the offloading boot or compression therapy may be secured, smoking and alcohol use may discontinue can change the care plan completely. In these cases, the wound healing classification would move from maintenance status (requiring moisture reduction) to a healable wound (now requiring moisture balance). In some instances, maintenance wounds may still progress in a healing trajectory and close. It is through optimizing each individual risk and causative factor that could potentially tip the wound into a healing trajectory.

Moisture Management for Nonhealable Wounds

Figure 2. Moisture Management for Nonhealable Wounds (Goodman, 2021)



A cautious and conservative approach should be taken when wounds are identified as lacking the ability to heal. Lack of arterial blood supply (ischemia), malignancy with cutaneous metastasis, progressing non-treatable dermal disorders or end of life skin changes where the individual may be in a negative protein balance and multiple organ failure are some examples of a nonhealable wound. For these wounds, moisture reduction is key. By reducing the moisture levels on the wound surface, bacteria are thereby reduced, subsequentially decreasing the risk of potential infection. This is especially true when the host defence is weakened as in an immunocompromised individual.

In many cases with a nonhealable wound, the goal is to simply "maintain" a stable wound status and prevent infection. A case example would be a 90-year-old female on renal dialysis (end stage renal disease) with a non-operable ischemic foot. The foot presents as a black mummified, dry and stable necrotic state. Prevention of deep and surrounding tissue infection and sepsis is the goal and povidone iodine with a dry dressing was implemented. Extra diligence should be taken to have the antimicrobial solution applied to into the surface *between* the necrotic and non-narcotic tissue around the ankle to minimize the chance of tissue becoming moist and promoting

bacteria spread. With this moisture reduction and control of bacterial growth, this individual could continue with their activities of every day life for weeks, months and possibly years.

In the case of the nonhealable wound, the goals of healing the wound are secondary. Instead, emphasis is shifted to patient-centered concerns including the optimization of pain management and activities of daily living. This often requires some counselling with the patient and / or their circle of care as this is may be new and uncharted waters as they realize the wound may not heal. Providing support through a trusting patient-to-caregiver relationship is needed. Unique goals from the patient and their circle of care should be prioritized, documented and shared with the interprofessional team.

The healability classification of wounds can change necessitating prompt treatment changes. An individual with a nonhealable ischemic foot may have revascularization surgery, ideally resulting with palpable pulses in this limb. The wound is no longer considered a nonhealable wound since the cause has been corrected. This requires a different moisture management approach by appropriate use of moist wound healing strategies, as the wound is now considered healable. Healing may be delayed with reperfusion injury.

Antiseptics applied topically are often used for the purposes of moisture reduction and bacteria reduction. Here, the goal of reducing bacteria takes priority and subsequent impact of cytotoxicity is less important. Antiseptic solutions vary in their degree of cytotoxicity. Antiseptics will be discussed later in the chapter.

Another case example in the nonhealable classification would be the common presentation of black necrotic heel caps for a frail elderly individual confined to bed. A monophasic pulse is determined by audible handheld doppler assessment and a weak pulse may be palpable. It was determined that this patient is not amenable for foot revascularization and tissue debridement would be considered to be contraindicated except to remove “non-viable slough” without causing bleeding. Painting the black eschar cap and surrounding skin with povidone iodine daily and keeping the heel open to air could be the safest and most appropriate approach for reducing moisture and bacteria. Other strategies would be to float the heel to reduce any causative pressure concerns. In many cases, these black heel caps over time may further desiccate, loosen and fall off with the slow healing process occurring under the cap.

Moisture Management, Antiseptics, and Dressing Selection

Moisture Management and Antiseptics

Most antiseptics have a broad spectrum of action on cell walls, membranes, cytoplasmic organelles and DNA, making them bactericidal (McDonnell G, 1999). Antiseptic use should be reserved for nonhealable and maintenance wound healing classification. There is a general increasing momentum for antiseptic stewardship, similar to antibiotic stewardship, meaning that appropriateness of antiseptics should be justified and not overused without reason.

Moisture Management and Dressing Selection

At dressing change, the removed dressing should be examined along with the wound base. This includes assessing for:

- leaking dressing edges or striking through dressing backing to outer environment (problematic)
- sticking of dressing to wound bed (problematic) especially with visible bleeding points on removal
- saturation of the dressing (size or dressing type to be assessed): 75-100% heavy exudate, 25-75% moderate exudate and <25% small/scant exudate
- wound assessment including notation of the wound healing progression or a stalled wound
- patient input and feedback regarding past, current and future dressings

In a healable wound, there should be minimal or no adherence of the dressing to the wound bed, indicating that more moisture or moisture retentiveness is needed. On the other hand, if the wound is maintenance or nonhealable, one would expect the wound bed to be completely dry, following moisture reduction principles.

All dressings fall into the moisture continuum ranging from low to high exudate absorbing capabilities, as illustrated in this figure.

Figure 4. Dressing Selection and Moisture Continuum 2021©.

Dressing Selection & Moisture Continuum

Low Exudate ——————————————————————-High Exudate

Hydrogels	Transparent Films	Hydrocolloids/ Acrylics	Alginates	Foams	Super-Absorbents (Diaper technology)
Donates moisture	Neither donates or absorbs moisture	Donates and absorbs a small to moderate amount of moisture	Absorbs moderate to large amount of moisture (Longer wear time)	Absorbs moderate to high amount of moisture (Foams vary and have a fluid exchange with wound surface)	Absorbs and "locks in" moderate to copious amount of moisture

Reference – Adapted from: Sibbald RG, Elliott JA, Ayello EA, Somayaji R. Optimizing the moisture management tightrope with Wound Bed Preparation 2015. Adv Skin Wound Care 2015;28(10):466-76

The size of the dressing selected can have a direct impact on moisture management. If the wound is moderately or heavily draining and a smaller than recommended dressing size is selected, this is going to result in excessive fluid on the wound bed and strike through will occur. In this case the wear time of the product will not be reached. Now there is also a risk of bacteria moving into the wound bed. On the other hand, if moisture needs to be reduced on the wound surface level, using a larger product than expected may help facilitate this goal. This is where patient and provider experience can positively influence the moisture management outcomes. If dressings overlap normal skin; consider protecting the wound margin (film forming liquid acrylate, zinc oxide, petrolatum).

Another dressing product selection factor that can influence moisture management is the readily accessible product formulary. Depending on location and resources, dressing choices to achieve moisture management goals may be very different. Some product formularies may be restrictive pertaining to limited product sizes available in an effort to reduce cost. This practice may adversely affect the wound healing trajectories. Also, in remote or under resourced locations, provider creativity may be required using less expensive products to achieve similar outcomes

Table 2. Summary of Modern Dressing Categories & Wound Healing Classifications

SUMMARY OF MODERN DRESSING CATEGORIES & WOUND HEALING CLASSIFICATIONS				
Class	**Description**	**Moisture Management Impact on healable Wound**	**Moisture Management Impact on Nonhelable/Maintenance**	**Indications / Contraindications**
Adhesive Transparent Films/ Membranes	Semipermeable adhesive sheets; impermeable to water molecules, micro-organisms	Appropriate: May create an occlusive barrier against bacteria	Contraindicated: may cause excessive maceration, water surface fluid collection and wound deterioration, infection and sepsis	Should not be used on draining or infected wounds Caution on fragile skin Should stay in place for several days
Nonadherent	Sheets of low adherence; prevents sticking to tissue; non-medicated tulles	Appropriate: Often used as a wound contact layer where moisture is wicked through nonadherent to secondary dressing	May be appropriate: Allows any moisture to wick through to secondary level (may need slits in the contact layer)	Prevents sticking to the tissue; May decrease pain at dressing change; May be left in place for several days
Hydrogels (Autolytic debridement)	Polymers with high water content; available in gels, solid sheets or impregnated gauze	Appropriate: When used to promote autolytic debridement or if wound too dry	Contraindicated: May cause excessive maceration, bacteria proliferation, wound deterioration, infection and sepsis	Should not use on draining wounds; Avoid using solid sheets on infected wounds
Hydrocolloids (Autolytic debridement)	May contain gelatin, sodium carboxymethylcellulose, polysaccharides and/or pectin; adhesive sheet dressings are occlusive with polyurethane film outer layer	Appropriate: When used to promote moisture balance for optimal healing May be coupled with alginate as the contact layer underneath Promotes autolytic debridement	Contraindicated: May cause excessive maceration, bacteria proliferation, wound deterioration, infection and sepsis	Should not be used on draining or infected wounds; Caution on fragile skin Should stay in place for several days; Odour may accompany dressing change and should not be confused with infection
Acrylics (Autolytic debridement)	Two layers of adhesive transparent film that contain clear acrylic pad within	Appropriate: When used to promote moist wound environment for healing Promotes autolytic debridement	Contraindicated: May cause excessive maceration, bacteria proliferation, wound deterioration, infection and sepsis	Use on low-moderate exudate levels; Dressing stays in place for extended time; Wound may be visualized through clear dressing
Calcium Alginates (Autolytic debridement)	Calcium sodium Alginate (seaweed derivative) in sheets or fibrous ropes	Appropriate: Helps manage optimal moisture levels for healing by converting to gel when moist Promotes autolytic debridement Bioresorbable and silver combination options	May be appropriate: If varying levels of moisture within one wound, can help absorb to manage this challenge	Inappropriate to use on dry wounds; Low tensile strength – not to be used to pack into narrow tunnels/sinuses; Some are bioresorbable
Composite dressings	Combination dressing layers to increase absorbency	Appropriate: Helps manage optimal moisture levels for healing by converting to gel when moist Promotes autolytic debridement Bioresorbable and silver combination options	May be appropriate: If varying levels of moisture within one wound can help absorb to manage this challenge	Inappropriate to use on dry wounds; Low tensile strength – not to be used to pack into narrow tunnels/sinuses; Some are bioresorbable
Super-Absorbents	Highly absorbent dressing with fluid repellent backing	Appropriate: Helps manage, absorb and lock fluids Prevents leakage, strike-through Breathable, not occlusive	May be appropriate: If varying levels of moisture within one wound can help absorb to manage this challenge	Use on moderate to copious fluid levels Can stay in place for several days Versatile in form and function
Foams	Adhesive or non-adhesive polyurethane foam; some with occlusive back, sheet or cavity packing, some with fluid lock; Function as “fluid exchange”	Appropriate: For low to moderate exudating wounds where dressing change is several days; Periwound protection needed and frequent monitoring initially to observe for maceration	Contraindicated: May act as an occlusive layer, thereby increasing risk of excessive maceration and moisture, bacteria proliferation, wound deterioration, infection and sepsis	Occlusive foams contraindicated for heavy exudating or infected wounds

SUMMARY OF MODERN DRESSING CATEGORIES & WOUND HEALING CLASSIFICATIONS				
Class	**Description**	**Moisture Management Impact on healable Wound**	**Moisture Management Impact on Nonhelable/Maintenance**	**Indications / Contraindications**
Charcoal	Odour-absorbing charcoal within the product; This product does not reduce bacteria unless is a combination with an antimicrobial; Ideally the cause of odour should be corrected if possible	Appropriate: If moisture levels low to moderate; Does not interfere with wound healing	May be appropriate; For dry, stable wounds with odour; For moderate to heavy exudating, inappropriate as charcoal may be inactivated by moisture Best approach is to target odour by managing bacteria or cause of odour	Ensure edges are sealed or picture framed closed to enhance odour-absorbing feature
Hypertonic	Sheet, ribbon or gel impregnated with concentrated sodium; Requires frequent changing, easy to use	May be Appropriate: If excessive purulent exudate promote movement from in wound outwards	Not appropriate: Not appropriate on dry wounds; May increase pain	Stimulates wound cleansing by moving purulent exudate outward, thereby reducing bacterial burden

Adapted from Canadian Association of Wound Care and Revised from Wound Bed Preparation 2012.

Conclusion and References

CONCLUSION:

Optimal moisture management is a necessary clinical intervention that does require ongoing attention and revision by health care providers. Patients and their circle of care input can contribute useful information that delicately considers optimal healability along with ideal moisture management and controlled bacterial levels. Dressings need to match form and function including moisture management.

REFERENCES:

Attinger CE, Janis JE, Steinberg J., et al. (2006). Clinical approach to wounds: debridement and wound bed preparation including the use of dressings and wound-healing adjuvants. Plast Reconstr Surg.117(7) Suppl, 72S–109S

Beam JW. (2008). Occlusive dressings and the healing of standardized abrasions. J Athl Train. 43(6), 600–607

Coutts P, Woo KY, Bourque S. (2008). Treating patients with painful chronic wounds. Nurs Stand. 23(10), 42–46.

Dyson M, Young S, Pendle CL., et al. (1998). Comparison of the effects of moist and dry conditions on dermal repair. J Invest Dermatol. 91(5), 434–439

Gray D, White R, Cooper P, Kingsley A. (2010) Applied wound management and using the wound healing continuum in practice. Wound Essentials. 5, 131–139.

Hackl F, Kiwanuka E, Philip J., et al. (2014). Moist dressing coverage supports proliferation and migration of transplanted skin micrografts in full-thickness porcine wounds. Burns. 40(2), 274–280.

King A, Stellar JJ, Blevins A, Shah K N. (2014) Dressings and products in pediatric wound care. Adv Wound Care (New Rochelle), 3(4), 324–334.

McDonnell G, Russell AD. (1999). Antiseptics and disinfectants: activity, action, and resistance. Clin Microbiol Rev, 12:147-179

Ousey K, Cutting KF, Rogers AA, Rippon MG. (2016). The importance of hydration in wound healing: reinvigorating the clinical perspective. J Wound Care. Mar;25(3)122-130.
doi: 10.12968/jowc.2016.25.3.122. PMID: 26947692.

Powers JG, Morton LM, Phillips TJ. (2013). Dressings for chronic wounds. Dermatol Ther. 26(3), 197–206

Sibbald RG, Elliott JA, Ayello EA, Somayaji R. (2015) Optimizing the Moisture Management Tightrope with Wound Bed Preparation 2015. Adv Skin Wound Care, 28(10), 466-476

Sibbald RG, Elliott, JA, Persaud-Jaimangal R, Goodman L, Armstrong DG, Harley, C, Coelho S, XI N, Evans R, mayer DO, Zhao XIU, Heil J, Kotru B, Delmore B, LeBlanc K, Ayello EA, Smart H, Tariq G, Alavi A. (2021) Wound Bed Preparation 2021. Adv Skin Wound Care,

Sibbald RG, Woo K, Ayello EA. (2006) Increased bacterial burden and infection: the story of NERDS and STONEES. Adv Skin Wound Care, 19, 447-461

Tan ST, Dosan R. (2019). Lessons from epithelialization: The reason behind moist wound environment. The Open Dermatology Journal. 13, 34-40. DOI: 10.2174/1874372201913010034

CHAPTER 7

Chapter 7: Debridement

Chapter 11: Debridement

Authors: Erin Rajhathy, MCISc-WH, BScN, RN, NSWOC, WOCC(C); Nancy Parslow, MCISc-WH, RN, NSWOC, WOCC(C) and Mary Hill, MN, BScN, RN, NSWOC, WOCC(C).

Learning Objectives

- Describe the purpose and the mechanisms of action for six methods of wound debridement
- Identify indications, contraindications and special considerations for each method of debridement
- Determine each debridement method prerequisites to avoid potential patient harm related to each method of debridement
- Describe the roles and importance of collaboration with the interprofessional team in making debridement decisions.

Abstract

Debridement is an essential component of wound bed preparation. There can be a high level of risk to the patient, especially when performed by someone who has not completed advanced, curriculum based theoretical and practical education programs specific to wound management and debridement. Advanced knowledge and experience is required to accurately identify anatomical structures, the various tissue types, and structures that lay beneath the skin to avoid serious harm to the patient. Ability to differentiate healthy tissue from nonviable tissue is required by all health care professionals prior to performing debridement. Advanced education, both theoretical and practical, exist to provide health care professionals with appropriate training in managing wounds, care plan development and debridement decisions. Health care professionals with appropriate education and experience understand the importance of collaboration with the interprofessional team when making wound management and debridement decisions. regarding the management of wounds and debridement. In addition to proper education and experience, health care professionals should understand the risks of patient harm associated with all methods of debridement when performed in various settings.

Clinical Case

Mr. Jones is a 75-year-old man with shooting pain in his leg during his morning walk.He also injured his foot one month ago while working in the garage. A black scab formed (Figure 1) that he complains "won't go away". During your assessment, he tells you he used to smoke one package of cigarettes a day for 25 years but quit five years ago. His doctor is monitoring his blood sugar levels for diabetes and told him to avoid sugar and lose some weight, which is why Mr. Jones has started to walk every day. Is debridement appropriate for this wound? Let's find out together by considering Mr. Jones throughout this chapter

Figure 1 Hard black eschar on the heel of Mr. Jones

Introduction

The word necrosis comes from the Greek word *nékrōs* meaning dead body, or corpse. Today, necrosis refers to localized death of living tissue (Merriam-Webster, n.d.). Necrotic tissue, herein referred to as nonviable tissue, is a well-known causative factor in delayed wound healing. Nonviable tissue contains cellular and metabolic waste, senescent fibroblasts and epithelial cells, and often harbours bacteria increasing the risk of wound-related infection. Nonviable tissue may prolong the inflammatory phase of healing; thereby, delaying wound closure (Sibbald et al., 2021).

Debridement, originally defined as an unbridling or removal of damaged tissue from the wound, first appeared as a clinical term in France during the 17th century. Debridement is a core component of wound bed preparation (refer to Chapter 1 for details about wound bed preparation) and is often required to restore and further promote the process of wound healing (Harris, 2009). There are various methods of debriding wounds; however, all methods share the same goal of removing nonviable tissue, other proinflammatory components, and to enable better visualization of the wound bed (Harris, 2009; WOCN Society, 2018). Although debridement is considered by many to be a necessary step of wound bed preparation, it does come with varying levels of risk that may result in unintentional patient harm. Therefore, it is imperative for health care professionals to have the knowledge, skills, and judgment to initiate, or perform, debridement.

Nurses Specialized in Wound, Ostomy and Continence Canada (NSWOCC) Debridement: Canadian Best Practice Recommendations for Nurses (2021) highlights the importance of advanced education for all health care professionals involved in debridement, regardless of profession or discipline (NSWOCC, 2021). A competency-based education program for both advanced wound care and debridement, that contains theoretical and practical components, is strongly recommended as foundational requirements prior to engaging in debridement. In addition to a rigorous education program, it is imperative for regulated health care professionals to work within their professional scope of practice (NSWOCC, 2021). This chapter will use Mr. Jones to guide the reader through appropriate assessment parameters and considerations for the different types of debridement.

Tissue Types

The integumentary system, or skin (and its associated structures), is the largest organ of the human body and primarily serves as a physical barrier between the external and internal environments (Marieb & Hoehn, 2010). As the human body's primary method of protection, the skin's associated structures work to maintain a surface pH of 4.1 to 5.8 (Lukić et al., 2021) to stave off excess surface bacteria. In addition to impeding infectious pathogens, the skin also provides us with sensation, regulates our body temperature, and synthesizes Vitamin D. It is essential for anyone involved in any method of debridement to identify anatomical structures and know physiological processes of the skin and that which lay beneath it, as unintentional injury to structures such as muscle, tendons, and nerves may result in potential loss of function.

Assessing the process of tissue death can help the clinician determine what tissue(s) may need debriding. It is equally important for anyone authorizing or performing debridement to be able to accurately identify and separate healthy tissue from nonviable tissue. There are many different types of tissue, and within each type there may be further categories. Accurate identification of the wound bed is necessary to anticipate healing time, risk of infection (Grey et al., 2006), and develop safe and appropriate care plans. Note: Tissues and underlying structures must remain moist to maintain viability.

The 11 slides provided below

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://ecampusontario.pressbooks.pub/skinandwoundcare/?p=816#h5p-4

Epithelial tissue, or epithelium, covers the body's surface and provides boundaries between the internal and external environments (Marieb & Hoehn, 2010). Functions include protecting the surface of the wound from infective pathogens and further injury (Alhajj et al., 2020). Tissue colour can be pale pink/white islands within the wound bed in partial thickness or advancing border in full thickness wounds. Management of epithelial tissue requires protection and maintenance of adequate hydration. Observing epithelial cells at the wound edges can provide information about the quality of the wound bed. An advancing border usually indicates a reasonably healthy wound bed whereas rolled wound edges (epibole) or unattached edges indicate something is amiss and consultation with the wound specialist and interprofessional team is warranted.

Granulation tissue is required for wounds to heal by secondary intention as new blood vessels develop to form connective tissue which fills the wound during the proliferative stage of healing. Healthy granulation tissue is moist and pink to red in colour (Figure 2). Formation of healthy granulation tissue requires enough circulation to carry

oxygen and nutrients to the wound bed. If circulation is significantly impaired, or when underlying comorbidities, such as low hemoglobin are present, the granulation tissue may be pale pink (Figure 3). Unhealthy granulation tissue may appear dark or dusky in colour and bleed easily (Wound Source, 2021). In some instances, excess granulation may develop called hypergranulation tissue. This unhealthy tissue is often due to excess moisture or rising bacterial levels and should cue the health care professional to reassess the plan of care to treat the underlying cause. In fact, any tissue above the level of skin should be referred to a wound specialist (defined below).

Adipose tissue, or fat, is most often found in the subcutaneous layer of skin and is usually yellowish/white in colour (except for newborns when it is brown) and globular. It provides the body with insulation and cushioning and contains various structures including blood vessels, nerves, and lymphatic vessels (Albaugh & Loehne, 2010). The colour will change to a darker yellow if adipose tissue becomes damaged (Figure 4).

Fat pads located in the feet, often can be confused with slough therefore accurate identification of the underlying structure is imperative, especially prior to debridement.

Muscle supports the skeletal structure to enable functional body movement. Healthy striated muscle is bright red in appearance (Figure 5) related to the abundance of vasculature throughout and has a firm, rebound feel on palpation (Albaugh & Loehne, 2010). Asking the patient to contract the muscle in and around the wound can confirm muscle is in fact exposed. Like fascia, healthy muscle can be inappropriately identified as granulation tissue, when assessed by someone without advanced education and preceptorship in wound management, increasing the risk of significant harm and unintentional debridement.

Fascia is a dense connective tissue adjoining muscle and organs and can be found directly beneath the subcutaneous layer. It provides support for skin, muscles, tendons, organs, and ligaments by providing shape and reducing friction during movement. It is primarily collagen and therefore is shiny and white in colour and often appears as fibrinous bands or sheath (Figure 6). Unintentional debridement of fascia significantly increases the risk of infection, as microbes spread easily along this tissue type (Albaugh & Loehne, 2010), and creates friction in areas where there should be no friction such as between muscle and other organs or structures. Fascia can very easily be mistaken as fibrinous tissue or slough (Figures 5 and 6) by an untrained or novice eye and therefore should be managed in consultation with a wound specialist and collaboration with the interprofessional team.

Tendon or ligament is a tough band of tissue that connects two other tissues together (i.e., bone to muscle or bone to bone, respectively). Its colour can range from white to yellow depending on the level of hydration. Healthy tendons are shiny and white (Figure 7). When damaged, or dehydrated, it darkens to a yellowish colour as it begins to die. Therefore, maintaining moisture in tendons is crucial. Tendons can be located very close to the skin's surface in some areas (Figure 8) and are commonly damaged during sharp debridement by a self-taught or self-educated health care professional (Harris, 2009). Like muscle, when asking the patient to move the associated limb the tendon can be seen to contract in the wound bed.

Nerves are grayish-white in colour and located within the subcutaneous tissue layer placing them at high risk for unintentional injury. Nerves are required for internal communication and motor function, so when cut or damaged, muscle and motor function fails, and touch sensation is lost.

Bone is white or pale yellow (Figure 3) and hard on palpation, when healthy. Bone is often missed in the visual assessment therefore palpating with a gloved finger or gently probing the wound base with the wooden end of a cotton tipped applicator stick to confirm the hard bone confirmation. When a patient's wound reveals exposed bone and infection is suspected, especially in diabetic foot ulcers, a referral for further evaluation and treatment to a wound care team may be needed for consideration of systemic antibiotics. Management includes promoting the growth of granulation tissue and maintaining a moist and clean environment to prevent infection (Young, 2015). Only specially trained health care professionals with surgical skills including surgeons and podiatrists should be debriding bone.

Blood vessels are found throughout the body and include both the arterial and venous systems. Knowing the anatomy of the vascular system is extremely important as wounds can develop in areas over large arteries making

debridement risky. Wounds located over major arteries should not be debrided outside of a well-controlled setting with access to appropriate resources including a vascular surgeon.

Types of Necrotic Tissue

Nonviable tissue is a term used collectively to describe different types of necrotic tissue. Necrotic tissue can be any tissue that is no longer viable due to inadequate blood supply. When necrotic tissue hardens and becomes black, it is referred to as hard black eschar (Figure 9), and as autolysis occurs the texture and colour changes and it becomes a soft brown eschar (Figure 10), then further transitions to adherent grey/yellow slough (Figure 11) and loosely adherent slough (Figure 12).

Eschar, black and brown, and can be hard/dry or soft/wet. If the wound is determined to be healable, debridement may be indicated (refer to Chapter 1 for descriptions of healable, nonhealable) if the wound is considered nonhealing or nonhealable, debridement may be contraindicated and therefore the best method of management includes painting the wound and periwound skin with povidone iodine and covering it with a dry gauze-based dressing. Inappropriate debridement of stable eschar, especially on a heel, can cause infection, amputation, and even death.

Slough is often the term used by novice health care professionals to describe anything other than granulation tissue or eschar. Slough is moist, soft, solid, or stringy dead tissue primarily composed of leukocytes, macrophages, fibroblasts, and other apoptotic cells. In addition to apoptotic cells, it also commonly contains bacteria and biofilms.

Prolonged presence of nonviable tissue in the wound bed inhibits the normal healing trajectory by maintaining an inflammatory state. Inability to accurately identify anatomy and structures results in inappropriate debridement and risk of harm to the patient. When planning treatment, it is important to remember different tissue types can appear similar; however, the underlying etiology may be unrelated and therefore require a completely different method of care (Young, 2015). Before debriding, stop and think.

Debridement Methods

DEBRIDEMENT

The most appropriate method of debridement is largely dependent on the level of nonviable tissue in the wound; however, the decision to debride and the method used must align with the goals and preferences of the patient. Many factors should be considered when ordering or performing debridement, including context, cost, and system factors.

The optimum debridement modality

Debridement is intended to replicate and facilitate a natural bodily function. In most cases, when someone inadvertently cuts themselves, the normal phases of wound healing occur and wound closure is achieved in a timely fashion. A scab forms while proteolytic enzymes in wound fluid break down the connective tissue until the scab falls off, and clean slightly pink epithelium remains and continues to heal by forming scar tissue to close the wound increasing tissue strength and eventually softening and may disappearing over time.

Debridement is thought to restore natural processes in stalled wounds, so normal wound healing can occur. The medical approach to debridement is not new. We have known for centuries that honey appeared to be helpful even if its autolytic and enzymatic debriding action was not understood at the time. To date there is a lack of persuasive evidence for use of honey to debride wounds however in some unique cases where all factors are considered there may be an appropriate use.

In the case of Mr. Jones's foot, the health care professional must first follow wound bed preparation concepts. This is described in detail in Chapter 1. First, aim to treat the underlying cause of the wound, address patient-centred concerns, and establish healability. Patient assessment, including vascular supply using ankle-brachial pressure index (ABPI), audible handheld Doppler or imaging for lower limbs, is a foundational prerequisite for debriding wounds on the lower extremities. If determined to be healable, clinicians may now begin to consider the best approach for managing his wound.

Black eschar presents a particular obstacle as it impedes visualization of the wound bed. The first likely task is to determine that the wound is healable, obtain patient consent and then utilize a suitable method of debridement to allow visualization of the wound bed, wound edges, and any exposed underlying structures. Table 1 provides guidance regarding factor(s) that require consideration for each debridement method. Autolytic debridement is considered the slowest and least expensive while active surgical debridement, recommended to be performed by a surgeon in an operating room, is rapid; although, it is likely the most expensive intervention.

Table 1 Comparative desirability of factors across the six modalities of debridement for a healable wound

	Autolytic	Mechanical	Enzymatic	Biological	CSWD	Surgical
Speed	6	3	5	4	2	1
Selectivity	1	6	2	3	4	5
Pain	1	5	2	3	4	6
Exudate	5	3	4	6	2	1
Infection	6	3	5	2	4	1
Cost	4	4	2	3	5	6

Note. This table compares factors across six debridement methods where 1 is most desirable and 6 is least desirable. CSWD = conservative sharp wound debridement.

Alone, Table 1 does not provide sufficient information to proceed with debridement. Table 2 provides the definition, indications, contraindications, precautions, advantages, and disadvantages for six methods of debridement included in this chapter. All forms of wound debridement pose potential risk for the patient; therefore, access to an interprofessional wound care team is crucial for consultation to avoid making potentially dangerous decisions. Although not well defined, debridement (and care below the dermis) is a controlled act in many countries and each health care professional is accountable should unintentional negative outcomes occur. Important factors that require consideration regarding an appropriate debridement method also includes safety of the setting, availability of appropriate supplies and equipment, and the availability of emergency medical intervention should there be potential unintended outcomes for the method. Some wounds should not be debrided until the interprofessional team has been consulted and agreed upon the wound etiology and plan of care. Prior to initiating any form of debridement, it is imperative to obtain and document informed patient consent.

- What results would you need to help inform your treatment plan?
- In the case of Mr. Jones, what assessment parameters are needed to determine if debridement is appropriate?
- What effect would each method of debridement potentially have on Mr. Jones's wound?

List 1 *Summary of the six different debridement modalities*

Autolytic

- **Definition:** the body's natural process for debridement; further facilitated by moisture-donating or moisture-retentive dressings that activate the body's enzymes present in wound exudate to promote the destruction of nonviable tissue.
- **Indications:** healable, uncomplicated wounds with minimal amounts of nonviable tissue.

- **Contraindications**: sensitivity to products, patients with peripheral arterial disease, ischemic wounds, and diabetic foot ulcers; patients who are palliative or end-of-life where healing is not the goal; and where acute infection or sepsis is suspected.
- **Advantages**: is selective; activates the body's natural process; readily available and inexpensive; simple application; minimal training and skill required; suitable for all care settings; not usually painful
- **Disadvantages**: slowest form of debridement; risk of infection due to anaerobic bacteria; risk of maceration; increased product utilization and nursing time.
- **Other considerations**: amount of exudate determines dressing; periwound protection required.

Mechanical

- **Definition**: removal of nonviable tissue through the application of external force.
- **Indications**: healable wounds containing large amounts of slough or infected chronic wounds.
- **Contraindications**: painful wounds or in patients with bleeding disorders, peripheral arterial disease, ischemic wounds, persons with diabetes; patients who are palliative or end-of-life.
- **Advantages**: rapid process for the removal of large amount of slough; may disrupt biofilm; some methods are readily available; suitable for most settings.
- **Disadvantages**: nonselective; can damage healthy tissue; can be painful and cause bleeding; ineffective with dry eschar; time consuming; cost related to frequent dressing replacement.
- **Other considerations**: many methods including dressings and monofilament pad.

Enzymatic

- **Definition**: introduction of proteolytic enzymes to the wound to dissolve nonviable tissue.
- **Indications**: healable woun**Biological**ds containing moist nonviable tissue and partial thickness wounds.
- **Contraindications**: rare sensitivity to collagenase; dry necrotic eschar; wounds where acute infection or sepsis are suspected.
- **Advantages**: selective, nontraumatic debridement; suitable for all care settings; minimal training required; fast application; usually not painful.
- **Disadvantages**: requires a prescription in most countries; daily application; if no coverage, can be costly; is slower than CSWD; risk of maceration so requires periwound protection.
- **Other considerations**: inactivate by metal ions.

Biological

- **Definition**: application of sterile, medical-grade larvae into the wound to digest soft nonviable tissue and bacteria to promote wound healing by softening and liquefying nonviable tissue.
- **Indications**: healable wounds containing moist, nonviable tissue. Suitable when surgical debridement is not an option or when wounds are infected.
- **Contraindications**: patients with allergies to egg, soybean, or fly larvae; not to be used on facial wounds, upper gastrointestinal wounds, open vessels or near major vessels, deep wounds, cavities, or sinus tracts; patients on anticoagulant therapy and where the position/location of the wound would

affect survival of larvae.

- **Advantages**: selective, rapid form of debridement; assists in the removal of biofilm; inexpensive due to short length of time required; can remain in place for 4 to 5 days.
- **Disadvantages**: increased cost compared to autolytic; requires an order from a prescriber; medical grade required and not always available; time consuming application.
- **Other considerations**: pain may present in ischemic wounds; bleeding can occur; do not use occlusive dressings over larvae to ensure viability.

CSWD

- **Definition**: removal of clearly identifiable, nonviable tissue including senescent cells and bacteria using sharp instruments including sterile scalpels, curettes, or scissors and forceps (does not extend to bleeding tissue).
- **Indications**: healable wounds containing nonviable tissue including callous.
- **Contraindications**: where there is inadequate pain control, impaired perfusion, exposed bone, tendons, or ligament; patients who are immunocompromised, on anticoagulant therapy, or have bleeding disorders; wounds in temporal areas, on the neck, axilla, groin, or other areas close to major blood vessels, nerves, and tendons; in patients with advanced age, multiple comorbidities, or in those who are palliative or near end-of-life; should not be performed by anyone without advanced education, training, knowledge, skills, and judgment or where there is no access to sterile equipment.
- **Advantages**: selective and rapid form of debridement; best used in combination with other methods; can be performed at the bedside (see section on infection control and practice setting); cost effective.
- **Disadvantages**: requires performance by only those with advanced training; higher risk of complication; setting may not be suitable; increased risk of bleeding, infection, and pain; sterile equipment required.
- **Other considerations**: requires a sterile field and should only be done by a health care professional with advanced education and training; requires access to safe disposal of sharps.

Surgical

- **Definition**: may include viable and nonviable tissue and most commonly performed by a surgeon under sterile conditions with sedation or anesthesia.
- **Indications**: healable wounds with extensive nonviable tissue, where there is need to extend into viable tissue, or where urgent debridement is needed for life or limb threatening infection good vascular flow exists.
- **Contraindications**: patients with advanced age, multiple comorbidities, poor general health, palliative, or near end-of-life, those on anticoagulant therapy, with bleeding disorders, or inadequate tissue perfusion; lack of an experienced surgeon.
- **Advantages**: selective; very rapid; stimulates the healing process; removes biofilm and infected tissue.
- **Disadvantages**: risk of surgical complications may warrant admission to hospital; requires anesthesia; requires health care professional able to perform surgery.
- **Other considerations**: risk of postoperative bleeding and pain.

INTERPROFESSIONAL TEAM COLLABORATION IN DEBRIDEMENT

Prior to initiating debridement, a comprehensive assessment of the patient and the wound should be conducted. Assessment includes consultation with various interprofessional team members to ensure debridement is appropriate and to verify the most appropriate method of debridement to minimize potential risks of harm associated with the debridement.

Consultation with the interprofessional team ensures the patient will receive the optimal method of debridement at the appropriate time. In some situations, it is advisable to avoid debridement and leave nonviable tissue intact to dry.

Decisions about debridement should not be determined in isolation of other health care professionals. A collaborative team approach includes dialogue with other professionals with advanced knowledge, skills, and experience in debridement to provide valuable insight to ensure patient safety, optimal wound outcomes, and efficient use of resources.

Prior to initiating and performing debridement, it is important to:

- determine when a referral is recommended
- solicit the help of others on your team who have expertise in performing debridement
- connect with your team members
- ensure appropriate follow up and monitoring is in place post procedure
- assess potential risks associated with the procedure.

Other professionals that may have advanced education, knowledge, training, and experience in debridement described by their scope of practice may include specialized nurses, nurse specialized in wound, ostomy, and continence (NSWOC), physiotherapists, chiropodists, podiatrists, and physicians, including vascular surgeons.

What members of the interprofessional team should be consulted for Mr. Jones?
Other pertinent questions to ask yourself about Mr. Jones include:

- How would you connect with your team?
- What is Mr. Jones' health status, wound healing potential, and wound goals?
- Who can help you determine the cause of his wound?
- Is debridement appropriate for this wound? If yes, what method is most appropriate? If not, how do you plan to keep it dry and free of infection?

Special Considerations for Lower Extremity Wounds

Patients with multiple comorbidities present complex challenges increasing the risks associated with debridement. Wound healing is anticipated when there is adequate perfusion to the affected area and when underlying causative factors are addressed. Patient risk factors such as nutritional status, some medications, smoking, and chronic disease processes should be considered during the patient assessment and optimized to support wound healing.

Debridement is recommended for healable wounds. Chronic diseases such as diabetes mellitus (DM) and peripheral arterial disease reduce the level of perfusion to the lower extremities thereby minimizing the delivery of oxygen and nutrients required for wound healing. Any method of debridement (including use of a semi-occlusive dressing) on a lower limb without adequate perfusion can have devastating effects including sepsis, amputation, and death.

Close monitoring is required for patients with DM and peripheral vascular disease due to risks for slow wound healing, infection, and rapid wound deterioration.

Factors that influence wound healing in a patient who has prolonged elevated glucose levels related to diabetes include:

- Stiffening of the arteries (calcification) rendering them noncompressible resulting in inaccurate elevated Ankle Brachial Pressure Index (ABPI) readings (consider audible handheld Doppler test);
- atherosclerosis (narrowing of arteries), reducing perfusion of oxygen and nutrients especially in the small capillaries of the lower extremities which slows wound healing;
- decreased perfusion as glucose replaces the oxygen and nutrients delivered by red blood cells;
- decreased white blood cell function, decreasing the efficacy of the immune system resulting in increased the risk of infection; and
- progressive neuropathy from damaged nerves causing numbness. Loss of sensation decreases the ability to feel pain, increasing the risk for traumatic injury; delays wound detection; and prolongs implementation of required interventions, especially on the foot.

Peripheral artery disease (PAD), defined as atherosclerotic occlusive disease (narrowing of arteries) of the lower extremities, results in reduced blood flow and impaired oxygen and nutrient delivery to the tissues resulting in impaired wound healing. Peripheral arterial disease increases the risk of thrombosis causing vessel occlusion and increasing the potential for lower extremity amputation.

Peripheral arterial disease is more severe and diffuse in persons with DM as increased blood viscosity and fibrinogen production increases plaque development. Smoking also increases the risk for PAD.

The most common symptom of PAD is claudication characterized by cramping or aching pain in the calves, thighs, or buttocks when ambulating but relieved with rest. Lower limb assessment, including an ABPI, may be unreliable and computed tomography angiography (CTA) may be required to confirm PAD.

- Lower limb assessment (LLA) is mandatory for all wounds located on the lower limb or foot regardless of etiology
- Pain history and structure of the limbs should be included in the assessment
- Assess for neuropathy and loss of protective sensation (LOPS) using a 10g monofilament
- The LLA should include a visual inspection to differentiate signs of ischemia; assessment of pulse strength, regularity, and waveform, capillary refill (or toe brachial pressure index, audible handheld

Doppler and photoplethysmography (PPG), if available)

- Presence of pulses in the foot alone is not a reliable indicator of perfusion status
- Consider the potential benefit of a referral to a vascular surgeon for bilateral lower extremity CTA and to review options for revascularization (NSWOCC, 2021)

- What do you think a LLA or CTA would reveal about Mr. Jones?
- What are his risk factors for PAD and how do your findings impact your decision about the plan of care?
- Does Mr. Jones require a referral to the interprofessional team for further assessment regarding debridement decisions?

Limbs without adequate perfusion should NOT be debrided until the patient has seen a vascular surgeon. This includes avoiding the use of moist wound healing using autolytic debridement method.

Debridement of any kind is contraindicated for adherent dry eschar on heels, ischemic limbs, toes, and digits. These wounds should be kept dry, free from moisture, and debridement avoided unless the eschar becomes unstable or there is evidence of infection. In these cases, the black eschar caps on heels for example, can serve as a protective barrier from bacteria entering. In some cases, if there is borderline vascular supply, the wound may still heal underneath the black cap over time and eventually the cap will fall off. Wounds of this type should be referred to the interprofessional team for further assessment. An urgent referral for surgical debridement in a controlled setting is recommended for unstable eschar when acute infection or sepsis is suspected and if aligned with the goals of care (NSWOCC, 2021).

Debridement Best Practices

PRACTICE SETTING AND INFECTION CONTROL

Debridement options may be limited in the home environment due to safety concerns such as cleanliness, lighting, availability of additional personnel and the risk of contamination due to pets. To optimize safety home care patients can attend a home care wound clinic for the more invasive types of debridement.

Environment and infection control are two very important considerations when determining the type of debridement, particularly CSWD. All organizations involved in the delivery of wound care in any health care sector including acute care, long term care, primary care, and home and community care should have debridement resources and policies available based on current evidence. The decision to debride should be made only after a thorough assessment of the patient, wound, and environment to ensure the setting is appropriate with infection control measures in place. Safety, infection control, and cleanliness of the surrounding environment should factor into the decision when assessing patients in their home or in the community. Specifically, CSWD poses the greatest risk of harm to patients: it is therefore important the environment is conducive to performing the debridement safely both for the patient and the regulated health care professional. The home environment lacks resources and may be unpredictable; therefore, CSWD is strongly encouraged to be performed in a community or outpatient clinic setting. If this alternative cannot be accessed, CSWD should only be performed in the home by highly skilled and experienced health care professionals.

Consider the following during the assessment to determine if the setting is safe to perform the debridement modality.

- Prior to the initiation of CSWD, determine what resources and personnel are available during and post procedure to manage and monitor for potential adverse events such as bleeding, pain, anxiety, damage to underlying structures, or loss of consciousness. Rural areas tend to pose the greatest risk in managing adverse effects to debridement due to the remote locations.
- Is the patient's environment safe to perform the procedure? Look for cleanliness, adequate lighting, and ability for the patient to be positioned in such a way as to ensure visibility of the wound, patient comfort, and proper body mechanics for the health care professional performing debridement.
- Ensure you have adequate uninterrupted time available to conduct the required assessments and perform the procedure.
- Ability to maintain a clean or aseptic environment is crucial to maintain infection control practices and avoid cross-contamination of the wound. Availability of potable water, unpredictable pets, pet hair, bed bugs, cockroaches and personal hygiene of the patient can impact contamination of the wound.
- Assess for the type of sterile equipment required such as single-use, disposable supplies when debriding in the patient's home.
- Ensure appropriate supplies and equipment are available to prevent infection and cross-contamination

of the wound, patient, significant other, and health care professional.

- Ensure there are available methods for the safe disposal of contaminated materials including, but not limited to, biological waste, contaminated dressings, sharps, and larvae.

When you arrive at Mr. Jones's house to assess his wound, you notice his house is cluttered and there are dirty dishes and empty fast-food containers in the kitchen. The house is dirty and clumps of pet hair are everywhere. The lighting is poor as the blinds are closed over the windows and appear bent and broken. Mr. Jones is apologetic about the state of his house and mentions his partner passed away 6 months ago he was the one who cooked and cleaned the house. When assessing Mr. Jones's wound, using the flashlight on your phone, you see he has wrapped his foot with paper towel and secured it with duct tape.

After assessing Mr. Jones's home environment, where is the most appropriate setting to perform wound care on Mr. Jones? What type of assessments need to be conducted to assess the cause of pain? What would you be concerned about with this information?

REASSESSMENT OF DEBRIDEMENT

It is the responsibility of the regulated health care practitioner to ensure a follow-up assessment is scheduled to reassess debridement outcomes, patient response and to perform additional serial debridement, if required. While this chapter focuses on debridement specifically, assessment parameters identified here should only come after a comprehensive holistic patient and wound assessment has been conducted to determine continued treatment appropriateness. Using a validated wound assessment tool can aid the practitioner in determining wound progression, or lack thereof, and frequency for serial debridement. As tissue changes throughout the debridement process, reassessing for the most appropriate method of debridement should be done at each visit. Considerations when choosing a method of debridement may include, but are certainly not limited to, speed, selectivity, pain, exudate, infection, and cost (see Table 1). Therefore, it is imperative these factors are assessed at each visit pre- and post- debridement and at regular intervals by the authorizer. Since debridement poses a risk to the patient, especially when on the lower limbs, it is essential for documentation to be prescriptive and clear to avoid any errors that could potentially be devastating.

When assessing nonviable tissue, one must consider the type, colour, amount, and adherence to determine whether the method of debridement is impacting the wound positively and meeting the goals of care instituted by the interprofessional team and the patient (HSE, 2018; Young, 2011). The type of nonviable tissue will change in a specific order with effective mechanical, autolytic, and enzymatic methods of debridement. Progression of

properly debriding tissue advances from hard black eschar to a very loosely adherent white/yellow slough (Figures 9, 10, 11, and 12). Likewise, adherence of tissue should become weaker as tissue progresses through the natural debridement process.

Reassessment should consider the time required between visits to ensure the method of debridement has sufficient time to demonstrate effect. If no change is evident, revision to the plan of care is required. For wounds deemed nonhealing, where surgical interventions or modifiable barriers are addressed, it is appropriate to discuss, with the interprofessional team, whether debridement would now be indicated.

CANADIAN DEBRIDEMENT BEST PRACTICE RECOMMENDATIONS

The development of best practice recommendations guides consistent and standardized wound debridement practices for health care professionals. They have the potential to positively influence patient safety related to all methods of debridement across the continuum of care and to be circulated and implemented widely at all professional levels. Health care administrators in a variety of health care settings should consider using these types of documents to further define debridement and support safe and effective high-quality patient care.

The 12 best practice recommendations for nurses in Canada are adapted below in Table 3 (NSWOCC, 2021, Appendix 2). Refer to the original document for the levels of evidence and applicable individual references. There are 12 recommendations and accompanying rationales developed by a national task force of expert Canadian nurses. Regulated health care professionals other than nurses may derive some useful information from the discussion about the different debridement modalities and considerations for the decision-making process. [Add links to BPG, QRG]

Three recommendations are health system-related, four are nursing-related, and five are patient-centred. The scope of practice, organizational recommendation and environmental assessment concern the health care organizational policy and procedures as foundational prerequisites for health care professionals to have the mandate to debride patients. Nine of the recommendations are directly related to assessment parameters prior to initiating or performing any method of debridement and one recommendation about reassessment post debridement.

Table 3 *Adapted best practice recommendations*

Recommendation	Category	Description
1. Scope of Practice	Nursing	**As a prerequisite**, all classes of nurses must work within the controls of federal and provincial/territorial legislation, regulatory bodies, organizational policies, and individual competency. Nurses are accountable for knowing their national code of ethics and expectations, respective provincial/territorial practice standards and guidelines, their employer's policies, procedures, and operational guidelines, and their competence and limitations for all methods of debridement.
2. Organizational recommendations	Health system	**As a prerequisite,** employers/organizations should ensure all policies and procedures, or operational resources related to debridement, including the type/method of debridement each class of nurse is authorized to initiate or perform. This includes the specific level of education, training (including mentorship), and experience required to perform the method of debridement.
3. Prior to initiation of debridement	Nursing	**Before initiating** any method of debridement, the nurse must: – be knowledgeable about the different types of debridement and the level of skill and training required to perform each method;- be aware of their own attitudes, limitations, skills, and competency;- recognize the indications, precautions, and contraindications for the various debridement methods;- evaluate the patient's health status and wound goals, wound assessment findings and wound healing potential to determine if a consultation with the interprofessional team would be beneficial to confirm decisions regarding debridement; – and be able to identify, manage and mitigate potential complications and adverse events, including anxiety, pain and bleeding.
4. Education & preceptorship	Nursing	**Before initiation** or performing debridement, successful completion of a recognized wound management program and an additional competency-based debridement module is highly recommended. In addition, mandatory clinical preceptorship is strongly advised prior to independently performing CSWD. Other forms of debridement equally require education and preceptorship, however, the need for a preceptor would depend on the level of risk associated with the method.
5. Patient assessment	Patient	**Before initiation** of debridement the nurse must conduct a comprehensive patient assessment.
6. Wound assessment	Patient	**Before initiation**, a comprehensive wound and periwound skin assessment, using a validated assessment tool is recommended to assist the nurse to identify the wound etiology, and identify barriers to healing. Debridement of any kind is contraindicated for stable dry eschar on heels, ischemic limbs, toes, and digits. An urgent referral for acute surgical debridement is recommended when acute infection or sepsis is suspected and when aligned with goals of care.
7. Environmental assessment	Health system	Assess the patient's environment to ensure the setting is safe to perform the debridement modality. **Before initiation** of CSWD resources and personnel must be available to manage potential adverse events.
8. Wound healing goals	Patient	**Before initiation** of any method of debridement it is essential to establish realistic goals that align with the patient's goals, including concerns and cultural traditions and the goals for wound healing (healing, nonhealing, nonhealable).
9. Informed consent	Patient	**Before initiation**, informed consent should include legal and ethical considerations, organizational requirements, and should be obtained for all forms of debridement. The method used to obtain informed consent and the patient's response must be documented in the patient's record.
10. Product knowledge	Nursing	**Before initiation**, nurses must be knowledgeable about wound care products and therapies used both above and below the dermis before using them in practice. Off-label use of products is not permitted.
11. Reassessment	Patient	**Thereafter**, regular reassessment of the patient and wound is imperative.
12. Cost-effectiveness	Health system	**Before initiation,** consider all associated costs before selecting the method of debridement, including costs to the health care system, the employer or organization, the nurse, the patient/significant other.

Clinical Pearls

Certain types of debridement such as autolytic and mechanical have been part of wound care practice for many decades and, although they are frequently initiated under the direction of a wound care specialist or physician, they can be routinely performed by a variety of regulated health care professionals including nurses, physiotherapists, others and in some instances the patient or caregiver (McNichol et al., 2021). Although all forms of debridement pose potential risks to the patient, some have a greater risk of patient harm such as CSWD and therefore should only be performed by a wound care specialist with advanced wound care training, additional debridement education with mentorship, and demonstrated competency in the skill.

1. An advanced curriculum based wound care course is highly recommended for regulated health care professionals who practice wound care regularly in their practice. Because CSWD has a high level of risk of patient harm, the completion of an additional debridement educational program and clinical preceptorship to gain competency in debridement skills is strongly recommended.
2. Assess your facility/employer/governing body policies, procedures, and directives for debridement, especially CSWD. Know and outline your scope of practice, as some more aggressive forms of debridement may be restricted in some jurisdictions for certain health care professionals.
3. Knowledge of wound healing processes; comprehensive patient assessment parameters; mechanism of action for each method of debridement and associated indications, contraindications, and precautions; wound care dressings; and when to refer are crucial when managing a patient with a wound.
4. Be aware of your own attitudes, limitations, skills, and competency is essential to providing safe and effective wound care and any form of debridement.
5. Debridement of any kind should NOT be performed without a firm diagnosis or until the cause of the wound is determined. If you do not know the etiology, **STOP** and consult the interprofessional team.
6. When in doubt about whether to initiate a form of debridement, **DON'T.**
7. **DO** collaborate with the interprofessional team who specialize in wound management and debridement.
8. Where able, all wounds should be assessed at every dressing change and at minimum weekly to evaluate the impact of the chosen debridement method and overall patient response.
9. All forms of debridement can carry high risk when initiated inappropriately; however, CSWD is considered highest risk and can significantly harm the patient, even when performed by health care professionals with appropriate knowledge, skills, and judgment.
10. If you are unable to accurately identify the tissue types in the wound or if tissue protrudes from the wound, immediately refer to the interprofessional wound care team.
11. Caution should be considered with signs and symptoms of infection of the wound as debridement of any type may be contraindicated until the wound is assessed and debridement is deemed appropriate by the interprofessional wound care team.
12. Special care and consideration are required for patients with multiple comorbidities as there is increased risk of impaired healing ability and harm with debridement. This population of patients should be referred to an interprofessional wound care team.
13. Debridement of any kind is contraindicated for adherent dry eschar on heels, ischemic limbs, toes, and digits.

References

Albaugh, K., & Loehne, H. (2010). General management principles in patients with wounds. In J. M. McCulloch & L. C. Kloth. (4th ed.). F. A. Davis.

Alhajj, M., Bansal, P., & Goyal, A. (2020). Physiology, granulation tissue. StatPearls. https://www.ncbi.nlm.nih.gov/books/NBK554402/

Bates-Jensen, B. M., & Serena, T. E. (2012). Management of necrotic and nonviable tissue. In C. Sussman & B. Bates-Jensen. (4th ed.). Wolters Luwer | Lippincott Williams & Wilkins.

Debridement Best Practice Recommendations Quick Reference Guide. Nurses Specialized in Wound, Ostomy and Continence Canada. 2021 http://nswoc.ca/wp-content/uploads/2021/09/Debridement-BPR-Quick-Reference-Guide-copyrighted.pdf

Grey, J. E., Enoch, S., & Harding, K. G. (2006). Wound assessment. *British Medical Journal, 332*(7536), 285-288. https://doi.org/10.1136/bmj.332.7536.285

Harris, C., Coutts, P., Raizman, R., & Grady, N. (2018). Sharp wound debridement: patient selection and perspectives. Chronic Wound Management and Research, 5, 29-36. https://doi.org/10.2147/CWCMR.S146747

Harris, R. J. (2009). The nursing practice of conservative sharp wound debridement: Promotion, education and proficiency. *Wound Care Canada, 7*(1), 22-30.

Health Service Executive (HSE). National wound management guideline 2018. https://healthservice.hse.ie/filelibrary/onmsd/hse-national-wound-management-guidelines-2018.pdf

Lukić, M., Pantelić, I., & Savić, S. (2021). Towards optimal pH of the skin and topical formulations: from the current state of the art to tailored products. *Cosmetics, 8*, 69. https://doi.org/10.3990/cosmetics8030069

Marieb, E. N., & Hoehn, K. (2010). Human anatomy and physiology (8th ed.). Pearson Benjamin Cummings.

McNichol, L., Ratliff, C., & Yates, S. (2021). *Wound, Ostomy and Continence Nurses Society Core Curriculum: Wound Management*. (2nd ed.). Wolters Kluwer.

Merriam-Webster. (n.d.). Necrosis. Available at: https://www.merriam-webster.com/dictionary/necrosis

Nurses Specialized in Wound, Ostomy and Continence Canada. (2021). Debridement: Canadian Best Practice Recommendations for Nurses. (1st ed.). [internet] http://nswoc.ca/wp-content/uploads/2021/05/NSWOCC-Debridement-Best-Practice-Recommendations-April-2021.pdf

Position Statement: Nurses & Debridement. Nurses Specialized in Wound, Ostomy and Continence Canada. (2021) [internet] http://nswoc.ca/wp-content/uploads/2021/05/NSWOCC-Debridement-Position-Statement-May2021.pdf

Sibbald, R. G., Elliott, J. A., Persaud-Jaimangal, R., Goodman, L., Armstrong, D. G., Harley, C., Coelho, S., Xi, N., Evans, R., Mayer, D. O., Zhao, X., Heil, J., Kotru, B., Delmore, B., LeBlanc, K., Ayello, E. A., Smart, H., Tariq, G., Alavi, A., & Somayaji, R. (2021). Wound Bed Preparation 2021. *Advances in Skin & Wound Care*, *34*(4), 183–195. https://doi.org/10.1097/01.ASW.0000733724.87630.d6

Wound Ostomy and Continence Nursing Society. Wound, Ostomy and Continence Nursing: Scope and Standards of Wound Ostomy Continence Practice, 2nd Edition. An Executive Summary. *J Wound Ostomy Continence Nurs*. 2018;45(5):369-387. https://doi.org/10.1097/WON.0000000000000438

Wound Source. (2021). Chronic wound management: types of wound tissue. Available at

https://www.woundsource.com/blog/chronic-wound-management-types-wound-tissue#:~:text=Unhealthy%20granulation%20is%20dark%2C%20dusky,the%20normal%20wound%20bed%20surface.

Young, T. (2011). Reviewing best practice in wound debridement. *Practice Nursing, 22*(9), 488-92. https://doi.org/10.12968/pnur.2011.22.9.488

Young, T. (2015). Accurate assessment of different wound tissue types. *Wound Essentials, 10*(1), 51-54. Retrieved from https://www.woundsme.com/uploads/resources/content_11581.pdf

Self-Check

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://ecampusontario.pressbooks.pub/skinandwoundcare/?p=1031#h5p-5

CHAPTER 8

Chapter 8: Venous Leg Ulcers

VENOUS LEG ULCERS

Authors:

- Dr. Robyn Evans BSc MD CCFP FCFP
- Cathy Burrows RN, BScN, MScCH (Wound Prevention & Care)

Learning Objectives

1. Review wound management strategies for patients with venous leg ulcers
2. Identify patient venous leg ulcer concerns
3. Assess appropriate treatment and management options for venous leg ulcers

INTRODUCTION

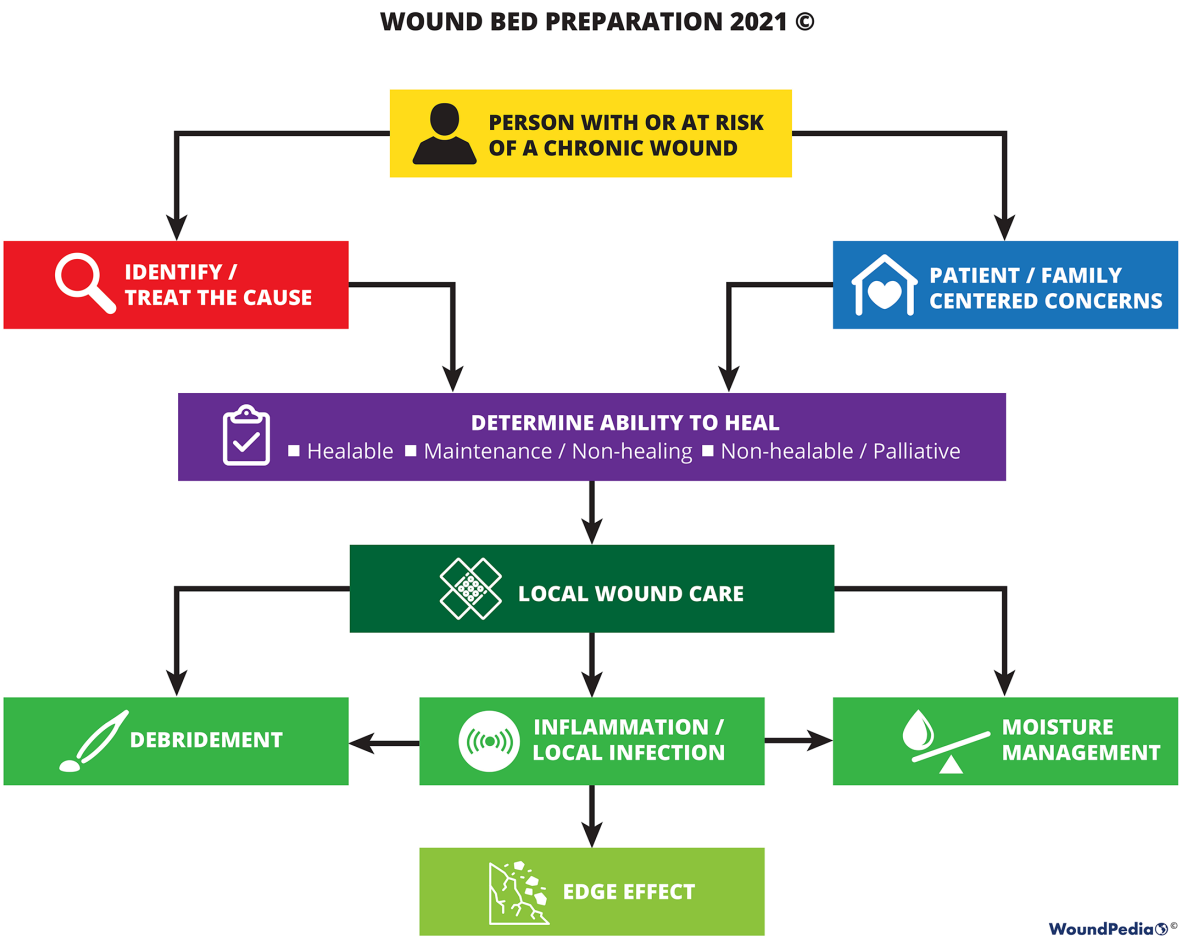
Venous leg ulcers (VLUs) are the most severe manifestation of chronic venous disease (CVD). Due to their chronic nature, high recurrence rate, and slow healing time, VLUs account for 80% of all leg ulcers seen in patients with CVD (Nicolaides, 2020). VLUs impose a heavy socioeconomic burden on patients' quality of life and have a major impact to the healthcare system due to the cost and duration of care.

This chapter will discuss the diagnosis, treatment and management of VLU's using Wounds Canada Best Practice Recommendations for the Treatment and Management of Venous Leg Ulcers (Evans et al., 2019), Wound Bed Preparation 2021 (Sibbald et al., 2021) and expert opinion.

Venous leg ulcers are chronic with high recurrence rates that pose a challenge for clinician management in the most efficient and cost-effective manner. Accurate diagnosis and treatment involves incorporating the principles of wound bed preparation to address moisture management and bioburden while addressing the cause and patient centred concerns. Further consideration specific to venous disease requires the use of compression therapy along with other medical and surgical options.

The Wound Management Cycle and the Wound Bed Preparation Paradigm (Figure 1) are practical guides to assist clinicians treating and managing VLU's following a logical and systematic care plan that is customized to meet patient-centred concerns (Evans et al., 2019).

Figure 1: Wound Bed Preparation Paradigm 2021 (Sibbald et al., 2021). Used with permission from WoundPedia



Used with permission from WoundPedia 2021

Treating the Cause

TREATING THE CAUSE

Assessment

The assessment of venous leg ulcers requires a comprehensive history and physical examination to elucidate symptoms and signs for both venous and arterial disease. It is recognized that arterial disease co-exists in about 25% of cases (O'Donnell, 2014). Evaluation of the arterial system is important to assess the healing potential as well as the type and strength of safe compression application. The pathophysiology of venous leg ulcers is associated with sustained venous hypertension due to chronic venous insufficiency (CVI). Return of fluids from the lower extremity occurs by movement from the superficial veins through the perforators to the deep venous system and back to the right side of the heart.

This chapter concentrates on the venous system, however there is additional evidence for the contribution of the lymphatic system to manage fluid in the lower extremity (Woodcock, 2012). Damage to the lymphatic system can contribute to venous disease and vise versa. Congestion in the venous system can result from 3 main mechanisms:

- 1) **Failure of the calf muscle pump:** Meulendijks et al. (2018) have identified the calf muscle dysfunction as a strong predictor of VLU severity and impaired healing. Any process that prevents heel-toe walking pattern will be a risk for venous congestion. Some examples include joint issues in the extremity, shuffling gait or disease processes including muscular or neurological diseases (e.g., Parkinson's disease).
- 2) **Valvular disease**: Valves in the veins can become inefficient because of continuous downward pressure on the system or genetic weakness. Examples include obesity (higher body mass index), multiple pregnancies or even employment that requires long hours of sitting or standing.
- 3) **Obstruction**: The major cause of venous obstruction is a history of a deep vein thrombosis causing damage to the deep venous system. With deep vein thrombosis and surface compression, there may be an intolerable increase in pain because the surface veins are compressed and cannot support adequate venous return to the heart.

Risk factors for arterial disease should be evaluated in the history and physical examination as listed in Table 1. These are similar to coronary artery disease, with smoking, diabetes and advanced age being the most common.

Table 1 Components of a History and Physical Examination

History	Risk factors for venous disease- may include genetic factors, obesity, standing occupations, smoking Co-morbid conditions: (diabetes mellitus, connective tissue diseases, inflammatory conditions), arterial risk factors History of previous or with current venous ulcer(s)- use Clinical-Etiology-Anatomy-Pathophysiology (CEAP) classification Symptoms of venous congestion (edema below the knee)
Bedside examination	Blood pressure (BP) Lower leg examination and ulcer characteristics Palpate for pulses at the femoral, popliteal, dorsal pedis and posterior tibialis Ankle Brachial Pressure Index (ABPI) or Audible Handheld Doppler (AHHD) Gait assessment including walking aids, footwear, physical activity and ankle joint range of motion
Laboratory	Blood glucose level, HbA1c If indicated: complete blood count, kidney (creatinine), liver function, additional co-morbid issues Thrombophilia screen if deep vein thrombosis (DVT) history unexplained, young age, family history -Factor V/ Prothrombin Gene mutations, Antiphospholipid Antibody, Deficiencies – Anti prothrombin, Protein C/S (Merriman, Greaves, 2006)
Vascular laboratory	ABPI and more extensive arterial studies if indicated Venous Duplex Doppler (often indicated when ABPI is below 0.70)
Allergies/Sensitivities	Oral Medications – especially those that can impair healing Topical agents – avoid common sensitizers
Self-care abilities / Psychosocial issues	Activities of daily living – meals, shopping, financial stability Continence status – incontinence issues Patient concerns – support system: circle of care, pain
Nutrition	Weight- BMI: <18.5 Underweight 18.5-24.9 Normal 25-29.9 Pre obesity 30-34-9 Obesity Class 1 35-39.9 Obesity Class 2 >40 Obesity Class 3 Validated Canadian Nutrition Screening Tool (Yes x2 – Registered Dietitian consult for further assessment) -Have you lost weight in the past 6 months without trying to lose this weight? (If the patient lost weight and regained it, it is not considered weight loss) -Have you been eating less than usual for more than a week?
Medications	Immuno-suppressants/ oral steroids over 20 mg Assess drug interactions: if adding drugs (antibiotics/ other drugs-agents) Venous disease: lower leg edema, at rest, with ambulation (R/O claudication with arterial disease)
Pain	Procedure-related to wound (e.g., dressing change, debridement, infection) Related to lower leg edema, compression bandages or local wound dressings

Table 1 Modified from & reproduced with permission: Best Practice Recommendations for the Treatment & Management of Venous Leg Ulcers. 2019. Wound Care Canada (Evans et al., 2019)

Symptoms related to venous congestion may include swelling, aching, throbbing, and cramping of the legs, particularly at the end of the day. Venous stasis causes a disruption of the epithelial barrier, commonly seen as contact irritant dermatitis that comprises about 80% of contact dermatitis. Allergic contact dermatitis with itchiness is also common. It is important to illicit all topical agents that are being applied to the leg as many contain sensitizers and allergens (Sibbald et al., 2007). The difference between contact dermatitis and cellulitis is reviewed in Table 2.

Table 2. Dermatitis versus Cellulitis in the lower leg: Reproduced with permission: Wound Care Canada

Presentation	Stasis Dermatitis with erosions (loss of Epidermis with Epidermal base) 	Cellulitis with Ulcer (loss of Epidermis with a dermal or deeper base) 
Symptoms / General Signs	Afebrile Itching, discomfort most common Varicose veins/ Potential deep vein thrombosis May be unilateral or bilateral	May have fever Painful Relevant history of venous disease, ulcer Most often unilateral
Specific Signs	*Normal temperature *Erythema, inflammation *Itch but may be tender *Vesicles and crusting *Lesions on other body parts (e.g., other leg, arms, trunk) ***If blisters, or pain along with deep inflammation consider secondary infection***	NERDS and STONEES tool (Woo, Sibbald, 2009) – Any 3 of the following 7 criteria for infected ulcers: *Size of ulcer has increased *Temperature: Elevated (3°F or greater than mirror image) *Os- Latin for Bone probing or exposed bone *New areas of breakdown *Erythema, Edema (Cellulitis) *Exudate increased *Smell – often gm-ve/ Anaerobes
Portals of Entry	Stasis dermatitis with loss of the epidermal barrier (erosion, ulcer) allows allergens to penetrate	Usually unknown; break in skin, ulcers, trauma, tinea pedis (foot fungus), intertrigo implicated (between toes).
Laboratory	Often nothing is seen	May have elevated WBC count especially neutrophils Skin swabs – Staphylococcus aureus or Streptococcus most often identified

Table 2. Dermatitis versus Cellulitis in the lower leg: Reproduced with permission: Wound Care Canada

Pain related to venous ulceration is common and is reported in over 60% of patients (Hofman et al., 1997). Claudication and rest pain are symptoms of arterial insufficiency. Claudication is a reproducible pain that occurs in the lower extremity after walking a defined distance and is relieved by rest. Rest pain is most common at night or when in a recumbent position with the leg elevated that is relieved by hanging the leg in a gravity-aided dependent position or by walking. This level of pain would require an urgent vascular surgery consult. Characteristics and location of ulcerations may also give clues to the presence of arterial compromise. Distal punched out ulcers are more characteristic of arterial compromise (Evans et al., 2019).

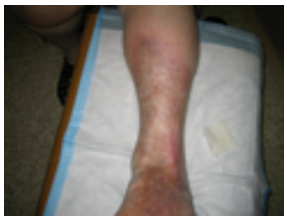
Physical Findings

Characteristic changes associated with venous insufficiency are illustrated in Table 3. Changes characteristic of arterial disease could include cool extremity, muscle atrophy, dependent rubour and distally located ulcers with a punched-out appearance. Decreased hair growth and nail changes (thickening, loss of lustre) may be less reliable. The physical finding of edema in the lower extremity could also be related to more systemic disease

including congestive heart failure, liver, renal and gastrointestinal issues causing fluid overload, especially if the edema is bilateral and extends above the knee. This of course can co-exist with localized lower leg venous disease complicating the management of our patents. With edema it is also important to consider and rule out an acute deep vein thrombosis or a ruptured Baker's cyst.

Table 3 Physical changes and presentation of symptoms related to venous disease

Physical changes	Presentation	Comments
Edema		– Observed as perceptible increase in volume of fluid in skin and subcutaneous tissue, characteristically indented with external finger pressure – Usually occurs first in ankle region where the long saphenous vein is most superficial and curved but may extend to leg and foot – Worsens with dependency and improves with leg elevation (Carmel & Bryant, 2016).
Stasis changes kk		– Eczematous changes make the skin vulnerable with redness and scaling (stasis dermatitis) often associated with pruritus – Management involves the use of emollients, humectant moisturizers or topical corticosteroids if red & inflamed – Contact irritant dermatitis & allergies may occur with some topical agents
Hemosiderin Staining (Hemosiderosis) Hyperpigmentation		– When vein valves fail & red blood cells are forced out of capillaries, they break down releasing hemosiderin pigment + melanin, results in gray-brown gaiter skin pigmentation (mod. from Carmel & Bryant, 2016)
Corona phlebectatica (starburst veins radiating below the malleoli above and onto the side of the foot)		– Fan-shaped pattern of numerous small intradermal veins on medial or lateral malleoli – Often an early sign of advanced venous disease Also known as malleolar flare or ankle flare – "The corona phlebectatica (CP) abnormally visible cutaneous blood vessels at the ankle with 4 components: venous cups, telangiectasias – blue* & red, capillary stasis spots* *most important elements."(Uhl et al., 2012)
Varicosities		– Usually tortuous, but tubular saphenous veins with reflux may be classified as varicose veins (varix, varices, or varicosities) – Blue colour, swollen, twisted, superficial or deep – Common locations: ankle, back of the calf or medial aspect of the leg (Carmel & Bryant, 2016)
Acute Lipodermatosclerosis (LDS)		– Acute lipodermatosclerosis presents with an extremely painful (even to light touch) red to purple indurated warm area on the lower leg – Often misdiagnosed as cellulitis, phlebitis, panniculitis or acute morphea – Progression-months/years to chronic – More likely bilateral than cellulitis (3° Fahrenheit warmer than the mirror image on the other leg) – Acute lipodermatosclerosis often transitions to subacute or chronic changes (Miteva, 2010)

Physical changes	Presentation	Comments
Chronic Lipodermatosclerosis (LDS)		– Localized chronic inflammation and fibrosis of dermal skin and subcutaneous tissues of lower leg, sometimes associated with scarring or contracture of Achilles tendon – LDS may be proceeded by diffuse inflammatory edema of the skin that may be painful; referred to as acute LDS – The chronic form is part of severe venous disease or C4 in the CEAP classification (Carmel & Bryant, 2016)
Inverted champagne bottle deformity		– This is a form of lipodermatosclerosis with subcutaneous fibrosis that leads to proximal leg swelling with skin tightening & narrowing band at the distal calf (gaiter area)
Atrophy blanche		– Localized, often circular whitish & atrophic areas (hypopigmented) surrounded by dilated capillaries & may have hyperpigmentation. Often described as porcelain white scars – When vein valves fail & red blood cells are forced out of capillaries, they break down releasing hemosiderin pigment + melanin, results in gray-brown gaiter skin pigmentation (mod. from Carmel & Bryant, 2016)Atrophy blanche is common, occurring in 1/3 of patients with venous disease but also may represent livedoid vasculopathy in 50% of cases, especially if the changes extend to the dorsal base of the toes (Alavi et al., 2014) – Associated with coagulation abnormalities in 50% – Atrophy blanche pain due to vascular occlusion (Alavi et al., 2014, Carmel & Bryant, 2016)
Venous ulcer		– Full-thickness defect of the skin, most frequently in ankle or lower gaiter region, that fails to heal spontaneously and is sustained by CVD – Ulcers often have a granulation tissue base (firm pink) with serpiginous margins (irregular snake-like) and are less likely to have eschar, debris, or tendons in the base of the ulcer

Reproduced with permission: Wound Care Canada

Clinical-Etiology-Anatomy-Pathophysiology (CEAP) Classification of Venous Disease

Clinical-Etiology-Anatomy-Pathophysiology (CEAP) Classification of Venous Disease

It is considered best practice to use the Clinical-Etiology-Anatomy-Pathophysiology (CEAP) classification system that represents an international consensus method to categorize chronic venous disease **(Table 4**). This classification system although not correlated with outcomes, does provide the clinician with a structured framework with the C or Clinical being the most useful when in clinical practice. The most recent update was published in 2020 (Musil, 2021). The major change is C4, corona phlebectatica that is considered an early marker for the development of more advanced disease. There is now a designation for a recurrent ulcer listed below as C6r.

Table 4. The CEAP Classification for Venous Disease

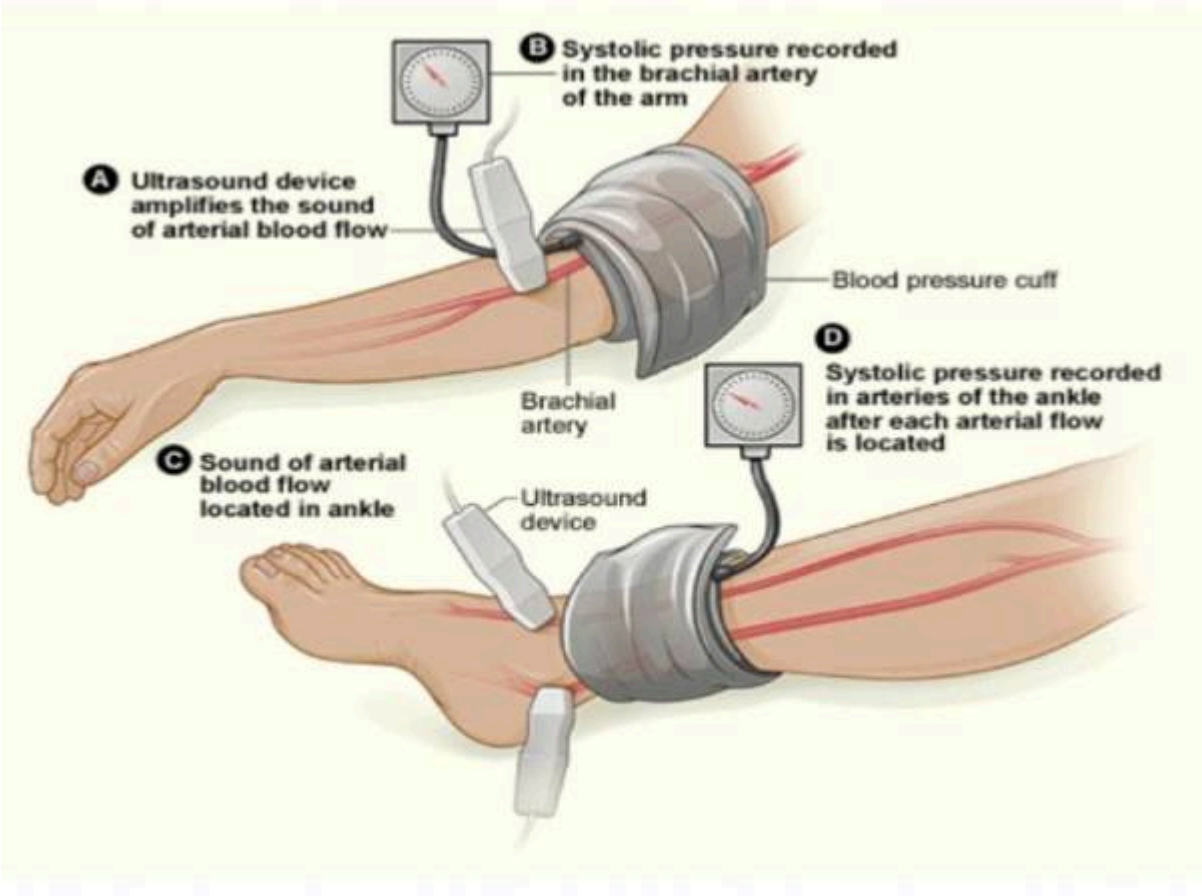
CEAP tool	Meaning
C	Clinical findings
E	Etiological factors
A	Anatomical site
P	Pathophysiological cause

Clinical	C0	No visible or palpable signs of venous disease
	C1	Telangiectasias or reticular veins
	C2	Varicose veins
	C3	Presence of oedema
	C4a	Eczema or pigmentation
	C4b	Lipodermatosclerosis or atrophie (atrophy) blanche
	C4c	Corona phlebectatica
	C5	Evidence of a healed venous leg ulcer
	C6	Active venous leg ulcer symptoms
	C6r	Recurrent ulcer
Etiological	Ec	Congenital
	Ep	Primary
	Es	Secondary (post-thrombosis)
	En	No venous etiology
Anatomical	As	Superficial veins
	Ap	Perforating veins
	Ad	Deep veins
	An	No venous location identified
Patho-Physiologocal	Pr	Reflux
	Ap	Obstruction
	Ad	Reflux and obstruction
	An	No venous pathophysiology identified

Ankle Brachial Pressure Index

Ankle Brachial Pressure Index

Figure 2: How to Perform an ABPI



The illustration shows the ankle-brachial index test. The test compares blood pressure in the ankle to blood pressure in the arm. As the blood pressure cuff deflates, the blood pressure in the arteries is recorded.

Interpretation of ABPI values

Vascular assessment

Palpation of the dorsalis or posterior tibial arteries with a palpable pulse indicates at least 80mmHg in the foot. A normal ABPI is 0.9 or greater with some compromise of the arterial circulation between 0.7 -0.9. An ABPI between 0.5- 0.7 indicates mild to moderate disease and a referral to a vascular surgeon for a more comprehensive assessment is recommended. The absence of a palpable pulse is the most sensitive clinical sign of arterial insufficiency (Morley, 2018)9.

In 2015, Alavi, Sibbald and Mayer (Senior author Swiss Vascular Surgeon) et al. conducted a study to determine the accuracy of audible arterial foot signals with an Audible 8 MHz Handheld Doppler ultrasound for identification of significant peripheral arterial disease as a simple, quick, and readily available bedside screening tool (Alavi et al., 2015). Two hundred consecutive patients referred to an interprofessional wound care clinic underwent audible handheld Doppler (AHHD) ultrasound of both legs. As a control and comparator, a formal bilateral lower leg vascular study including the calculation of Ankle Brachial Pressure Index and toe pressure (TP) was performed at a certified vascular lab. Their study conclusion determined that audible handheld Doppler ultrasound proved to be a reliable, simple, rapid, and inexpensive bedside exclusion test of peripheral arterial disease in diabetic and nondiabetic patients (Alavi et al., 2015).

Table 5. Ankle Brachial Pressure Index Values and Interpretation

Ankle Brachial Pressure Index	Diagnosis/Interpretation for Arterial Disease
>1.40	Concern for non-compressible arteries (example diabetes mellitus, renal diseases) Further vascular tests should be performed
1 to 1.40	Normal
0.91 to 0.99	Borderline
≤ 0.90	Abnormal range Peripheral arterial disease
0.7 to 0.9	Mild disease
0.41 to 0.69	Moderate disease
< 0.4	Severe disease (critical limb ischemia)

Reproduced from Wounds Canada with permission

Any multiphasic sound (biphasic, triphasic) on the AHHD can be used as an indicator of adequate blood supply to heal. The AHHD can be performed with the client seated or in any position and does require them to lay flat for 20 minutes prior (as with the ABPI). With the AHHD, there is no potential for pain caused by inflation of a blood pressure cuff around the ankle. Also, the results are not influenced by calcified vessels, especially when calculating the ABPI in patients with diabetes. The audible recording can be documented as a MP3 or WAV file on a smartphone. If the signal is monophasic or absent, segmental lower leg duplex Doppler studies need to be performed and vascular referral is advised.

Unfortunately, venous leg ulcers have a long healing trajectory with approximately 30% unhealed at 24 weeks (Evans et al., 2019). The Venous Leg Ulcer Risk Assessment tool is a validated tool to predict the risk of a VLU not healing at week 24.11 www.vlur-risk-tools.org.au/

Patient-Centered Concerns

PATIENT-CENTRED CONCERNS

Assessment of Pain:

Assessment of pain related to venous leg ulcers using a validated tool is important, as patients regularly report mild to moderate or severe pain. Clinicians have a range of tools that make it possible to evaluate the patient's pain pre-, during and post- procedure and at regular intervals. Pain affects patients' mental health and wellness, and therefore their behaviours and attitudes toward care planning.

Practitioners can access pain screening tools at painbc.ca

Assessment of Nutritional Status

Protein malnutrition and malabsorption from gastrointestinal distress can contribute to chronic leg edema associated with VLUs. As well, VLUs can be heavily exudating, making fluid and protein intake important to consider. It is important to assess the nutritional status of individuals with or at risk of VLUs using a validated tool.

The Canadian Nutrition Screening Tool is a validated tool that asks two questions:

1. Have you lost weight in the past 6 months without trying to lose this weight? (if the patient lost weight and regained it, it is not considered weight loss) and
2. Have you been eating less than usual for more than a week? (Canadian Nutritional Society, 2014).

Two yes responses would indicate a positive screen result and requires a referral to a registered dietitian for an in-depth nutritional assessment.

Assessment of Quality of Life (QoL): A wide variety of quality-of-life and health-related quality-of-life assessment tools are available. To assess the patient's quality of life generally, the 36-Item Short Form Health Survey (SF-36) is effective in clinical practice. A shorter version of the SF-36 is available as the SF-12. The Wound QoL tool can be used to measure quality of life in patients with chronic wounds (Vasquez, 2008).

Patient Adherence

Addressing patient adherence is often overlooked. Adherence to recommended treatment modalities, especially compression therapy, is important for positive, long-term outcomes. Listening to the patient's preferences, adjusting treatment plans, adequate pain management, providing psychosocial support and securing funding for compression garments are only a few factors to consider. Clinicians should include the patient and their circle of care to develop a mutually agreed upon plan of care.

Compression Therapy

Compression Therapy

Historically venous leg ulcers are managed with compression therapy. Compression therapy has been one of the earliest treatments known to medicine dating back as early as the Neolithic period (5000-2500 BC). Compression therapy has evolved from rudimentary bandaging to more sophisticated systems and remains the gold standard for the management of venous leg ulcers. Although the basic principles of compression remain the same; there are new approaches to management that may offer enhanced and promising healing outcomes. A 2021 Cochrane Review (Shi et. al) searched the most recent RCT's to determine if compression therapies (short-stretch inelastic bandage, four-layer elastic compression bandage, and Unna's [zinc oxide] boot) versus no compression (usual care) improved wound healing outcomes. The evidence suggests that:

- people wearing compression bandages or stockings probably experience complete ulcer healing more quickly
- more people treated using the compression bandages or stockings are likely to experience complete ulcer healing within 12 months.

However, we did not find clear evidence to tell if using compression bandages or stockings causes any unwanted effects.

Compression therapy choices are based on:

- Strength of the compression (measured in mmHg especially for elastic systems)
- Type of compression (short stretch inelastic or long stretch elastic stretch)
- Size and shape of the limb
- Skill of the clinician
- Frequency of required dressing changes (re-useable options for frequent changes)
- Patient centered issues (pain is often greater with elastic systems with high pressure at rest)
- Self management options –Velcro wraps or compression hosiery, tubular stockinette options)

Wounds Canada offers clinicians the Product Picker for VLU's

When applying compression, it is important to start at the base of the toes and continue up the leg to include the heel and up to two finger widths below the popliteal fossa (posterior knee). The following photos demonstrate both correct and incorrect application of compression therapy.

Photo showing the correct application of compression bandage start at the base of the toes and continue up the leg to include the heel and up to two finger widths below the popliteal fossa

Photo showing incorrect application of compression bandage where it was not started at the base of the toes and only to mid calf, not to 2 fingers below the posterior knee

Photo showing incorrect application of compression bandage where the heel is prominently exposed

It is important to rule out arterial disease. Photo showing signs of vascular compromise (areas of necrosis [black])

With the application of any compression system, it is important to follow the manufacturer's guidelines. Some manufacturers suggest that the compression system can be worn up to seven days. Caution should be noted when initiating compression as there will be a high level of exudate for the first few days and therefore, the dressings should be changed more frequently to prevent maceration.

See picture below that demonstrates signs of maceration.

With the first application of a compression device [Multilayer Compression System-MCS, Tubular PS or compression bandage (CB)], patients often report that the compression feels 'too tight'. This may influence adherence. It may take several days before patients are accustomed to wearing compression. This compression-related discomfort is usually experienced around the ankle or foot. Discomfort or pain below compression may be due to the new experience of the 'pressure on the leg' but may also be due to incorrect sizing (Rabe et al., 2020), infection, edema, fluid mobilization or inflamed venous disease.

Forefoot edema and edema above the compression system can occur, particularly in patients with lymphedema. In this patient population, forefoot edema can lead to possible fungal and secondary bacterial infections between the toes. Risk of skin damage and further misshaping of the limb due to bandage slippage are common issues that are encountered (Green, 2020).

Photo showing misshaping of legs due to long term incorrect application of compression bandages.

Initially, if patients are unable to tolerate a high-level compression therapy, start with a lower-level compression therapy to move some of the fluid and gradually increase the pressure as tolerated.

Recurrence rates of venous ulcers have been reported as high as 70%. Compression therapy is a life-long commitment that requires daily wear to prevent venous leg ulcer recurrence. When determining the appropriate compression/hosiery for each patient the following should be considered (Evans et al., 2019):

- Affordability
- Comfort
- Ease of application
- Non-allergenic
- Able to fit into the patient's shoes

Wound Cleansing and Moisture Management

Wound Cleansing

Wound cleansing and skin care are an integral part of managing patients with VLU's. An expert Advisory Board came to a consensus that the term 'wound cleansing' should be replaced with 'wound hygiene' as the term to resonates with health professionals to support optimal care (Murphy et al., 2019). The purpose of wound hygiene is to remove surface contaminants, bacteria, dead tissue and excess wound fluid from the wound bed and surrounding skin (McLain et al., 2021).

Wound and skin hygiene should be performed at every dressing change. This is particularly important in venous leg ulcer patients as dressings and compression therapy often have longer wear time (sometimes up to 1 week). Dressing changes present the only opportunity for a thorough skin and wound assessment, evaluation of current compression therapy, wound cleansing, and skin moisturizing. Moisturizing the skin is recommended to maintain healthy skin integrity. For patients who are capable of showering, this is recommended. The removal of dressings to shower can enhance both physical and psychological well-being. Each of these interactions provide an opportune time for patient education and long-term planning.

Various products can be used for cleansing including, saline, potable water, and proprietary products with surfactants. Surfactants are widely used to help remove foreign matter, biological debris, and biofilm. The surfactant lowers the surface or interface tension between a liquid and a solid (such as debris and biofilm), helping to disperse surface components. The dispersed solids can then be removed more easily with a cleansing pad or cloth (Murphy et al., 2019). It is important to avoid products with a high pH (destroys the antibacterial skin's acid mantle). Perfume or masking scents in products can be irritating to the skin and cause contact allergic dermatitis that can lead to further skin breakdown.

Moisture Management

Venous leg ulcers represent a unique challenge for both patients and clinicians. Their common location on the gaiter area is problematic with gravity moving fluid and exudate downwards. In addition, they are usually large in size and may present with copious exudate and resulting maceration. This exudate can be the result of inflammation, infection or edema making moisture management an important consideration.

A balanced moist wound environment facilitates cellular growth and collagen proliferation within a healthy noncellular matrix. Okan et al., 2007 assert "a balanced moist surface facilitates the action of growth factors, cytokines, and chemokines, thus promoting cellular growth and the establishment of a provisional wound matrix." Moist wound healing is recommended for healable venous leg ulcer wounds where the cause can be corrected. Re-epithelialization is ideal on a flat surface. Excess moisture in the wound bed can impair the healing process and damage the surrounding skin, leading to periwound maceration. If the excess moisture is left unchecked, healing can be impeded. There may also be subsequent breakdown and further deterioration of the wound bed.

In contrast, inadequate moisture in the wound environment, related primarily to exposure of the wound environment to air, promotes wound desiccation, necrosis, eschar formation resulting in poorer wound healing rates. The formation of eschar, therefore, slows the ability of regenerative cells (keratinocytes) to migrate from the

wound periphery into the wound center (Okan et al., 2007). For nonhealable/maintenance wounds, the goals of care are focused on decreasing moisture and bacteria levels while prioritizing patient comfort. Optimal migration and re-epithelialization are hindered by eschar formation.

Medical and Surgical Considerations

Medical and Surgical Considerations (Only FDA approved treatment can be listed here).

There are many ongoing studies evaluating pharmacological agents including skin substitutes, sulodexide (glycosaminoglycan fractions), growth factors and platelet rich plasma (Rafetto et al., 2020). The most used medical therapy is pentoxifylline (Trental) that has the greatest benefit with woody fibrosis (lipodermatosclerosis) and ulcers present for more than a year. This methylxanthine (caffeine derivative) does have evidence for healing when used with and even without compression (O'Donnell et al., 2014).

Surgical options in select patients are directed at removing the incompetent superficial vein and diverting venous flow to the deep system (Evans et al., 2019). It is important to obtain duplex venous studies to evaluate the location of the reflux. Most surgical procedures are limited to pathology in the superficial system. The procedures that are available for surgical management are superficial vein stripping and endovenous ablation techniques (laser and chemical). Currently the Canadian provincial health insurance will pay for saphenous vein ligation and stripping procedures for venous leg ulcer patients. Further research is underway to evaluate the evidence for perforator surgery (Rafetto et al., 2020).

Adjunctive Therapies and Organizational Support

Adjunctive Therapies

Adjunctive therapies are to be used in combination with best practices for patients with healable venous leg ulcers where the cause is known and can be corrected. Some modalities to be aware of are therapeutic ultrasound, electrical stimulation and electromagnetic therapy (Team et al., 2019). Neuromuscular electrical stimulation (NMES) has been shown to improve circulation, reduce edema, and improve wound healing outcomes.

Organizational Support

Organizational and system support according to the Best Practice Recommendations for the Prevention and Management of Venous Leg Ulcers (Evans et al., 2019) states that "decision-makers, and those who oversee financial budgets recognize the importance of providing evidence-informed, cost-effective care for the prevention and management of venous leg ulcers."

There is often limited budgets and resources, challenging clinicians to provide appropriate care. It is imperative that healthcare systems allow resources for care providers to deliver venous ulcer care within their designated scope of practice. As well, decision-makers on a macro level (administrators, managers, local and regional governments) must assess the value of best practices and continued education for team members as these translate to improved, cost-effective patient outcomes.

Venous disease organizational issues that need to be considered include:

- Adequate funding for compression garments or the newer self-adjustable hook and- loop fastener systems. This would be a consideration for primary and secondary prevention optimizing the management of venous ulcers.
- The role of self-management for venous disease through education and access to compression garments including hook-and-loop fastener systems
- Funding for physiotherapy assessment and treatment programs to improve calf-muscle pump function
- Funding for footwear that accommodate lower-limb devices and garments (compression)

Authors

Dr. Robyn Evans is currently the Medical Director of the Wound Healing Clinic at Women's College Hospital, involved in research and teaching. She also is a full-time family physician in the community. She is part of the faculty of the International Interprofessional Wound Course through the University of Toronto. She is medical lead for Wounds Canada to support the development of inter-professional education programs for clinicians as well as delivery and evaluation of these programs.

Cathy Burrows developed and coordinated the Leg Ulcer Clinic- QEII Health Sciences Centre, Halifax, NS-1999-2012.Past President CAWC-2007-2009.Recipient of Excellence in Nursing award- College of Registered

Nurses of NS- 2007. Masters in Wound Care, University of Toronto- 2008.Clinical Advisor- Wound Care Canada- 2011-to date. Currently a clinical/educational consultant with Perfuse Medtec Inc.

Conclusion and References

CONCLUSION

Venous leg ulcer management can be very challenging representing a high socioeconomic burden but also have a high incidence of recurrence. A systematic approach to management of venous leg ulcers offers clinicians a way to improve wound healing outcomes and reduce the incidence of recurrence. It is incumbent on the treating clinicians to educate patients regarding the need for lifelong compression therapy.

REFERENCES

Alavi et al. (2015). Audible handheld Doppler ultrasound determines reliable and inexpensive exclusion of significant peripheral arterial disease. Vascular https://wound.echoontario.ca/wp-content/uploads/2019/05/Alavi-2015-Doppler-Perpherial.pdf

Evans, R *et al*. Best Practice Recommendations for the Prevention and Management of Venous Leg Ulcers. A supplement of Wound Care Canada; [2019, November]: pp 1-70. Available [on-line]: **https://www.woundscanada.ca/index.php?option=com_content&view=article&id=110&catid=12&Itemid=724#how-to-cite-a-bprs**

Hofman D, Ryan TJ, Arnold F, Cherry GW, Lindholm C, Bjellerup M, et al. Pain in venous leg ulcers. J Wound Care. 1997;6(5):222–224.

Mariani, F. The Compression Therapy Study Group. Compression: Consensus document based on scientific evidence and clinical experiences. 2009 13:978-88-7711-650-5 [Available on-line]: https://www.researchgate.net/publication/304624717_Compression

Merriman L, Greaves M. Testing for thrombophilia: an evidence-based approach. Postgrad Med J. 2006;82:(973)699-704. [PMID 17099087]

Meulendijks AM, de Vries FMC, van Dooren AA, Schuurmans MJ, Neumann HAM. A systematic review on risk factors in developing a first-time Venous Leg Ulcer. J Eur Acad Dermatol Venereol. 2019 Jul;33(7):1241-1248. doi: 10.1111/jdv.15343. Epub 2019 Apr 1. PMID: 30422345.

Murphy, C. et al. Defying hard-to-heal wounds with an early antibiofilm intervention strategy: 'wound hygiene'. Journal Of Wound Care Vol 28, No. 12, December 2019 https://www.magonlinelibrary.com/action/doSearch?AllField=wound+cleansing&ContentGroupKey=10.12968%2Fjowc.2019.28.issue-12

Musil, D. What's new in the 2020 update of the CEAP classification system of chronic venous disease? Vnitr Lek Summer 2021;67(3):143-148. https://pubmed.ncbi.nlm.nih.gov/34171953/

Nicolaides. A. The Most Severe Stage of Chronic Venous Disease: An Update on the Management of Patients with Venous Leg Ulcers. Adv Ther. 2020 Feb;37(Suppl 1):19-24. doi: 10.1007/s12325-020-01219-y. Epub 2020 Jan 22. https://pubmed.ncbi.nlm.nih.gov/31970660/

O'Donnell TF Jr, Passman MA, Marston WA, Ennis WJ, Dalsing M, Kistner RL, et al. Management of venous leg

ulcers: Clinical practice guidelines of the Society for Vascular Surgery and the American Venous Forum. J Vasc Surg. 2014;60(Suppl 2):3S–59S.

Parker CN, Finlayson KJ, Edwards HE. Predicting the likelihood of delayed venous leg ulcer healing and recurrence: Development and reliability testing of risk assessment tools. Ostomy Wound Manag. 2017;63(10):16–33. Assessment Tools and Clinical Guidelines. On-line available https://painbc.ca/health-professionals/assessment-tools

Sibbald, RG, Cameron, J. Dermatologic aspects of wound care. In: Krasner D, Sibbald RG. Chronic Wound Care: A Clinical Source Book for Healthcare Professionals. 4th ed. Malvern, PA: HMP Communications; 2007. pp. 221–232.

Woodcock TE, Woodock TM. Revised Starling equation and the glycocalyx model of transvascular fluid exchange: an improved paradigm for prescribing intravenous fluid therapy. British journal of Anaesthesia. 2012. 108 (3), 384-394

CHAPTER 9

Chapter 9: Diabetic Foot Ulcers

Authors:

- Dr. Laurie Parsons MD, FRCPC
- Tobi Mark BSc(Hon), DCh

Learning Objectives

- Review the problem of diabetic foot ulceration: background, pathophysiology and features
- Evaluate appropriate treatment for diabetic foot ulcers: local wound care and offloading considerations

SCOPE OF THE PROBLEM

An increase in the incidence of diabetes globally is having major impacts on both health care systems and on the lives of persons with diabetes (PWD) (Hopkins et al., 2015). A recent Cochrane review found that diabetic foot ulcer (DFU) prevalence was 6.3% globally and highest in North America at 13% (95%CI: 10.0-15.9%), (Zhang et al., 2017). The annual cost associated with DFU in Canada has been calculated at $547.0M with an annual cost per patient of $21,371 (Hopkins et al., 2015). Another study found the average mean cost for DFU admission of $22,754, compared to the $10,169 for the top 5, most expensive, other medical conditions (Syed et al., 2020).

In statistics from the USA, 85% of lower leg amputations (LLA) are preceded by a DFU and being a PWD confers a 15-20 fold higher risk of a LLA (Pemayun et al., 2015). Walsh et al. (2017) examined the risk of dying as an independent factor for PWD and an amputation. Using a UK database, they examined the records of 20,737 patients and found that PWD and a new foot ulcer, had a 5% chance of dying within the first year and a 42% chance of death within 5 years. Even adjusting for other major comorbidities associated with diabetes, they still had significant correlation between DFU and death with a correlated hazard ratio of 2.48% (Walsh et al., 2016).

Armstrong et al. (2017) reports a lifetime risk of a PWD developing a DFU, to be as high as 19-34%. Unfortunately, the recidivism rate of DFU is even higher, with an estimate of 40% of patients will have a recurrence within one year and up to 60% within 3 years of healing a DFU.

This concept of high recidivism means that from a health economics point of view, we should consider allocating a significant proportion of health care resources to the prevention of DFU as a lower cost option than treating the complications of DFU; and to consider patients with DFU as having a chronic disease issue requiring ongoing and regular foot care and surveillance.

Pathogenesis

The journey from DFU to LLA begins with a small traumatic or surgical injury to the skin and is related to a complex interplay between peripheral neuropathy, poor glycemic control, foot deformity, peripheral vascular disease and limited joint mobility. Even PWD who do not have clinically demonstrable peripheral vascular disease will have local tissue ischemia secondary to microvascular changes. Approximately 60-80% of these ulcers will heal while 24% will lead to a LLA (Pemayun et al., 2015). A decreased immune response in PWD is a result of the negative effects of hyperglycemia on leukocyte function which increases the risk of a wound infection (Ogrin et al., 2015). Ulceration, secondary to neuropathy, poor local blood flow and decreased immune response, is due in large part to the metabolic effects of hyperglycemia, but also due to other risk factors such as smoking, dyslipidemia, obesity and hypertension (Syed et al., 2020). As well, ethnicity and associated genetic factors have been shown to be a risk factor for the development of neuropathy (Jhamb et al., 2016). Amputation is almost invariably a result of infection from a contiguous ulcer, leading to osteomyelitis (Berli et al., 2017; Volmer-Thole & Lobmann, 2016).

Healing a diabetic foot ulcer is complex. The following discussion will explore key aspects of the care of a diabetic foot ulcer in relation to the Wound Bed Preparation paradigm as depicted in Table 1.

Table 1 Wound Bed Preparation 2021 Ten Final Statements for patients with DFU

No.	Statement	Sub statements
1	Treatment of the cause	A. Determine if there is sufficient blood supply to heal/adequate perfusion. B. Identify the cause(s) as specifically as possible or make appropriate referrals C. Review cofactors/comorbidities: Bony deformities (amputations, bunions, calluses), signs of potential osteomyelitis (exposed bone, probe to bone, purulent discharge), callus and evidence of previously healed ulcers) D. Choose appropriate offloading device
2	Patient-centered concerns	A. Manage pain (diagnosis and treatment) B. Evaluate activities of daily living through the lens of wearing an offloading device, mobility/exercise, eating habits, psychological wellbeing (mental health), and support system (patient circle of care, access to care, and financial constraints), ability to drive C. Evaluate habits: smoking, alcohol, substance use, personal hygiene D. Empower patients with education and support to increase treatment adherence (coherence)
3	Determine healability (status may change)	A. Healable: adequate blood supply to heal and treated the cause B. Maintenance: adequate blood supply to heal where the patient either cannot or will not adhere to the plan of care/healthcare system does not have appropriate resources C. Non healable: inadequate blood supply and/or a cause that cannot be corrected (e.g., terminal cancer, negative protein balance)
4	Local wound care: monitor wound history and clinical examination	A. Document wound(s): location, longest length × widest width at right angles, wound shape, wound bed, exudate, margin, undermining, tunneling, surrounding skin condition and photoimaging when available B. Cleansing: gently with water, saline, or low-toxicity antiseptic agents C. Reassess and document wounds at appropriate, regular intervals D. Assess callusing regularly (weekly)
5	When appropriate, debride wounds with adequate pain control.	A. Consider sharp surgical debridement (to bleeding tissue) for healable wounds and conservative surgical debridement for maintenance/nonhealable wounds B. Evaluate the need for alternative debridement modalities: autolytic with dressings, enzymatic, mechanical, or biologic C. Callus care
6	Assess and treat wounds for infection/inflammation	A. Treat local infection (three or more NERDS criteria) with topical antimicrobials (silver, iodine, PHMB/chlorhexidine, methylene blue/crystal violet, surfactants) B. Consider treating deep and surrounding infection (three or more STONEES criteria) with systemic antimicrobials C. Evaluate and alleviate persistent inflammation including consideration of anti-inflammatory agents (topical dressings, systemic medication)
7	Moisture management As per the University of Texas Wound Classification system (Lavery et al. 1996): daily dressings with a thin dressing choice may be more appropriate as bulky dressings may increase local pressure on the wound and surrounding tissues	A. Healable, moisture balance, and autolytic debridement: alginates, hydrogels, hydrocolloids, acrylics, films B. Moisture balance alone: super absorbents, foams, calcium alginates, hydrofibers, hydrocolloids, films, hydrogels C. Non healable and maintenance wounds and moisture reduction: if antibacterial needed, low toxicity topical anesthetics: chlorhexidine/PHMB, iodine, acetic acid D. Wound packing: saline wet (donate moisture) or dry (absorb moisture) but not antibacterial; PHMB gauze: antibacterial, non-release above the wound (stays in the gauze) only not in the wound surface; povidone iodine or other antiseptic soaked gauze: antibacterial above and on wound surface
8	Evaluate the rate of healing- a healable wound should be 20%-40% smaller by week 4 to heal by week 12	A. Stalled (healable) wounds should be re-evaluated for alternate diagnoses; consider wound biopsy, further investigation, and/or referral to an interprofessional assessment team to optimize treatment
9	Edge effect: use active therapies for stalled but healable wounds	A. Some active modalities have weak to mixed evidence and should be only used after interprofessional assessment of the patient and with regular re-evaluations B. Skin grafts have variable but positive evidence, and cellular and/or tissue-based products may or may not be cost effective at this time C. Evidence for using NPWT as an adjunctive therapy for stalled healable wounds
10	Organizational support	A. Organizational support may include a culture conducive to interprofessional education and patient-centered care, standardized evidence-informed protocols, adequate staffing, and established quality improvement programs that may include audits, prevalence and incidence studies, patient navigation

Abbreviations: NERDS, Non-healing, Exudate increase, Red friable granulation, Debris or dead cells, and Smell; PHMB, polyhexamethylenebiguanide; STONEES, Size enlargement, Temperature increase of ≥3° F versus the opposite limb mirror image temperature, Os (bone exposed or direct probing), New areas of break down on the wound margin, Exudate increase, Erythema and/or Edema, and Smell.

Offloading

Adapted from Sibbald et. Al 2021 Wound Bed Preparation 2021.
Used with permission from WoundPedia
Treat the cause

OFFLOADING

Pressure reduction, termed offloading, is necessary to heal diabetic foot ulcers. Common wound sites include the dorsal aspects of lesser digits, the apices of digits and the plantar metatarsophalangeal joints. Healing is often problematic on the plantar surfaces of feet on which ambulation occurs. Without the reduction of pressure, diabetic foot wounds are slow to heal. Wounds occur due to multiple factors including genetics, poor footwear, trauma, gait abnormalities and surgery (Botros et al., 2019). Affected feet often have structural limited ranges of motion in the ankle, subtalar and metatarsophalangeal joints leading to higher plantar pressures (Crisologo et al., 2019; Wrobel & Najafi, 2010). The goal of offloading is to reduce plantar pressures and shearing force while allowing a reasonable amount of ambulation (Crisologo et al., 2019).

Offloading is achieved through devices designed to redirect higher pressures away from wound sites and redistribute pressures more evenly across the foot. General guidelines for offloading plantar DFU are described in Table 2. There are published guidelines available to direct the selection of an offloading device such as the Offloading Plantar Pressures in Diabetes Product Picker that includes a comprehensive list of devices. Selection of the most appropriate device should be made in consultation with patient-centered concerns. Offloading should consider the following factors: location of the wound, presence of infection, presence of disease (neuropathy, PAD, inflammatory disorder), skin integrity of surrounding area, gait abnormalities, balance, activity level (e.g. how many hours of the day is the patient on their feet?), occupation (e.g. are there footwear constraints at work?), housing conditions (e.g. are there stairs in the home?), funding available and patient adherence to attend all follow up visits (Botros et al., 2019; Crisologo et al., 2019; Lu & McLaren, 2017).

CONSERVATIVE OFFLOADING OF NEUROPATHIC PLANTAR FOREFOOT AND MIDFOOT ULCERS

Location matters. The location of the wound is a starting point to guide the selection of the device as shown in

Figure 1. First line offloading options for forefoot and midfoot neuropathic plantar wounds include knee high devices with an appropriate foot-device interface (Botros et al., 2019; Bus et al., 2020; (Lazzarini & Jarl, 2021). Knee high devices can be removable or irremovable. Common irremovable devices include total contact casts (TCC) and removable cast walkers made irremovable with bandaging (instant TCC). Specialized training is required to apply total contact casts to prevent iatrogenic events. Irremovable devices better offload than removable devices since they cannot be easily removed by the patient (Botros et al., 2019; Lazzarini & Jarl, 2021). However, despite best practice recommendations, TCCs are prescribed less often in practice due to the specialized training involved, time-intensive nature of application and patient factors (Fife et al., 2014; Wu et al., 2008).

Removable cast walkers require modifications of their insoles to be customized to the patient's foot (foot-device interface) (Bus et al., 2020). Second line and third line offloading options for forefoot and midfoot neuropathic wounds include removable knee-high devices and ankle-high devices, respectively (Bus et al., 2020). Removable cast walkers are available in both ankle and knee heights. These options should be explored if the patient is unable to tolerate an irremovable device due to any of the offloading factors described earlier.

Fourth line options include orthopedic footwear and felted foam modifications (Bus et al., 2020). In the author's experience, felted foam padding can be combined with other offloading modalities in appropriate cases to enhance offloading. The use of padding requires an understanding of each patient's foot biomechanics to mitigate the edge effect.

CONSERVATIVE OFFLOADING OF NEUROPATHIC PLANTAR HEEL ULCERS

Plantar heel wounds are challenging to offload. Consider using a knee-high offloading device or alternative offloading device that is shown to reduce heel pressures (Bus et al., 2020). Lu and McLaren (2017) recommend total contact casts with modifications, healing sandals with insole modifications and non-weight bearing options to offload plantar heel wounds.

Table 2 *Offloading Device Considerations According to the Location of a Plantar DFU*

Wound Location	Offloading Device Consideration	
Forefoot and Midfoot	First line	Irremovable knee-high device: • TCC • Instant TCC with foot-device interface
	Second line	Knee-high removable cast walker with foot-device interface
	Third line	Ankle-high removable cast walker with foot-device interface
	Fourth line	Orthopedic footwear +/- felted foam
Heel	Modified TCC, healing sandals with insole modifications, non-weight-bearing	
Adapted from (Botros et al., 2019; Bus et al., 2020; Lu & McLaren, 2017)		

Considerations and Complications of Offloading

The presence of ischemia and/or infection affects the choice of offloading. Offloading must not impede circulation or exacerbate infection. TCCs can be used in the case of mild ischemia **or** treated mild infection, but not when both are present (Bus et al., 2020). Knee-high removable cast walkers can be used with caution in the presence of both mild ischemia and mild infection (Bus et al., 2020). However, a referral to a specialty wound clinic may be warranted to assess for the safest choice of offloading in these more complex cases.

Figure 1 *Sample Offloading Devices for DFU*

Note: Panel A: TCC with a cast shoe Panel B: Removable cast walker with a plastazote and poron foot-device interface exposed Panel C: Surgical shoe. Panel D: Semi-compressed felt plantar metatarsal pad with "U" cut to offload the right 2nd metatarsal phalangeal joint.

Photos courtesy of Tobi Mark, Eliot To, Nouhad Hamam and Alex Krutow

Patient Education

Patients require instruction on how to don and doff offloading devices. Assess each patient's gait wearing the device to ensure they are stable and any risk of falls has been mitigated with the use of mobility aids (e.g. canes, walkers and crutches). A medical referral may be necessary to assess for the use of mobility aids and to ensure the home environment is safe for use of the offloading device. A shoe-levelling device can be worn on the contralateral

limb to address any leg length discrepancies that may occur due to the offloading worn on the affected foot (Bus et al., 2020; Lazzarini & Jarl, 2021).

Patients must wear their offloading during every step taken, both inside and outside their home, to be effective. Activity modification to decrease the amount of walking and exercise is often necessary. Excessive weight-bearing may cause skin irritation or exacerbate wounds. Clear verbal and written instructions should be given on what to do in case of any adverse events due to the use of an offloading device. Patient education is a process and should be addressed at every clinical visit.

Cost Considerations

Offloading devices have an associated global cost. In Ontario, offloading devices alone are estimated to cost an average of $1425 per patient (Diabetes Canada, n.d.). It is important to be aware of any available local funding strategies, governmental or non-governmental, to subsidize the cost of offloading. Third party insurance may supplement the cost of devices.

Surgical Offloading

Surgery can be used to address underlying structural abnormalities, especially if conservative measures fail (Botros et al., 2019; Bus et al., 2020). Surgical procedures include the digital flexor tenotomy, Achilles' tendon lengthening, metatarsal head resection and joint arthroplasty (Bus et al., 2020). A referral to a surgeon with a specialty in foot surgery may be required. Surgical options may be maintained with conservative offloading.

Lifelong Offloading

Offloading is a lifelong process. It is important to discuss this concept with patients often so that reasonable expectations are formed incorporating patient-centered concerns. Facilitate discussion to help patients understand how standing on their DFU prolongs healing. Following wound closure, tensile strength of the epithelialized skin of healed wounds is only 80% of that of unwounded skin (Levenson et al., 1965). Healed areas are at risk of future breakdown and new areas of risk may develop over time. Custom inserts, orthotics and orthopedic shoes are often necessary to redistribute pressures across the plantar foot and provide stability. At times, specialized braces may be required. The Charcot Restraint Orthotic Walker (CROW) is designed to offload the Charcot foot. Building a culture of the acceptance of lifelong offloading is critical to treatment success.

Patient-Centered Concerns

Recurrence rates in DFU are more likely in patients with significant peripheral vascular disease, poor glycemic control and with significant bony deformities or gait abnormalities. For patients, once admitted to a multidisciplinary wound clinic, socio-economic deprivation alone does not account for a poor wound healing outcome or for increased recurrence of DFU's (Hicks et al., 2018). However, of the 80% of DFU which are considered healable, the most common reason, resulting in recurrence, is from nonadherence to wearing the recommended offloading device and to performing the recommended daily foot care routine (Dubský et al., 2013). The term, nonadherence however, should be re-examined in the context of the patient's perspective. A better terminology might be to address the barriers to care that a PWD with a DFU, experiences during their wound healing journey. Although offloading devices are to be worn constantly whenever weight-bearing, consider these scenarios which are a small sample of the difficulties our PWD may experience:

- Taking the time to apply a device in the middle of the night in a rush to toilet may not be feasible
- These devices are best used on dry pavement and are treacherous on icy sidewalks. Some of our patients live in rural areas where mud, dust and water are a concern.
- In some climates, heat and humidity make wearing these devices uncomfortable and encourage periwound maceration
- Driving may be prohibitive
- PWD and limited vision will need to ask another person to do the daily foot routine
- Significant flexibility is required to view the bottom of your foot or to apply socks which are a requirement to wear in devices

Newer technologies are also employed to help overcome these barriers to care, including 'smart' insoles, alert the wearer to pressure peaks . Infrared thermometry can be used for early detection of inflammation and also provides an early warning sign with patient self-monitoring of repetitive trauma. For acute Charcot arthropathy, there may be an 8-15 degrees Fahrenheit temperature difference than the mirror image on the other foot.

Temperature normalization may allow gradual re-ambulation with plantar pressure redistribution devices (Armstrong et. Al 1997, 2002). .

Devising appropriate care plans must always take into consideration the needs of the patient and their circle of care. Understanding the patient perspective and developing ways to circumvent barriers are needed to help clinicians in this work (Armstrong et al., 2017). It is important to understand the social determinants of health in the context of health inequity. Patients may have a history of poor experiences in the health care system. Lived experiences of historical trauma, racism and discrimination may affect communication and adherence to treatment regimes. Adopting a critical theoretical lens may contribute to better outcomes. Critical health literacy aims to empower patients to understand structural inequities of power and oppression and gain a greater control over their health (Matthews, 2014).

LOCAL WOUND CARE

Wounds should be cleansed with sterile water, normal saline or other low-toxicity antiseptic solutions (Sibbald et al., 2021). Ensure that all cleansing fluid is removed following irrigation. This is especially important when the base of the wound is not visible. Wounds should be assessed and classified as healable, maintenance and non-healing to direct the treatment regime.

Debride Healable Wounds When Appropriate

Using the DIME (devitalized tissues, infection/inflammation, moisture balance and edges preparation) framework, diabetic foot wounds often accumulate hyperkeratosis (callus) around the wound margins requiring debridement (Snyder et al., 2016). Debridement enables the clinician to fully assess wound depth, removes necrotic (dead) tissue which can lead to infection, reduces peak plantar pressures, disturbs biofilm and allows for the collection of culture specimens (Botros et al., 2019). Healable diabetic foot wounds are commonly debrided by sharp surgical debridement using a scalpel or curette (Botros et al., 2019; Sibbald et al, 2021). Most healable diabetic foot ulcers require serial debridement at each clinical visit to remove the callous that forms around the wound edges (Alavi A, et al, 2014). Without ongoing removal of callous, pressure is increased at the wound edges and delays wound healing. Specialized training is required for sharp surgical debridement. Consider conservative surgical debridement for maintenance or non-healable wounds to remove devitalized tissue (Sibbald et al, 2021). Other methods of debridement include autolytic, mechanical, enzymatic and biological.

Moisture Management

The selection of each wound dressing should address the features of each diabetic foot ulcer and patient centered concerns. Keep it simple. Moist, interactive dressings can be used on healable wounds (Sibbald et al, 2021). However, exercise caution in the use of moist interactive dressings in healable diabetic foot wounds as these wounds often tend to have an excess of moisture in the authors' experience. Maintenance and hon-healable wounds benefit from moisture management and antiseptic dressings (Sibbald et al, 2021). Be aware of the bulk of dressings. Ensure dressings are not too bulky and fit into offloading devices to avoid negative effects (Hilton et al., 2004).

Basic dressings are good options to begin with in the treatment of diabetic foot ulcers due to the high frequency of dressing changes and associated costs. Although the selection of dressing is important, proper offloading is key. It is more important what is taken off pressure-wise than put on.

Conclusion and References

CONCLUSION

Diabetic foot ulcers present a challenge to even the most experienced practitioner. Important considerations include the choice of offloading, patient-centered concerns and local wound care. An interprofessional approach is best that includes medicine, foot specialists (chiropody/podiatry), nursing and other specialties to ensure all aspects of care are addressed adopting a patient-centric approach.

REFERENCES

Alavi A, Sibbald RG, Mayer D, Goodman l, Botros M, Armstrong DG, Woo K, Boeni T, Ayello EA, Kirsner RS. Diabetic foot ulcers: Part II. Management. J Am Acad Dermatol. 2014 Jan; 70(1):21.e1-24.

Armstrong, D. G., Boulton, A. J. M., & Bus, S. A. (2017). Diabetic Foot Ulcers and Their Recurrence. *N Engl J Med*, *376*(24), 2367-2375. https://doi.org/10.1056/NEJMra1615439

Armstrong, D.G., Lavery L.A. (1997). Predicting neuropathic ulceration with infrared dermal thermometry. J Am Podiatr Med Assoc 87:336–337

Armstrong, D.G., Peters E.J.G. (2002). Charcot's Arthropathy of the Foot. Journal of the American Podiatric Medical Association. Vol. 92, No. 7, pp. 390-394.

Berli, M., Vlachopoulos, L., Leupi, S., Böni, T., & Baltin, C. (2017). Treatment of Charcot Neuroarthropathy and osteomyelitis of the same foot: a retrospective cohort study. *BMC Musculoskelet Disord*, *18*(1), 460-460. https://doi.org/10.1186/s12891-017-1818-4

Botros M, Kuhnke J, Embil J, Goettl K, Morin C, Parsons L, et al. Best practice recommendations for the prevention and management of diabetic foot ulcers. In: Foundations of Best Practice for Skin and Wound Management. A supplement of Wound Care Canada; 2017. 68 pp. Retrieved from: www.woundscanada.ca/docman/ public/health-care-professional/bpr-workshop/895-wc-bpr-prevention-and- management-of-diabetic-foot-ulcers-1573r1e- nal/le.

Bus, S. A., Armstrong, D. G., Gooday, C., Jarl, G., Caravaggi, C., Viswanathan, V., & Lazzarini, P. A. (2020). Guidelines on offloading foot ulcers in persons with diabetes (IWGDF 2019 update). *Diabetes/Metabolism Research and Reviews*, *36*(S1). https://doi.org/10.1002/dmrr.3274

Crisologo, P. A., Lavery, L. A., & La Fontaine, J. (2019). Conservative Offloading. *Clinics in Podiatric Medicine and Surgery*. https://doi.org/10.1016/j.cpm.2019.02.003

Diabetes Canada. (n.d.). *The economic impact of amputation prevention devices (2017-2018)*. Diabetes Canada Website. Retrieved October 30, 2021, from https://diabetes.ca/advocacy—policies/advocacy-reports/amputation-prevention-reports

Dubský, M., Jirkovská, A., Bem, R., Fejfarová, V., Skibová, J., Schaper, N. C., & Lipsky, B. A. (2013). Risk factors for recurrence of diabetic foot ulcers: prospective follow-up analysis in the Eurodiale subgroup. *Int Wound J*, *10*(5), 555-561. https://doi.org/10.1111/j.1742-481X.2012.01022.x

Fife, C. E., Carter, M. J., Walker, D., Thomson, B., & Eckert, K. A. (2014). Diabetic foot ulcer off-loading: The gap between evidence and practice. Data from the US Wound Registry. *Advances in skin & wound care*, *27*(7), 310–316. https://doi.org/10.1097/01.ASW.0000450831.65667.89

Hicks, C. W., Canner, J. K., Mathioudakis, N., Sherman, R. L., Hines, K., Lippincott, C., Black, J. H., & Abularrage, C. J. (2018). Neighborhood socioeconomic disadvantage is not associated with wound healing in diabetic foot ulcer patients treated in a multidisciplinary setting. *J Surg Res*, *224*, 102-111. https://doi.org/10.1016/j.jss.2017.11.063

Hilton, J. R., Williams, D. T., Beuker, B., Miller, D. R., & Harding, K. G. (2004). Wound dressings in diabetic foot disease. *Clinical Infectious Diseases*, *39*(Supplement_2). https://doi.org/10.1086/383270

Hopkins, R. B., Burke, N., Harlock, J., Jegathisawaran, J., & Goeree, R. (2015). Economic burden of illness associated with diabetic foot ulcers in Canada. *BMC Health Serv Res*, *15*(1), 13-13. https://doi.org/10.1186/s12913-015-0687-5

Jhamb, S., Vangaveti, V. N., & Malabu, U. H. (2016). Genetic and molecular basis of diabetic foot ulcers: Clinical review. *J Tissue Viability*, *25*(4), 229-236. https://doi.org/10.1016/j.jtv.2016.06.005

Lavery L.A., Armstrong D.G., Harkless L.B. (1996) Classification of diabetic foot wounds. J Foot Ankle Surg 35(6): 528–31 544–9

Lazzarini, P. A., & Jarl, G. (2021). Knee-high devices are gold in closing the foot ulcer gap: A review of offloading treatments to heal diabetic foot ulcers. *Medicina*, *57*(9), 941. https://doi.org/10.3390/medicina57090941

Levenson, S. M., Geever, E. F., Crowley, L. V., Oates, J. F., 3rd, Berard, C. W., & Rosen, H. (1965). The Healing of Rat Skin Wounds. *Annals of surgery*, *161*(2), 293–308. https://doi.org/10.1097/00000658-196502000-00019

Lu, S. H., & McLaren, A.-M. (2017). Wound healing outcomes in a diabetic foot ulcer outpatient clinic at an Acute Care Hospital: A retrospective study. *Journal of Wound Care*, *26*(Sup10). https://doi.org/10.12968/jowc.2017.26.sup10.s4

Matthews, C. (2013). Critical Pedagogy in health education. *Health Education Journal*, *73*(5), 600–609. https://doi.org/10.1177/0017896913510511

Ogrin, R., Houghton, P. E., & Thompson, G. W. (2015). Effective management of patients with diabetes foot ulcers: outcomes of an Interprofessional Diabetes Foot Ulcer Team. *Int Wound J*, *12*(4), 377-386. https://doi.org/10.1111/iwj.12119

Pemayun, T. G. D., Naibaho, R. M., Novitasari, D., Amin, N., & Minuljo, T. T. (2015). Risk factors for lower extremity amputation in patients with diabetic foot ulcers: a hospital-based case-control study. *Diabet Foot Ankle*, *6*(1), 29629-29629. https://doi.org/10.3402/dfa.v6.29629

Sibbald, R. G., Elliott, J. A., Persaud-Jaimangal, R., Goodman, L., Armstrong, D. G., Harley, C., Coelho, S., Xi, N., Evans, R., Mayer, D. O., Zhao, X., Heil, J., Kotru, B., Delmore, B., LeBlanc, K., Ayello, E. A., Smart, H., Tariq, G., Alavi, A., & Somayaji, R. (2021). Wound Bed Preparation 2021. *Advances in skin & wound care*, *34*(4), 183–195. https://doi.org/10.1097/01.ASW.0000733724.87630.d6

Snyder, R. J., Fife, C., & Moore, Z. (2016). Components and Quality Measures of DIME (Devitalized Tissue, Infection/Inflammation, Moisture Balance, and Edge Preparation) in Wound Care. *Advances in skin & wound care*, *29*(5), 205–215. https://doi.org/10.1097/01.ASW.0000482354.01988.b4

Syed, M. H., Salata, K., Hussain, M. A., Zamzam, A., de Mestral, C., Wheatcroft, M., Harlock, J., Awartani, D., Aljabri, B., Verma, A., Razak, F., Verma, S., & Al-Omran, M. (2020). The economic burden of inpatient diabetic foot ulcers in Toronto, Canada. *Vascular*, *28*(5), 520-529. https://doi.org/10.1177/1708538120923420

Volmer-Thole, M., & Lobmann, R. (2016). Neuropathy and Diabetic Foot Syndrome. *Int J Mol Sci*, *17*(6), 917. https://doi.org/10.3390/ijms17060917

Walsh, J. W., Hoffstad, O. J., Sullivan, M. O., & Margolis, D. J. (2016). Association of diabetic foot ulcer and death in a population-based cohort from the United Kingdom. *Diabet. Med*, *33*(11), 1493-1498. https://doi.org/10.1111/dme.13054

Zhang, P., Lu, J., Jing, Y., Tang, S., Zhu, D., & Bi, Y. (2017). Global epidemiology of diabetic foot ulceration: a systematic review and meta-analysis. *Ann Med*, *49*(2), 106-116. https://doi.org/10.1080/07853890.2016.1231932

Wrobel, J. S., & Najafi, B. (2010). Diabetic foot biomechanics and gait dysfunction. *Journal of Diabetes Science and Technology*, *4*(4), 833–845. https://doi.org/10.1177/193229681000400411

Wu, S. C., Jensen, J. L., Weber, A. K., Robinson, D. E., & Armstrong, D. G. (2008). Use of pressure offloading devices in diabetic foot ulcers: do we practice what we preach?. *Diabetes care*, *31*(11), 2118–2119. https://doi.org/10.2337/dc08-0771

Self-Check

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://ecampusontario.pressbooks.pub/skinandwoundcare/?p=1204#h5p-8

CHAPTER 10

Chapter 10: Pressure Injuries

Authors:

- Karen Smith
- Jolene Heil

Learning Objectives

- Review pressure injury risk assessment focusing on the patient as a whole
- Examine the principles of pressure redistribution
- Classify Pressure Injuries, the impact on patient well-being and the plan of care

INTRODUCTION

In this chapter, you will find an overview of how to reduce the risk for pressure injury (PI) formation and how to treat a person with an existing PI. It is important to understand that treatment of the wound itself is in conjunction with understanding the cause, as well as factors that affect wound healing.

Pressure injuries (PI) are defined as "localized damage to the skin and underlying soft tissue usually over a bony prominence or related to a medical or other device" (European Pressure Injury Advisory Panel [EPIAP], National Pressure injury Advisory Panel [NPIAP], Pan Pacific Pressure Injury Alliance [PPPIA], 2019)

PI's add significant cost to the healthcare system. A study conducted in the United States reported that a hospital acquired PI could cost $10,708 USD on average per person, and stage 3 & 4 PI's are associated with an average 14 day increase in length of stay (Padula & Delarmente, 2019). PI's also can have a significant effect on a person's quality of life and well-being.

Staging of Pressure Injuries

Documentation of tissue type involved in PI is important. The National Pressure Injury Advisory Panel developed a staging system to provide consistent documentation across all care sectors.

Prevention

Most PI's are avoidable and can be prevented. Risk assessment tools are designed to alert health care staff that a person is at risk for sustaining PI. There are a number of risk assessment tools that are validated for use including the Braden Scale for Predicting Pressure Sore Risk, the Norton Scale, or the Waterlow scale (Fletcher, 2017). These tools should be completed upon admission to a healthcare facility/agency within the first 24 hours of admission, and at regular intervals thereafter (RNAO, 2016). Risk assessment tools are an effective way of determining patient susceptibility to PI development and should always be used in conjunction with clinical judgement.

Treatment plans are an essential part of preventing PI's. After completing the risk assessment, it is beneficial to utilize the risk assessment tool to develop your plan. For example, if a person scores low in the mobility and nutrition categories (as in the Braden Scale for Predicting Pressure Sore), you will focus on implementing interventions to reduce these risk factors.

Support Surfaces and Equipment

Active and reactive support surfaces have been shown to reduce the incidence of PI's by up to 60% (McNichol, 2020). Active support surfaces are a powered surface with the capability to change load distribution properties, regardless of applied load. (Norton et al., 2011) Common examples are alternating pressure air mattresses. Reactive support surfaces are "a powered or non-powered support surface with the capability to change load distribution properties only in response to applied load. (Norton et al.,2011) Common examples are gel mattress or static low-air loss mattress. Support surfaces should be considered anytime a person is shown to be at risk of a PI. Choosing the right support surface is simplified by using a surface selection algorithm (Figure A, Norton et al). Clinicians should check all support surfaces to ensure they are working properly, prior to the person sitting or lying on them.

Support surfaces are an effective way to redistribute pressure over bony prominences but do not replace appropriate turning and repositioning. High risk individuals will require more frequent turning and repositioning than a person who is determined to be at moderate risk. Individuals who require assistance for transferring should be engaging in safe transfer techniques. These may include mechanical lifts, sliding boards, transfer poles and other transferring aids. Repositioning devices such as slider sheets are also beneficial in reducing friction and shear while moving a person in bed.

Table 1 Validation & Risk Assessment Score or Pressure Ulcer Description

Ability to change position in bed (ie. bed mobility	Validate Risk Assessment Score or Pressure Ulcer Description			
	At risk Or Redness present that fades quickly when pressure removed	Moderate risk or 1 pressure ulcer (excluding the heels) where the client can be positioned off the ulcer	High Risk Or 1 pressure ulcer (excluding the heels) and redness over another area	Very High Risk OR Multiple Pressure ulcers (excluding the heels) or the client cannot be positioned off of an ulcerated area
Total assist to change position in bed	Reactive Support surface (non-powered eg. air/gel/foam overlay)	Reactive Support Surface (eg. air/gel/foam overlay)	Active Support Surface Multi-Zoned Surface (eg. alternating pressure mattress, rotational surface) or a powered reactive support surface (eg. low air loss)	Active Support Surface Multi-Zoned Surface (eg. Alternating pressure mattress. rotational surface)
Moderate assistance with bed mobility	Reactive Support Surface (non-powered eg. air/gel/foam overlay)	Reactive Support Surface (eg. foam overlay with air section insert in the area of the wound)	Reactive Support Surface (non-powered eg. foam overlay with air section insert in the area of the wound)	Active Support Surface Multi-Zoned Surface (eg. alternating pressure mattress. rotational surface)
Client independent with or without a device with bed positioning (light assist may be required	Reactive Support Surface (High-density foam mattress)	Reactive Support Surface (eg. foam overlay with air section insert)	Reactive Support Surface (non-powered eg. air/gel/ foam overlay)	Active Support Surface (if the controls can be placed within the client's reach)
Users' Guide 1. With a validated risk assessment tool, determine the patient's level of risk or grade the patients with ulcers based on clinical descriptors. 2. Assess the level of mobility in bed and follow the column-and-row intersection to determine the appropriate reactive or active support system. 3. For more information on the reactive surfaces, see Figure 2, and for more information on active surfaces see Figure 3.				

TREAT THE CAUSE

Assessing how pressure injuries occur is important in prevention and to assist in healing of a PI. Even the most expensive dressing will fail if the precipitating cause is not identified and removed or modified. PIs occur as a result of pressure or pressure in combination with shear. The risk of injury is influenced by the magnitude and duration of tissue loading but also by susceptibility factors in the individual. (EPIAP, NPIAP, PPPIA, 2019)

In treating a PI, determine the source of the mechanical load while considering:

- direct pressure – the force perpendicular to the body
- shear – used to describe the force parallel to the skin surface which can deform deep tissue structures (e.g., skin moves in 1 direction and the bony skeleton moves in the opposite direction) and
- friction – a force in the interface between the body and a medical device which can be static (fixed) or dynamic (when there is movement between the surfaces) (EPIAP, NPIAP, PPPIA, 2019)

Examining your patient while being aware of the mechanical loads being placed on superficial and deep tissues in all positions of sitting, standing, lying is important to ascertain the cause of PI. The absolute pressure as well as the duration of the applied pressure is important to take into consideration. However, even low pressure can cause tissue damage if other susceptibility factors are present includingsuch as poor nutrition, moisture and high pressures can lead to tissue damage in a very short time. (Gefen & Levine, 2018; Lustig et al., 2018*).*

Susceptibility factors in the individual include advancing age, poor general medical condition, medications and nutritional levels and can influence the development and repair mechanisms of the skin and deeper structures.

Mobility and sensory perception of the individual also effects PI risks. The extent of factors to be addressed makes it important to work as a team in both the prevention and management of PI.

It is important to work with prescribing practitioners to identify any conditions or medications that might need to be assessed. Common examples of this include:

- Reviewing and possibly adjusting the many medications for inflammatory conditions including arthritis
- Optimal management of diabetes with acceptable glycemic control will assist in wound healing
- Assessment of oxygen saturation, peripheral pulses and capillary refill are important aspects to note and discuss with the team
- Involvement of rehabilitation professionals, especially the inclusion of occupational and physical therapists to assess mobility, all transfers and all surfaces used by the patient. This will contribute to wound healing as well as prevention
- Patients benefit from a review of how they might be altering their position to perform pressure redistribution maneuvers on a regular basis.

Some unique aspects of prevention and treatment of the cause of a PI arise particularly in special populations such as critically ill individuals, individuals with spinal cord injury, obesity, those receiving palliative care and in supported living environments.

Moisture from incontinence or perspiration can affect the barrier function of the epidermis and increase the potential for pressure injury. Incontinence is frequently associated with impaired mobility which contributes to the risk for PI development. The coefficient of friction is greater over moist skin contributing to skin breakdown. (Klassen et al., 2016). A whole team approach to managing moisture from incontinence is advised. Methods to schedule bowel care routines to prevent fecal incontinence (SCIRE, Spinal Cord Injury Research Evidence SCIREproject.com) include careful use of oral laxatives and facilitating bowel evacuation at scheduled times with routine timing, taking advantage of the gastrocolic reflex after meals as well as judicious use of rectal methods of stimulating evacuation with suppositories/enema/transanal irrigation etc., can promote better fecal continence. In some cases to facilitate healing of a PI, diversion with colostomy is required. Methods to manage urinary incontinence can include medications to improve the capacity for the bladder to retain urine, regular timed toileting regimens, careful management of fluid intake and if needed, diversion methods. These strategies may include condom drainage, indwelling urethral or suprapubic catheters or other more invasive surgical methods. As an adjunct to these measures, moisture absorbing pads or incontinence briefs in conjunction with skin protectants are used to reduce moisture at the skin surface. (Bernatchez et al., 2015) Management of moisture from perspiration includes assessment and management of the environment and body temperature. Occasionally, more active management can include medications or other treatments to reduce perspiration if severe.

Malnutrition contributes to an increased risk of wounds but also can delay wound healing (Agarwal et.al., 2010; Posthauer et al., 2015) In a Canadian prospective study, adult malnutrition was identified in 45% of patients admitted to hospitals over a 3-year period. Malnutrition in general is a reduced nutrition intake relative to needs (Mackay, 2019; Allard et al., 2016). The Academy of Nutrition and Dietetics and the American Society for Parenteral and Enteral Nutrition has adopted a standard diagnosis which includes weight loss as one of six criteria but there is growing recognition that malnutrition occurs even in overweight individuals. (White, 2012; Ness, 2018). The Canadian Malnutrition Screening Tool is recommended to be used to screen for early identification of those at risk for malnutrition. A positive screen indicates the need for a more detailed nutrition assessment by a nutritional specialist.

Root causes of malnutrition require input and possibly intervention from the patient, family and care team. Specific recommendations may be made regarding nutritional intake requirements of protein, calories, fluid and

micronutrients. The contribution of malnutrition to delayed healing of PI cannot be overstated. Individuals with significant PI often enter a spiral of inflammation and malaise which further reduces appetite and worsens their ability to heal. Engaging the patient in understanding the specific nutrition requirements to support PI healing can interrupt this cycle.

Most of the risk assessment tools for PI include assessment of sensory perception. (example *Braden, Spina Cord Injury Pressure Ulcer Scale*) The 2019 NPIAP guidelines recommend assessing sensory perception particularly with diagnoses associated with sensory impairment such as diabetes, spinal cord injury, peripheral arterial disease. Other patient conditions include altered consciousness like coma or patients under anesthesia. Reduced sensory perception may alter the patient's ability to respond to pressures placed on skin and deeper tissues. In addition, sensory perception needs to be taken into account during treatment planning and dressing changes.

There are situations, such as in patients with spinal cord injury, where the patient may not feel in the area of the wound but stimulation of dressing changes, bedside debridement etc. can cause mass reactions resulting in potential harmful elevations in blood pressure. Adequate pre-procedural analgesia is of critical importance in all patients. (Allen and Leslie 2019, Mhatre et al 2013*)*

Activity and mobility limitations are associated with the development of PI. Patients unable to independently mobilize in bed or chair are at risk of PIs on dependent areas of the body and generally over bony prominences. In addition, these high-risk areas for PIs can be put at further risk by contractures or limited range of motion. This limits the ability to position the patient where pressure can be distributed over the largest surface possible*.*

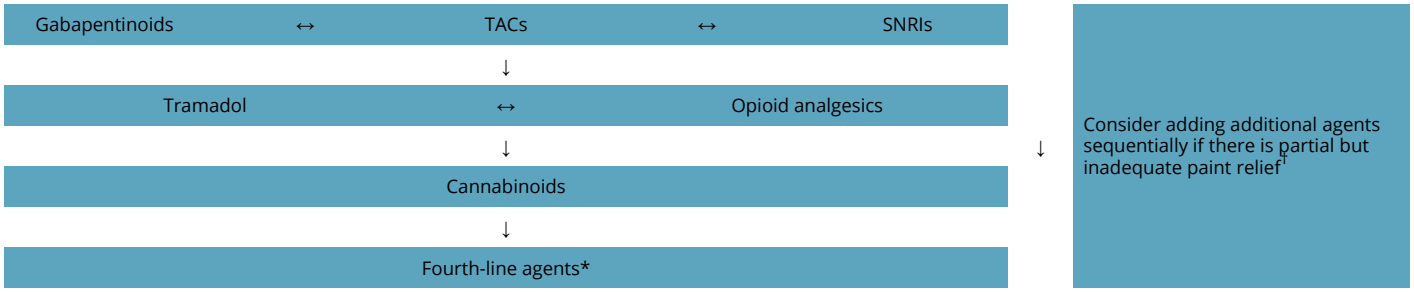
Friction and shear forces during transfers or other movement further increases the risk of injury to superficial or deep tissues respectively and influences the development or delayed healing of PI. An interprofessional team approach is required to investigate and optimize positioning, seating, transfers, management of contractures, tremors and spasticity in order to prevent and manage PIs.

Patient Centered Concerns

Pain management is important for optimal patient care. Pain is generally classed as nociceptive or neuropathic. Pain assessments should include documentation of the pain intensity, character and location at several time points, including during dressing changes and between dressing changes. As mentioned earlier, even when sensation is altered, it is important to address the need for pre-procedural analgesia.

Management of nociceptive pain can include oral medications including simple analgesia like acetaminophen or anti-inflammatories up to the judicious use of opiate medication. There are several neuropathic pain algorithms that have been published that provide guidelines for the stepwise management of neuropathic pain. In addition to these pharmacologic options, physical modalities including transcutaneous nerve stimulation, topical medications (lidocaine and others), mindfulness and cognitive behavioural therapy can be useful adjuncts for pain management (Moulin et al 2014, Mu et al 2017).

Figure 1. Algorithm for the pharmacologic management of neuropathic pain



SNRi – serotonin-norepinephrine reuptake inhibitors, TCA – tricyclic antidepressant
*Fourth-line agents include topical lidocaine (second-line for postherpetic neuralgia) methadone, lamotrigine, lacosamide, tapentadol, and botulinum toxin.
†There is limited randomized controlled trial evidence to support add-on combination therapy.
Adapted from Moulin et al

For cases unresponsive to these measures, involvement of pain specialists and interventional pain management may be warranted.

Table 2 Simplified Pain Component &Therapeutic Action

Simplified Pain Component	Therapeutic Action
Measurement tool	• Numeric Rating Scale, 0-10 (11-point scale; 0 = no pain, 5 = bee sting, 10 = slam the car door on your thumb; most people can live with a 3 or 4 out of 10) • Faces scale: cognitively challenged, young children, older persons
Neuropathic pain	• Burning, stinging, shooting, stabbing • Management strategies
Nociceptive pain	• Gnawing, aching, tender, throbbing • Acetaminophen, ASA, nonsteroidal anti-inflammatory drugs, narcotics (short/long acting)
Dressing removal	• Pull laterally to release adhesive bond and rotate like the hands of the clock before lifting up • Avoid strong adhesives (acrylates etc.) and use silicone adhesives or non adhesive dressings
Wound cleansing (sterile only required with immune compromise, deep postsurgical wounds)	• Use saline or (potable) water solutions at room temperature • Compresses or soaks are less traumatic than irrigation (make sure all solution is retrieved and you can visualize the base of the wound with no procedure induced bleeding or unnecessary trauma)
Debridement	• Topical EMLA is superior to other topical pain modalities • Use a thick layer and occlude with film type dressing for 10 to 30 minutes (shorter period for genitalia, face, folds; longer times on back or thick skin) • Can supplement topical agents with intralesional xylocaine with adrenalin (if not end artery and no other contraindication)
©WoundPedia 2021 Used with permission from WoundPedia	

Continuing with patient centered concerns, odour is often concerning for the patient and family. It is caused by anaerobic bacteria or necrotic tissue and can be distressing to patients. Management of this includes treating the cause of the offensive odour. Appropriate choices in dressings, possible debridement and addressing elevated bacteria levels may be useful. In addition, exudate can cause distress for patients and put surrounding skin at risk of breakdown. Assessment for the presence of superficial or deep infection with the use of NERDS and STONEES criteria and assessment for the contribution of edema will help in management of exudate. In order to optimize patient quality of life and coherence to the treatment plan, the patient needs to be integral to negotiation of management decisions along with their care network.

Determine Ability to Heal

Begin with the concepts of healable, non-healable and maintenance in your PI assessments. This will also help guide your local wound care strategies. Healable has adequate blood supply and the cause is corrected. Maintenance is where either patient or health system factors prevent healing. Non-healable is a wound with inadequate blood supply or a cause that cannot be corrected *(see Table 5).* Co-morbid conditions, including diabetes, renal failure etc., need to be optimized to facilitate healing. Adequacy of tissue perfusion is required to determine ability to heal.

Table 5. Summary of local wound care strategies

Wound Healability Classification	Considerations	Surgical Debridement	Inflammation/Infection Management	Moisture Management
Healable	Provide moist environment Promote granulation	Active	Treat inflammation/infection (topically or systemic) and antisepsis as required	Moisture balance
Maintenance	Decrease moisture and bacteria Prevent deterioration	Conservative (no bleeding)	Bacterial reduction—antisepsis	Moisture reduction
Nonhealable	Decrease moisture and bacteria Prevent infection Enhance comfort	Comfort removal of slough	Bacterial reduction—antisepsis	Moisture reduction
Adapted from Sibbald et al. Used with Permission ©WoundPedia 2021.				

Wound status including healability classification may change between these 3 categories. For example, a patient with pressure injury may be able to quit smoking which will improve tissue perfusion and potentially take a maintenance wound to a healable wound.

Local Wound Care: Wound History

Consider the assessment of a wound. When assessing a PI, it's important to gather additional information about the wound including:

- Location of the PI – The location of the wound may provide clues on which surfaces may be causing the pressure. For example, PIs on the ischial tuberosity's are often caused by the surface a person is sitting on, whereas PI's over the sacrum are often caused by surfaces the person is laying on.
- Duration of the PI – PI's that have been chronic and ongoing are more likely to become maintenance or non-healable, and repeated trauma to the wound can decrease the tensile strength of the skin (Ireton et al., 2013).
- Previous treatments – Gathering information on previous dressings can be useful in developing a plan for the person going forward.

Local Wound Care

Debridement

For PI's that are healable, it is important to remove any necrotic tissue. Necrotic tissue may harbor bacteria and facilitate infection, or produce a prolonged inflammatory response (Sibbald et al., 2021). Methods of debriding are reviewed in Chapter 1. For patients with decreased sensation to the wound, adequate pain control is still an essential component of sharp debridement to prevent adverse effect of the central nervous system eg. autonomic dysreflexia in a patient with a spinal cord injury.

For PI's that are considered non-healable or maintenance, conservative debridement may occur to manage symptoms and decrease bacteria in the wound. For PI's occurring on the lower legs and feet, debridement should only be considered if tissue perfusion is adequate (EPIAP, NPIAP, PPPIA, 2019).

Any debridement should only be performed by a skilled clinician who has the supports in place and when the skill is within their scope of practice.

Assess for infection and inflammation

NERDS and STONEES criteria have been detailed in previous chapters and are useful in guiding the assessment and treatment of infection and inflammation in PIs. Superficial swabs are not recommended to guide the diagnosis of infection in a PI. If deep and surrounding tissue infection is suspected with three or more of the STONEES criteria, identification of the organism requires tissue biopsy and culture or semi-quantitative swab technique e.g. Levine method (Angel et al., 2006).

Deep and surrounding tissue infection may extend to bone and cause osteomyelitis in some PIs. Seventeen to 43% of Stage 4 sacral PIs had histologic evidence of osteomyelitis (Turk et al., 2003). A bone biopsy is recommended (if feasible) to diagnose osteomyelitis if there is clinical suspicion as superficial cultures are not always reliable and imaging is limited by variable specificity (Hatzenbuehler et al., 2011). A comprehensive discussion of osteomyelitis is beyond the scope of this chapter but this is an active area of research in wound management (Wong et al., 2019).

Moisture Management

A moist wound environment is ideal for cells to grow in a healable PI. For a PI that is considered non-healable or maintenance, the goal is to keep the wound bacteria free and stabilize the wound environment. It is appropriate to use antiseptic solutions to maintain a dry wound environment, especially for PI's that occur on the feet or heels (EPIAP, NPIAP, PPPIA, 2019).

Evaluate Rate of Healing

A 20% to 40% reduction in size is expected by week 4, if not then the wound is unlikely to heal by week 12. If the wound is classed as healable but has stalled then referral for comprehensive interprofessional wound assessment is suggested. Also, be aware of atypical transformation in chronic wounds (Day & Chakari, 2018).

Refer for consultation for surgical correction if all contributing factors have been corrected, recognizing that there is a high risk of recurrence of PIs particularly if the patient has scoliosis, an oblique pelvis, diabetes, BMI<18.5 or an ischial PI. Recurrence risk ranges from 28.6 to 58.7%. (Schryvers et al., 2000; Bamba et al. 2017) For PIs that do not meet the expected rate of closure, a comprehensive reassessment of the individual including the PI, their environment and all potential causative factors are warranted.

Edge Effect

It is essential to address the cause and contributing factors that delay healing prior to treating a PI with adjunctive therapies. Electrical stimulation has been proven (level A evidence (EPIAP, NPIAP, PPPIA, 2019)) to support accelerated healing in stage 2, 3, and 4 PIs (RNAO, 2016; EPIAP, NPIAP, PPPIA, 2019).

Other active therapies (ultrasound, electromagnetic therapy, hyperbaric oxygen and topical oxygen) have lower levels of evidence, but may support healing of PI (RNAO, 2016).

Organizational Support

PI prevention and treatment cannot be performed by one individual healthcare profession alone. Interprofessional teams are necessary for optimal outcomes. The person with the PI along with family involvement is essential in PI prevention and treatment. Facilities and agencies need to allot resources to support effective PI prevention strategies. These may include organizational leadership, resources for prevalence and incidence surveillance, education for staff and sustainability strategies for such initiatives.

Conclusion and References

CONCLUSION

Risk assessment and prevention of a PI is an essential part of caring for a person. For persons at risk, appropriate interventions need to be in place and communicated to caregivers across the care continuum. Treating a person with a PI requires a holistic approach to provide treatment that will maintain health and quality of life.

REFERENCES

Allen KJ, Leslie SW. Autonomic Dysreflexia. [Updated 2021 Aug 19]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK482434/

Allard, J.P., Keller, H., Jeejeebhoy, K.N., Laporte, M., Duerksen, D., Gramlich, L., et al. Malnutrition at hospital admission: Contributors and impact on length of stay. A prospective cohort study from the Canadian Malnutrition Task Force. (2016) *Journal of Parenteral Enteral Nutrition* 40(4), 487–97

Agarwal, E., Ferguson, M., Banks, M., Batterham, M., Bauer, J., Capra, S., et al. (2013) Malnutrition and poor food intake are associated with prolonged hospital stay, frequent readmissions, and greater in-hospital mortality: Results from the Nutrition Care Day Survey 2010*. Clinical Nutrition 32(5), 737–45.*

Angel D.E., Lloyd, P., Carville, K., Santamaria, C.L., Hillis, S.L., Park, H., Scherubel, M. (2006) Diagnostic validity of three swab techniques for identifying chronic wound infection. *Wound Repair and Regeneration* 14(5), 548-57

Bamba R, Madden JJ, Hoffman AN, Kim JS, Thayer WP, Nanney LB, Spear ME. Flap Reconstruction for Pressure Ulcers: An Outcomes Analysis. Plast Reconstr Surg Glob Open. 2017 Jan 18;5(1)

Bernatchez, S.F., Mengistu, G.E., Ekholm, B.P., Sanghi, S., Theiss, S.D. (2015) Reducing friction on Skin at Risk: The Use of 3M TM Cavilon TM No Sting Barrier Film. *Advances in Wound Care* 4(12), 705-710

Day, D., Chakari, W., Matzen, S. H. (2018). Malignant transformation of a non-healing traumatic wound on the lower extremity: A case report. *International Journal of Surgery Case Reports* 53, 468-470. *Doi:* 10.1016/j.ijscr.2018.11.026

European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel, and Pan Pacific Pressure Injury Alliance. (2019). Prevention and Treatment of Pressure Ulcers/Injuries: Clinical Practice Guideline. The International Guideline. Emily Haesler (Ed.). EPUAP/NPIAP/PPPIA.

Fletcher, J. (2017). An Overview of Pressure Ulcer Risk Assessment Tools. *Wounds UK, 13(1),* 18-26.

Gefen, A., Levine, J. (2007) The false premise in measuring body-support interface pressures for preventing serious pressure ulcers. Journal of Medical Engineering & Technology 31(5), 375-80

Hatzenbuehler J, Pulling TJ. Diagnosis and management of osteomyelitis. Am Fam Physician. 2011 Nov 1;84(9):1027-33

Ireton, J.E., Unger, J.G, Rohrich, R.J. (2013) The Role of Wound Healing and Its Everyday Application in Plastic Surgery: A Practical Perspective and Systematic Review. *Plastic and Reconstructive Surgery Global Open* 1(1), e10-e19.

Klassen, M., Schipper, D., Masen, M. (2016) Influence of the relative humidity and the temperature on the in-vivo friction behaviour of human skin. *Biotribiology* 6, 21-28

Lustig, M., Levy, A., Kopplin, K., Ovadia-Blechman, Z., Gefen, A. (2018) Beware of the toilet: the risk for a deep tissue injury during toilet sitting. *Journal of Tissue Viability* 27(1), 23-31.

Mackay E. Malnutrition and wound healing. (2019) *Wound Care Canada* 17(3), 32-36.

McNichol, L., Mackey, D., Watts, C., Zuecca, N. (2020). Choosing a Support Surface for Pressure Injury Prevention and Treatment. *Nursing 2020 Wolters Kluwer Health Inc. 50(2),* 41-44. DOI-10.1097/01.NURSE.0000651620.87023.d5

Mhatre P, Huang M, Cohler M. Autonomic dysreflexia with negative-pressure wound therapy: a report of two cases. PM R. 2013 Mar;5(3):238-41

Moulin D, Boulanger A, Clark AJ, Clarke H, Dao T, Finley GA, Furlan A, Gilron I, Gordon A, Morley-Forster PK, Sessle BJ, Squire P, Stinson J, Taenzer P, Velly A, Ware MA, Weinberg EL, Williamson OD; Canadian Pain Society. Pharmacological management of chronic neuropathic pain: revised consensus statement from the Canadian Pain Society. Pain Res Manag. 2014 Nov-Dec;19(6):328-35.

Mu A, Weinberg E, Moulin DE, Clarke H. Pharmacologic management of chronic neuropathic pain: Review of the Canadian Pain Society consensus statement. Can Fam Physician. 2017 Nov;63(11):844-852.

Ness, S.J., Hickling, D.F., Bell, J.J., Collins, P.F. (2018) The pressures of obesity: The relationship between obesity, malnutrition and pressure injuries in hospital inpatients. *Clinical Nutrition* 37(5), 1569–74

Norton, Linda BScOT, OT Reg(ONT), MScCH; Coutts, Patricia RN, IIWCC; Sibbald, R. Gary MD, MEd, BSc, FRCPC(Med)(Derm), MACP, FAAD, MAPWCA Beds, Advances in Skin & Wound Care: July 2011 – Volume 24 – Issue 7 – p 324-332

Okan, D., Woo, K., Ayello, E.A., Sibbald, R.G. (2007). The Role of Moisture Balance in Wound Healing. *Advances in Skin & Wound Care 20,* 39-53.

Padula WV, Delarmente BA. The national cost of hospital-acquired pressure injuries in the United States. Int Wound J. 2019 Jun;16(3):634-640.

Posthauer, M.E., Banks, M., Dorner, B., Schols, J. (2015) The role of nutrition for pressure ulcer management. National Pressure Ulcer Advisory Panel, European Pressure Ulcer Advisory Panel, and Pan Pacific Pressure Injury Alliance white paper. *Advances in Skin and Wound Care* 28(4), 175–88

Registered Nurses' Association of Ontario (2016). Assessment and Management of Pressure Injuries for the Interprofessional Team, Third Edition. Toronto, ON: Registered Nurses' Association of Ontario.

Schryvers OI, Stranc MF, Nance PW. Surgical treatment of pressure ulcers: 20-year experience. Arch Phys Med Rehabil 2000;81:1556-62

SCIRE at https://scireproject.com/

Sibbald, R. G., Elliott, J. A., Persaud-Jaimangal, R., Goodman, L., Armstrong, D. G., Harley, C., Coelho, S., Xi, N., Evans, R., Mayer, D. O., Zhao, X., Heil, J., Kotru, B., Delmore, B., LeBlanc, K., Ayello, E. A., Smart, H., Tariq, G., Alavi, A., & Somayaji, R. (2021). Wound Bed Preparation 2021. *Advances in Skin & Wound Care*, *34*(4), 183–195.

Türk EE, Tsokos M, Delling G. Autopsy-based assessment of extent and type of osteomyelitis in advanced-grade sacral decubitus ulcers: a histopathologic study. Arch Pathol Lab Med. 2003 Dec;127(12):1599-602

White J. Consensus statement: ASPEN – Characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). (2016) *Journal of Academy Nutrition and Dietetics.* 112(5), 730–38

Darren Wong, Paul Holtom, Brad Spellberg, Osteomyelitis Complicating Sacral Pressure Ulcers: Whether or Not to Treat With Antibiotic Therapy, *Clinical Infectious Diseases*, Volume 68, Issue 2, 15 January 2019, Pages 338–342

Self-Check

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://ecampusontario.pressbooks.pub/skinandwoundcare/?p=1048#h5p-6

CHAPTER 11

Chapter 11: Skin Tears

- Author:
  Kimberly LeBlanc PhD, RN, NSWOC, WOCC(C), FCAN
  Samantha Wiesenfeld (Student Nurse)

Key Learning Statements

- Skin tears are prevalent wounds found predominantly among aging populations
- Skin tears are acute wounds, which have a high risk of becoming chronic and complex wounds if not managed appropriately
- The primary focus of skin tear management should be on skin tear prevention

The International Skin Tear Advisory Panel (ISTAP) defines Skin Tears (STs) as "*a traumatic wound caused by mechanical forces, including removal of adhesives. Severity may vary by depth (not extending through the subcutaneous layer)*" (LeBlanc et al., 2018).

Skin Tears are considered the most prevalent wound etiology found in the Long-term Care (LTC) setting (Carville et al., 2014). The prevalence of STs in the LTC population are reported between 3.9% and 26.0% (Chang et al., 2016; Koyano et al., 2016; LeBlanc, Christensen, et al., 2013; Skiveren et al., 2017; Woo et al., 2017). The ST incidence within the LTC population has been reported to be between 2.2% and 16.0% (Payne & Martin, 1990; Sanada et al., 2015). If improperly identified and managed, they can become chronic and complex wounds, leading to individual pain, suffering, and increased costs to the healthcare system (LeBlanc & Baranoski, 2011).

SKIN TEAR RISK FACTORS

Figure 1: Skin Tear Risk Framework © LeBlanc 2017 (used with permission)

General Health -Chronic/Critical Diseases – Aggressive BehaviourMobility – Dependence for Activities of Daily Living (including functional mobility) – History of falls Skin – History of previous skin tears – Skin changes Associated with Aging (skin Atrophy, Ecchymosis, Senile Purpura, Hematoma, Stellate Pseudi Scar) – Photo-damage	>	Mechanical Skin Trauma – Shear, Friction and/or Blunt Force TraumaIndividual / Care-giver / Healthcare Professional – Knowledge of Skin Tear Prevention Strategies – Attitude – Practice or Approach of providing Care Physical Environment – Healthcare Setting – Skin Tear Audit Programs – Support for skin tear Reduction ProgramsInterprofessional Approach to Care	>	Skin Tear Development

STs are frequently seen in the extremes of age, the critically and chronically ill, and those who require assistance with activities of daily living (ADLs) (LeBlanc & Baranoski, 2011; LeBlanc et al., 2018; Rayner et al., 2015). Furthermore, a history of falls, decreased levels of mobility, agitated behaviour and non-responsiveness are reported to be additional risk factors for ST development (LeBlanc et al., 2020; Strazzieri-Pulido et al., 2015).

In addition to the above-mentioned risk factors, it has been reported that the greatest predictor of ST development is having a history of previous skin tears (LeBlanc et al., 2020, 2021). LeBlanc, Woo, VanDenKerkhof and Woodbury (2021) concluded that other skin related issues such as skin changes associated with aging (skin atrophy, ecchymosis, senile purpura, and stellate pseudo scar), hematomas, and photo-damage present as risk factors for ST development (LeBlanc et al., 2020, 2021).

LeBlanc, Woo, VanDenKerkhof and Woodbury (2021) (Figure 1), maintain that the above-mentioned risk factors will not independently result in ST development. STs will develop from meditating factors that include exposure to:

- medical adhesives or other forms of mechanical skin trauma
- dismissive healthcare professional or caregiver attitudes towards ST prevention
- a physical environment which heightens the risk for STs
- lack of healthcare setting commitment to the prevention of skin tears.

SKIN TEAR PREVENTION

ISTAP maintains that the best method for managing STs is to develop a targeted prevention program (LeBlanc & Baranoski, 2011; LeBlanc et al., 2018) (Table 1). A 2014 study performed by Carville et al. (2014), reported that simply applying moisturizer / emollient once or twice a day can reduce skin tear incidence by up to 50% (Carville et al., 2014). Skin changes that occur due to aging can contribute to disruptions in the normal functioning skin barrier; ultimately resulting in the skin being more susceptible to ST development (Carville et al., 2014). Moisturizers can provide added protection against ST development by aiding in skin hydration.

Table 1. Risk reduction programme checklist (adpated from Lebalc and Baranoski, 2011)

RISK FACTOR	ACTION
Skin	• Inspect skin and investigate previous history of skin tears • Patient has dry fragile, vulnerable skin, assess risk of accidental trauma • Manage dry skin and use emollient to rehydrate limb as required • Implement an individualized skin care plan using a skin friendly cleanser (not additional soap) and warm (not hot) water • Prevent skin trauma from adhesives dressings and tapes (use silicon tape and cohesive retention bandages) • Consider medications that may directly affect skin (e.g. topical and systemic steroids) • Be aware of increased risk due to extremes of age • Discuss use of protective clothing (e.g. shin guards long sleeves or retention bandages • Avoid sharp fingernails or jewelry in patient contact
Mobility	• Encourage active involvement/exercises if physical function is impaired • Avoid friction and sharing (e.g. use glide sheets hoists) using good manual handling techniques as per local guidelines • Conduct falls risk assessment • Ensure that sensible comfortable shoes are worn • Apply clothing and compressions garments carefully • Ensure a safe environment – adequate lighting removing obstacles • Use padding for equipment (as per local policy) and furniture • Assess potential skin damage from pets
General health	• Educate patient and carers on skin tear risk and prevention • Actively involved a patient/carer in case of decisions were appropriate • Optimize nutrition and hydration referring to dietitian if necessary • Refer to appropriate specialist if impaired sensory perception is problematic (e.g. diabetes • Consider possible effects of medications and polypharmacy under patient's skin

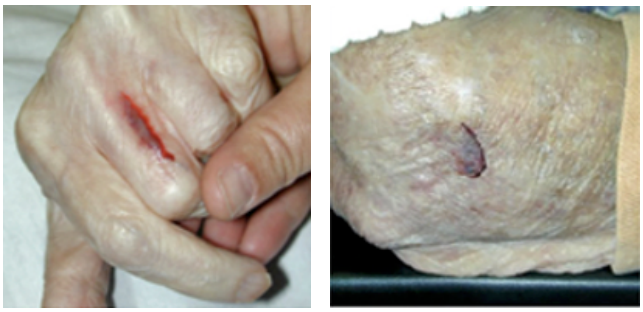
CLASSIFYING SKIN TEARS

The International Skin Tear Advisory Panel developed and validated the ISTAP Skin Tear Classification system (Figure 2) to establish common terminology and a standardized method for describing and documenting STs. This classification system should be used for the assessment and documentation of STs (LeBlanc, Baranoski, Holloway, Langemo., 2013).

IASTAP Skin tear Classification

Type 1

NO SKIN LOSS



Linear or Flap Tear which can be repositioned to cover the wound bed.

Type 2

PARTIAL FLAP LOSS

Partial Flap loss which cannot be repositioned to cover the wound bed.

Type 3

TOTAL FLAP LOSS

Total Flap loss exposing entire wound deb.

Figure 2: ISTAP ST Classification System ©ISTAP 2013 used with permission

"A flap in skin tears is defined as a portion of the skin (epidermis/dermis) that is unintentionally separated (partially or fully) from its original place due to shear, friction, and/or blunt force. This concept is not to be confused with tissue that is intentionally detached from its place of origin for therapeutic use e.g. surgical skin grafting" (Van Tiggelen et al., 2020).

SKIN TEAR ASSESSMENT

Initial management of STs should include controlling bleeding, re-approximation of wound edges and classification according to the ISTAP ST classification system (Figure 3).

SKIN TEARS

↓

Control Bleeding **ASSESS**

↓

CLEANSE

↓

APPROXIMATE WOUND EDGES CLASSIFY (Measure and Document)

↓

GOALS OF TREATMENT

- Treat the Cause
- Implement Prevention
- Protocol

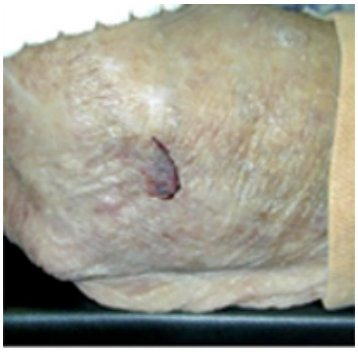
- Moist Wound Healing
- Avoid Trauma
- Protect Periwoud Skin

- Manage Exudate
- Avoid Infection
- Pain Infection

↓

TREATMENT OPTIONS IN ACCORDANCE WITH LOCAL WOUND CONDITIONS

TYPE 1: NO SKIN LOSS



Type 2: PARTIAL FLAP LOS

Type 3: TOTAL FLAP LOSS

SKIN TEAR MANAGEMENT

Skin tears are acute wounds which should have a wound healing trajectory of 14 to 21 days. Type 1 STs have the potential to be closed by primary intention, while type 2 and 3 STs will close by secondary intention. It is imperative that they are properly managed to prevent progression towards chronic and complex wounds (Figure 3) (LeBlanc, Baranoski, et al., 2013). Once the ST has been classified, the next steps include addressing patient concerns, treating the cause, initiating a ST prevention program, avoiding recurrent trauma, protecting the peri-wound skin, promoting moist wound healing, managing exudate, avoiding infection, and controlling pain (LeBlanc et al., 2018). ISTAP also recommends assessing for and controlling co-morbidities. This includes completing a lower leg assessment, if the ST is on the lower leg, and initiating compression therapy when indicated (LeBlanc et al., 2018). ISTAP further recommends that sutures, staples and skin closure strips should be avoided given the fragility of the ST peri-wound skin (LeBlanc et al., 2018).

Dressing selection should include products that will not add an increased risk for trauma, provide moist wound healing and manage pain (LeBlanc et al., 2018). LeBlanc and Woo (2021) conducted a pragmatic randomised controlled clinical study to evaluate the use of silicone dressings for the treatment of STs. They concluded that silicone dressings (silicone contact layers or silicone foam dressings) are a superior option for the treatment of STs. In their study, it was reported that STs healed almost two times faster with silicone dressings compared with conventional nonadherent dressings over the course of three weeks. Furthermore, the proportion of healed subjects was almost three times higher in the silicone treatment group.

Conclusion and Summary

CONCLUSION

Health care professionals must recognize STs as highly prevalent wounds found predominantly among the aging populations. STs are acute wounds that should heal in a timely manner, however, when mismanaged, they can become chronic and complex. Management of STs should center around ST prevention. When STs do occur, care must be taken to ensure that topical treatments decrease trauma, provide moist wound healing and manage pain.

REFERENCES

Carville, K., Leslie, G., Osseiran-Moisson, R., Newall, N., & Lewin, G. (2014). The effectiveness of a twice-daily skin-moisturising regimen for reducing the incidence of skin tears. *International Wound Journal*, 11(4), 446-453.

Chang, Y. Y., Carville, K., & Tay, A. C. (2016). The prevalence of skin tears in the acute care setting in Singapore. *International Wound Journal*, 13(5), 977-983.

Koyano, Y., Nakagami, G., Iizaka, S., Minematsu, T., Noguchi, H., Tamai, N., Mugita, Y., Kitamura, A., Tabata, K., & Abe, M. (2016). Exploring the prevalence of skin tears and skin properties related to skin tears in elderly patients at a long-term medical facility in Japan. *International Wound Journal*, 13(2), 189-197.

LeBlanc, K., & Baranoski, S. (2011). Skin tears: state of the science: consensus statements for the prevention, prediction, assessment, and treatment of skin tears. *Advances in Skin & Wound Care*, 24(9), 2-15.

LeBlanc, K., Baranoski, S., Holloway, S., & Langemo, D. (2013). Validation of a new classification system for skin tears. *Advances in Skin & Wound Care*, 26(6), 263-265.

LeBlanc, K., Campbell, K. E., Wood, E., & Beeckman, D. (2018). Best practice recommendations for prevention and management of skin tears in aged skin: an overview. *Journal of Wound Ostomy & Continence Nursing*, 45(6), 540-542.

LeBlanc, K., Christensen, D., Cook, J., Culhane, B., & Gutierrez, O. (2013). Prevalence of skin tears in a long-term care facility. *Journal of Wound Ostomy & Continence Nursing*, 40(6), 580-584.

LeBlanc, K., & Woo, K. (2021). A pragmatic randomised controlled clinical study to evaluate the use of silicone dressings for the treatment of skin tears. *International Wound Journal*.

LeBlanc, K., Woo, K. Y., VanDenKerkhof, E., & Woodbury, M. G. (2020). Skin tear prevalence and incidence in the long-term care population: a prospective study. *Journal of Wound Care*, 29(Sup7), S16-S22.

LeBlanc, K., Woo, K. Y., VanDenKerkhof, E., & Woodbury, M. G. (2021). Risk Factors Associated with Skin Tear Development in the Canadian Long-term Care Population. *Advances in Skin & Wound Care*, 34(2), 87-95.

Payne, R., & Martin, M. (1990). The epidemiology and management of skin tears in older adults. *Ostomy/wound management*, 26, 26-37.

Rayner, R., Carville, K., Leslie, G., & Roberts, P. (2015). A review of patient and skin characteristics associated with skin tears. *Journal of Wound Care*, 24(9), 406-414.

Sanada, H., Nakagami, G., Koyano, Y., Iizaka, S., & Sugama, J. (2015). Incidence of skin tears in the extremities

among elderly patients at a long-term medical facility in Japan: A prospective cohort study. *Geriatrics & Gerontology International*, 15(8), 1058-1063.

Skiveren, J., Wahlers, B., & Bermark, S. (2017). Prevalence of skin tears in the extremities among elderly residents at a nursing home in Denmark. *Journal of Wound Care*, 26(Sup2), S32-S36.

Strazzieri-Pulido, K. C., Peres, G. R. P., Campanili, T. C. G. F., & Santos, V. L. C. d. G. (2015). Skin tear prevalence and associated factors: a systematic review. *Revista da Escola de Enfermagem da USP*, 49, 0674-0680.

Van Tiggelen, H., LeBlanc, K., Campbell, K., Woo, K., Baranoski, S., Chang, Y., Dunk, A., Gloeckner, M., Hevia, H., & Holloway, S. (2020). Standardizing the classification of skin tears: validity and reliability testing of the International Skin Tear Advisory Panel Classification System in 44 countries. *British Journal of Dermatology*, 183(1), 146-154.

Woo, K. Y., Sears, K., Almost, J., Wilson, R., Whitehead, M., & VanDenKerkhof, E. G. (2017). Exploration of pressure ulcer and related skin problems across the spectrum of health care settings in Ontario using administrative data. *International Wound Journal*, 14(1), 24-30.

CHAPTER 12

Chapter 12: Inflammatory & Infected Wounds

Authors:

- Muskaan Sachdeva (BHSc)1,
- Afsaneh Alavi (MD, FRCPC)1,2

Learning Objectives

- To review the clinical features and management strategies of Hidradenitis Suppurativa
- To review the clinical features and management strategies of Pyoderma Gangrenosum
- To review the clinical features and management strategies of Vasculitis

HIDRADENITIS SUPPURATIVA

Hidradenitis suppurativa (HS) is a recurring, chronic, and inflammatory condition that affects skin predominantly in apocrine glands bearing areas, although the primary defect is in the hair follicle. The early primary lesions are solitary, painful, round nodules that may remain unchanged for weeks or months with occasional inflammation. In most severe cases, the nodules evolve to become abscesses and may burst spontaneously or after excision. The secondary lesions lead to the formation of tunnels or sinus tracts and release of serous, purulent, or blood-stained discharge with a foul odour. In some cases, ulcerations can occur. A characteristic feature of secondary lesions is hypertrophic scars which may appear as indurate plaques or linear rope like bands (Figure 1).

HS usually presents after puberty with a global prevalence of 1% in the general population. There is often a family history of HS and its associated diseases (severe acne, arthritis, Type 2 diabetes mellitus, metabolic syndrome and inflammatory bowel disease). In Danish young women, a peak prevalence of 4% has been reported. The causes of hidradenitis suppurativa are unknown however risk factors including tobacco, genetics, infections, immunity, and obesity have been hypothesized. HS is a genetically heterogenous disease with several different mutations. Furthermore, although bacteria are heavily involved in the clinical manifestation of HS, the micro-organisms do not play a causative role but secondary infections do occur. There also appears to be some hormonal factors associated with the disease. Specifically, the higher frequency in females, improvement of symptoms during pregnancy, and disease resolution after menopause indicate the importance of hormonal factors in HS. A study of immunological indicators also suggests that HS may be an auto-inflammatory disease, however, more investigation in this area is needed.

Figure 1: Clinical Presentation of Hidradenitis Suppurativa

To diagnose HS, three criteria must be met. Firstly, the typical lesions described above must be present. Secondly, the lesions must be present in the typical bodily areas (not always all regions) including perineal and perianal region, axillae, groin, buttocks, infra- and inter-mammary folds more commonly in females. Lastly, the lesions must be chronic and recurrent (at least 2 flares in 6 months).

The treatment is based on severity of the disease, patient's goals and the frequency of symptom exacerbation. Smoking sensation and weight loss are often beneficial in decreasing the frequency and severity of acute episodes. HS patients benefit from interprofessional disciplinary care with evaluation of associated comorbidities and risk factors. The management of HS is a combined medical and surgical therapies. The goal of medical therapy is to control the existing inflammation, prevention of flare and new lesions. The surgical management helps removal of irreversible tissue damage, the removal of biofilms inside the tunnels and tracts as the continuous trigger of inflammatory process. For patients with recurrent painful nodules with periods of remissions, treatments like antiseptics, keratolytics, antibiotics, intralesional steroids, are used to prevent primary lesions from evolving into abscesses. For management of moderate to sever HS, antibiotics, antiandrogens, and anti-TNF drugs along with appropriate surgical procedure are suggested. (Revuz, 2009).

PYODERMA GANGRENOSUM

Pyoderma Gangrenosum (PG) is a painful ulcerative condition and the worldwide incidence of PG is estimated to be 3 to 10 cases per million population per year (Monari et al., 2018). It usually presents between ages 20 to 50 years with up to 75% of PG being reported in association with a systemic disease including inflammatory arthritis, inflammatory bowel disease, and lymphoproliferative disorders. The aetiology of PG is still unknown, however, its frequent association with systemic disorders links PG to a probable underlying immunologic abnormality. Specifically, neutrophil dysfunction and interleukin-8 overexpression has been observed in some PG patients. The Pathergy phenomenon sometimes observed at the onset of PG further strengthens this hypothesis about immune disturbances.

The characteristic feature of PG is an ulcer with a raised, dusky red or purple inflammatory border and a necrotic base (Figure 2).

Primary eruptions are most common on the legs presenting as either solitary or multiple lesions. These begin as either a deep-seated painful nodule or a superficial hemorrhagic pustule, sometimes after a minor trauma (pathergy). The central ulceration occurs due to necrosis and releases a purulent and hemorrhagic exudate. The ulcer expands in one or more directions in a serpiginous (snake-like) pattern with an intense halo of bright erythema surrounding the margins (elevated rolled border). This expansion is a result of the burrowing extension of the undermined margin or from new hemorrhagic pustules in the borders. There can be one or more ulcers, and, in some cases, multiple ulcers combine to become multicentric, irregular ulcerations. PG has multiple morphological types with ulcerative (the most common), pustular (associated with inflammatory bowel disease – IBD), bullous associated with malignancy (especially acute myelogenous leukemia – AML) and vegetative (rare and with no association). In addition, 3 other ulcerative types of PG are reported: post-surgical PG, peristomal PG and drug induced PG.

Figure 2: Clinical Presentation of Pyoderma Gangrenosum

PG ulcers lose their typical characteristics by time and by partial treatment and may mimic any ulcers. The diagnosis of PG involves firstly ruling out other differential diagnoses and then, determining the presence of a treatable underlying systemic disorder. Often, procedures including blood work, biopsies for histopathology and culture, radiographic studies, flexible sigmoidoscopy, and colonoscopy are performed to rule other diagnoses based on the presenting clinical clues. Biopsy should have a predominant neutrophilic infiltrate for diagnosis as the only major criteria along with characteristic clinical features (Maverakis et al. 2018).

For ulcerative PG, the clinical presentation may include*:

- The need to rule out infection
- At least one lesion or multiple lesions on the legs
- Starts with small pustules, papules or vesicles and rapidly evolves
- Characteristic cribriform scarring (wrinkled paper-like)
- Responds to immunosuppressant therapy within a month (decrease in ulcer size)

*Modified from Maverakis et al. 2018

There is no single therapy that works for all PG patients. Instead, the treatment depends on lesion depth and rapidity of the expansion, the associated disorder, baseline patient status, and treatment tolerance. Wound management is critical in PG to improve healing. Cases with limited involvement can be treated with topical and intralesional treatments. More extensive and progressive lesions require systemic therapies. Corticosteroids the main stay of treatment but may have adverse events long term. The rapid acting agents including systemic corticosteroids or cyclosporine are often needed to control disease activity and the presence of new lesions. Other immunosuppressive agents including biologics (tumour necrosis factor – TNF inhibitors) can be used for long-term prevention of recurrences. Treatment of associated systemic disorders like inflammatory bowel disease is important but the activity of these diseases is not always directly linked to PG (Ruocco et al., 2009).

VASCULITIS

Vasculitis is defined as the destruction of blood vessel walls due to inflammatory cell infiltration. Cutaneous

vasculitis (CV), specifically, manifests most commonly on the lower legs as ulcers, purpura, purpuric papules, infarcts, infiltrating erythema (redness), urticaria (hives), livedo reticularis (net-like vasculature), nodules and digital gangrenes. Palpable purpura is the hallmark of cutaneous vasculitis and can be felt with your examining fingers and eyes closed.

The disease can progress in three ways:

• a single acute episode resolved within six months or less
• episodic relapses of showers of palpable purpura with symptom free periods
• a chronic disease with no remission.

The type of skin lesions depends on the size of the affected blood vessels. Small superficial vessel damage leads to purpuric papules and infiltrated erythema. Medium sized vessels at the dermal – epidermal junction results in the presence of nodules (elevated lesions with depth). Larger vessels in the subcutaneous fat are more likely on the proximal thighs and are more likely to ulcerate (loss of epidermis with a dermal or deeper base) (Figure 3).

Vasculitis damage to medium sized muscular arteries can result in nodules, ulcers, pitted scars and livedo reticularis depending on the extent of injury. Cutaneous vasculitis may be associated with internal organ damage. Commonly, the joints, liver and kidneys may be involved and less likely, the heart, lungs, GI tract and brain. Lastly, large vessel damage can lead to more serious symptoms including limb claudication.

Figure 3: Clinical Presentation of Vasculitis

The etiologic association of CV include 40% idiopathic cases (unknown cause), 20% adverse drug reactions, 22% related to infections, 12% associated with connective tissue disease, 10% related to IgA related small vessel vasculitis of the skin that can also affect the kidneys (previously known as Henoch Schonlein purpura) and less than 5% with malignancies. The annual incidence of biopsy proven CV is estimated to be 39.6-59.8 per million general population. Although it affects individuals from all ages, it is more prevalent in adult women with a mean age at onset of 47 years.

To diagnose CV, skin biopsy for routine light microscopy and direct immunofluorescent findings (around blood vessels with immunoglobulins or C3 complement) is performed to detect the disease and rule out other illnesses. To further support the diagnosis of CV, clinical history, physical and lab findings, along with angiographic assessment in selected patients may be needed. Specifically, information like affected vessel size, and the presence and type of internal organ involvement can assist in a specific diagnosis. Specialized tests are recommended including hepatitis B and C, comprehensive blood chemistry, complete blood count, urine analysis and chest radiographs. Consider HIV testing in selected patients. With chronic or recurrent disease, other immune tests including ANCA (antineutrophilic cytoplasmic antibodies), ANA (antinuclear antibodies) and ENA (extractable nuclear antigen includes Ro/SS-A antibody) and complement levels may be required. Selected patients may require urine toxicology for cocaine / levamisole, ECHO cardiography, visceral angiography and malignancy screening.

Furthermore, if CV is present, it is important to look for any treatable causes including infection, systemic disease, and drug adverse effects since etiology often dictates disease evolution. Treatment is dictated by disease severity. For short lived single episodes, measures like leg elevation, avoiding cold exposure and tight-fitting clothes, antihistamines, and anti-inflammatory agents are recommended. For persistent and recurrent disease with burning and itching sensations, dapsone and colchicine are commonly ordered. For moderate to severe disease with extensive persistent symptoms like ulcers and nodules, prednisone, azathioprine, and methotrexate are recommended. If there is risk of permanent damage or death, more aggressive treatment including high-dose

prednisone combined with cyclophosphamide or azathioprine are used. For treatment resistant disease with a specific underlying condition, novel therapies including TNF inhibitors are recommended (Carlson et al., 2006).

Authors:

Authors: Muskaan Sachdeva (BHSc)1, Afsaneh Alavi (MD, FRCPC)1,2
[1]Faculty of Medicine, University of Toronto, Canada
[2]Department of Dermatology, Mayo Clinic, Rochester, MN
Corresponding Author:
Afsaneh Alavi, MD, FRCPC
Department of Dermatology
Mayo Clinic , Rochester, MN
55905, United states
Email: alavi.afsaneh@mayo.edu
Figures: 2
Conflicts of interest:
Dr. Alavi received honoraria from AbbVie, Arcutis, BMS Boehringer-Ingelheim, Bausch Celgene, Dermira, Dermovant, DSBiopharma, Eli Lilly, EMD Serono, Galderma, Glenmark, GSK, Incyte, Ilkos, Janssen, LEO Pharma, Kyowa Kirin, Kymera, Merck, Novartis, Pfizer, Regeneron, Roche, Sanofi Aventis, UCB,Valeant, Xenon, and Xoma.
Ms. Sachdeva has no conflicts of interest to disclose.

References

Carlson, J. A., Cavaliere, L. F., & Grant-Kels, J. M. (2006). Cutaneous vasculitis: Diagnosis and management. *Clinics in Dermatology*, *24*(5), 414–429. https://doi.org/10.1016/j.clindermatol.2006.07.007

Jemec, G. B. (2012). Hidradenitis suppurativa. *New England Journal of Medicine*, 366(2), 158-164.

Maverakis E, Ma C, Shinkai K, Fiorentino D, Callen JP, Wollina U, Marzano AV, Wallach D, Kim K, Schadt C, Ormerod A, Fung MA, Steel A, Patel F, Qin R, Craig F, Williams HC, Powell F, Merleev A, Cheng MY. Diagnostic Criteria of Ulcerative Pyoderma Gangrenosum: A Delphi Consensus of International Experts. JAMA Dermatol. 2018 Apr 1;154(4):461-466. doi: 10.1001/jamadermatol.2017.5980. PMID: 29450466.

Monari, P., Moro, R., Motolese, A., Misciali, C., Baraldi, C., Fanti, P. A., Caccavale, S., Puviani, M., Olezzi, D., Zampieri, P., Trevisan, G., Nan, K., Fiorentini, C., Pellacani, G., & Gualdi, G. (2018). Epidemiology of pyoderma gangrenosum: Results from an Italian prospective multicentre study. *International Wound Journal*, *15*(6), 875–879. https://doi.org/10.1111/iwj.12939

Ruocco, E., Sangiuliano, S., Gravina, A. G., Miranda, A., & Nicoletti, G. (2009). Pyoderma Gangrenosum: An updated review. *Journal of the European Academy of Dermatology and Venereology*, *23*(9), 1008–1017. https://doi.org/10.1111/j.1468-3083.2009.03199.x

Revuz, J. (2009). Hidradenitis suppurativa. Journal of the European Academy of *Dermatology and Venereology*, 23(9), 985-998.

CHAPTER 13

Chapter 13: Burn Injury: Assessment and Management Principles

Author:

- Alan David Rogers (MBChB, MMed, FC Plast Surg, FRCSI, MSc, FACS)

Learning Objectives

1. Evaluate accurate depth and extent of burns to determine appropriate treatment
2. Recognize the role and criteria for referral to centralized burn units equipped with resources and multi-professional staff
3. Review the sequelae of burn injuries (and its treatment) that may include long term functional and psychosocial effects

INTRODUCTION

Although most burns are minor and can be managed on an ambulatory basis, severe burns and those that meet specific criteria should be referred to regional burn units (Palmieri, 2015) (Table 1).

Table 1. American Burn Association criteria for referral to a burn unit (Palmieri, 2015).

1	Partial-thickness burns >10% of the total body surface area
2	Deep burns
3	Burns involving the face, hands, feet, genitalia, perineum, or major joints
4	Circumferential extremity burns
5	Electrical burns and lightning injury
6	Chemical burns
7	Inhalational injury
8	Potentially complicating comorbidities
9	Significant associated trauma
10	Lack of qualified personnel or equipment for the care of children
11	Patients who require special social, emotional, rehabilitation, e.g., suspected child abuse

These units are staffed by specialist nurses, therapists, social workers, surgeons, dietitian, amongst others. Within such settings, burn care is a systematized, goal-directed process.

ETIOLOGY AND PATHOGENESIS

The severity of thermal injuries is influenced by patient age, the mechanism of injury, the duration of contact with the agent, the depth and extent of the burn, and the anatomical site involved. Most pediatric and geriatric burns are caused by scalds from boiling water or cooking oil. Flame burns are more common in adults, are often deeper and more extensive, and are responsible for most mortalities. Contact, electrical and chemical burns account for the balance, are frequently deep injuries to the palms of the hands, and may result in significant morbidity relative to the size of the burn.

Thermal injury is a unique form of traumatic injury; direct tissue injury to the skin with associated inflammation and plasma loss may compromise multiple organ systems if extensive. Three concentric 'Jackson zones' of tissue injury characterize a full-thickness burn: coagulation, stasis, and hyperemia (Hettiaratchy S, 2004) (Figure 2).

The central zone of coagulation results from coagulative and ischemic necrosis from direct contact with the heat source and may appear white or charred. The intermediate zone of stasis is usually red, and while it may initially blanch with pressure, the area may evolve to be deeper, depending on the success or otherwise of local and systemic resuscitation efforts. The outer zone of hyperemia blanches with the application of pressure, indicating that it has intact circulation.

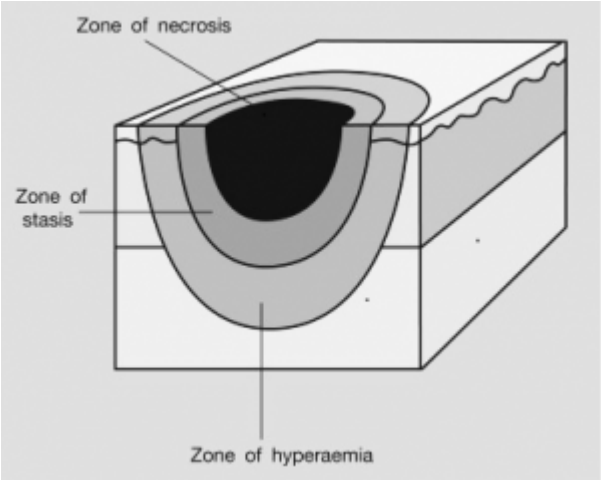


Figure 2. Jackson Zones of Burn Injury

Major burn injury is characterized by a syndrome of sustained hypermetabolism, with an exaggerated systemic release of cytokines and other mediators of inflammation. Increased vascular permeability leads to extravasation and edema, which becomes greater with the administration of the fluid necessary to maintain organ perfusion. Hypovolemia accounts for decreased perfusion and oxygen delivery which is exaggerated by evaporative and conductive water loss from the deficient epidermis. (Jeschke M, 2020) (Figure 3)

Table 2. Functions of the skin

1	Provides a protective barrier against mechanical, thermal and physical injury and hazardous substances.
2	Prevents loss of moisture.
3	Reduces harmful effects of UV radiation.
4	Acts as a sensory organ (touch, detects temperature).
5	Helps regulate temperature.
6	An immune organ to detect infections.

EMERGENCY MANAGEMENT

Initial assessment of a patient with a burn injury entails an Advanced Trauma Life Support (ATLS) style approach, including a primary survey to identify and treat immediately life-threatening conditions, followed by a secondary head-to-toe examination. For suspected inhalation injury, deep facial burns, and extensive burns, 100% oxygen is administered by face mask; early intubation and mechanical ventilation may be required. Patients with inhalational injury may experience upper airway swelling, acute respiratory failure (via several mechanisms), and carbon monoxide intoxication. For extensive burns, edema of the upper airway may increase rapidly during fluid resuscitation, especially in the context of facial burns, necessitating urgent preemptive intubation (Snell, 2013).

For major burns, intravenous access should be obtained and a urinary catheter inserted. All burns should be immersed in cool running water (not ice-water) for 20 minutes and then covered. Copious irrigation of the wound with water is indicated for chemical burns, and should continue until the surface of the wound has a neutral pH. Decompressive escharotomies are emergency procedures for constricting circumferential deep burns of the arms, legs, abdomen, and chest. The purpose of these procedures is to avoid ischemia distally or the restriction of chest excursion and breathing (Figure 4).

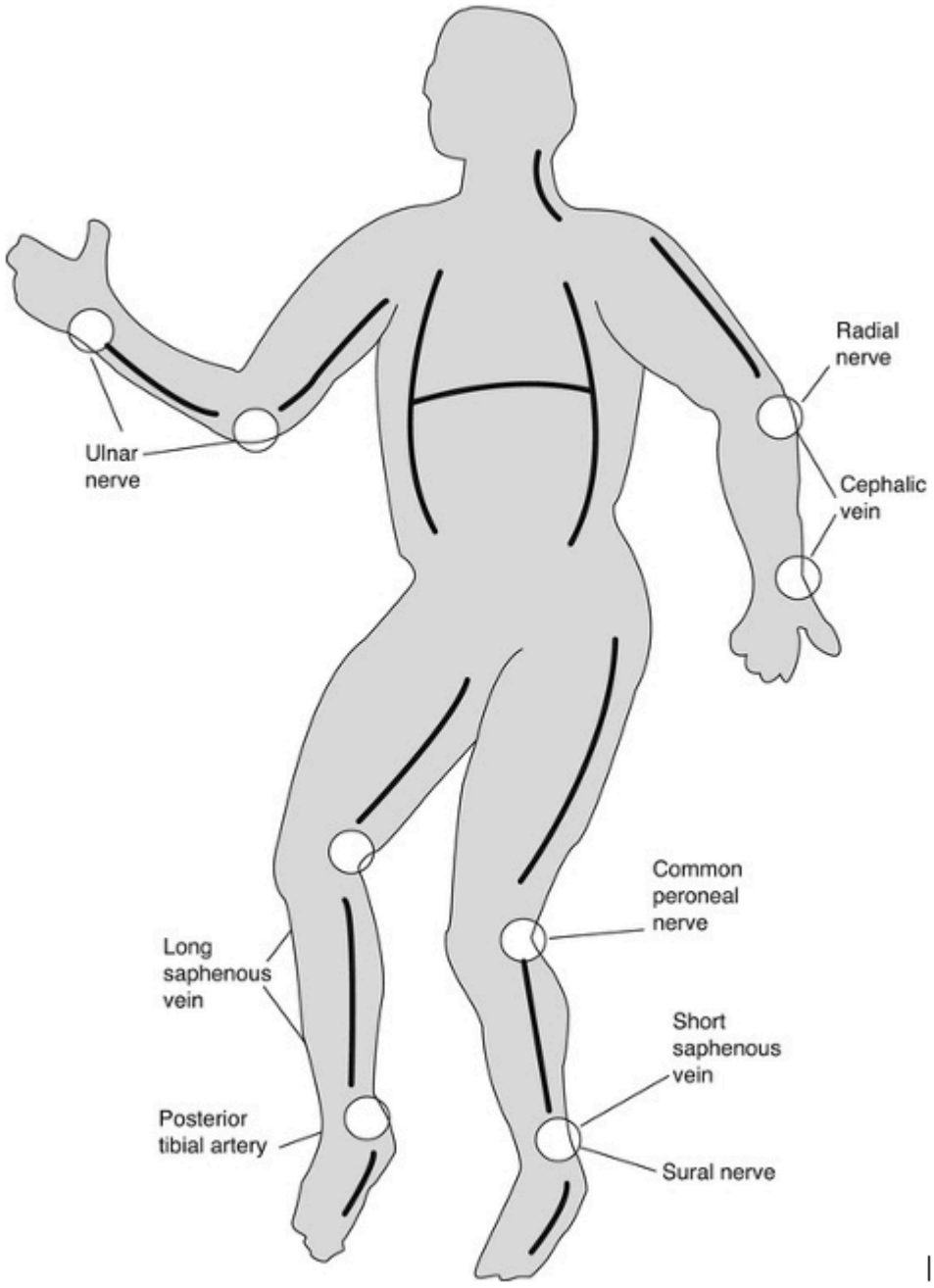


Figure 4. Locations for Escharotomy

BURN WOUND ASSESSMENT

The size of the burn injury is expressed as a percentage of the total body surface area (TBSA).
A number of methods of assessment are used, often in conjunction with each other. Methods used include:

1. The open adducted volar surface of the hand (including fingers) of the patient representing 1% of the TBSA
2. Regions of the body are allocated percentages of the TBSA depending on the age of the patient (Figure 5). (Strobel, 2018).

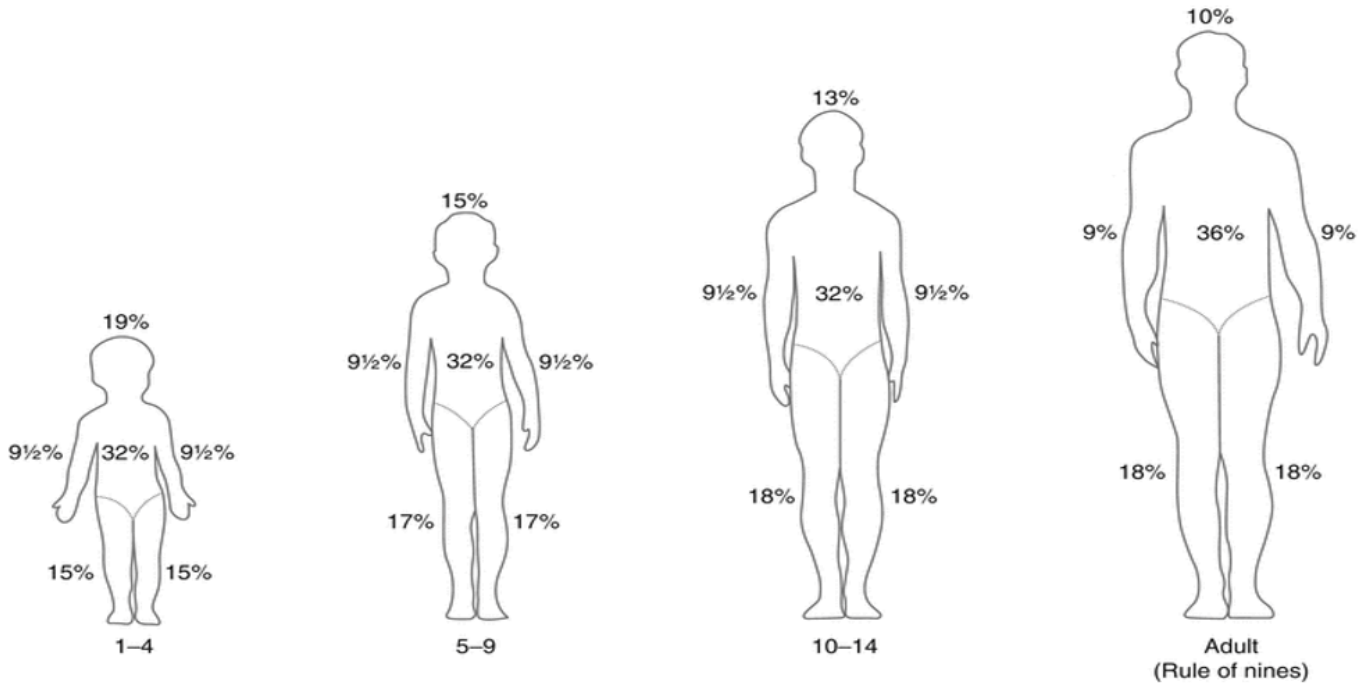


Figure 5. The Rule of Nines

The depth of the burn dictates whether conservative wound care (dressings) or surgical management should be employed and correlates with long-term appearance and function (Figure 6).

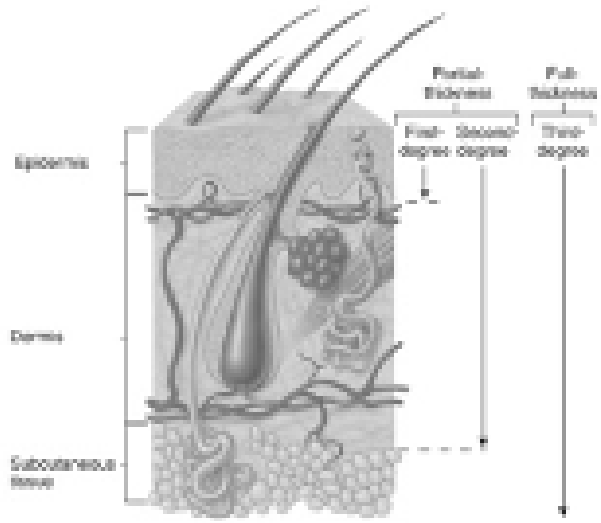


Figure 6. The layers of the skin

Early excision and skin grafting for deep burns has been shown to be beneficial in reducing infection and scarring, shortening hospital stays, and improving ultimate function. Skin grafting creates a donor site that is itself a superficial partial thickness injury, and must heal by secondary intention.

Superficial (first degree) burns injure only the epidermis, are erythematous without blistering, and are not included in the TBSA burn estimation. Superficial partial-thickness burns (superficial second degree), on the other

hand, are confined to the epidermis and the papillary layer of the dermis and usually heal within two to three weeks. Deep dermal/deep partial-thickness burns (deep second degree) involve the epidermis and dermis into the reticular layer and may require surgery. Full-thickness burns (third degree) have irreversible destruction of all elements of the skin. Many burns are a combination of injury depth, and accurate assessment may only be possible after a few days of observation, before a surgical course is chosen.

FLUID RESUSCITATION

Adequate fluid resuscitation is the most critically important aspects of early major burn care, and aims to maintain tissue and organ perfusion and minimize systemic sequelae, especially renal failure (Ho, 2020). Formal fluid resuscitation is required for burns exceeding 20% TBSA. This is usually admistered in the form of a crystalloid solution (usually lactated Ringers) at a volume of 3–4 ml per kilogram body mass per % TBSA during the first 24 h, titrated to maintain a urine output of 1ml per kg per hour in children, and 0.5ml per kg per hour in adults.

Patients who may require relatively more volume include those with full-thickness burns, inhalational injuries, electrical burns, and concomitant trauma, and for whom there was a delay in initiating resuscitation. A syndrome of overhydration has come to be known as “fluid creep” and may manifest as acute respiratory failure, pneumonia, multi-organ failure, the conversion of superficial into deeper burns, as well as abdominal, limb and orbital compartment syndromes (Saffle, 2007). Fluid resuscitation ‘failure’ may stem from an error in burn size estimation, fluid volume calculation, delay in initiating resuscitation, over-reliance on formula without titrating to effect, as well as neglecting the impact of sedating agents and analgesia on hemodynamics. Blind adherence to formula without regular evaluation and ongoing monitoring using urine output and clinical (blood pressure, pulse, sensorium) and biochemical tests (lactate, hematocrit) is perhaps the most significant concern.

Managing the Burn Wound

Superficial partial-thickness burns are usually healed within 3 weeks and are treated conservatively, which may include cleaning, debridement of blisters, topical antimicrobials, and/or occlusive or semi-occlusive dressings. Certain dressings may have an advantage over others in the management of partial-thickness burns and donor sites in terms of time to wound healing, number of dressing changes, ease of use, pain experienced, exudate management, and cost.

Silver sulfadiazine (flamazine) has been in use for several decades and remains an important dressing modality globally in the treatment of burns. It offers a cooling effect and is quick and easy to apply, smothered first in gauze. The Cochrane Review (2013) on dressings for superficial and partial thickness burns concluded "it is impossible to draw firm and confident conclusions regarding the effectiveness of specific dressings, however, silver sulfadiazine was consistently associated with poorer healing outcomes than biosynthetic, silicone coated and silver dressings whilst, hydrogel-treated had better healing outcomes than those treated with usual care." [Wasiak et al 2013]

An alternative may be a *tulle gras* (petroleum gauze or variant thereof) covered by moistened gauze and wrapped. Dressing choice may be influenced by the adherence of the wound contact layer, preferred duration and interval, the wound's moisture balance, and the presence of necrosis, slough, infection or eschar.

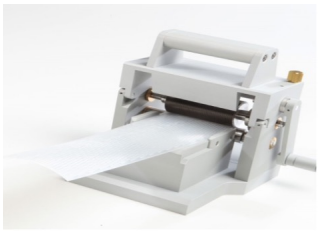
One should appreciate that all antiseptics are inherently cytotoxic. Selected agents can be diluted to offer a more biocompatible balance of antimicrobial efficacy and keratinocyte survival. Definitive temporary skin substitutes have been shown to effectively facilitate spontaneous healing in superficial partial thickness burns with a single application, and are able to reduce painful dressing changes considerably [Rogers, 2011].

Once surgically excised, deep burn wounds need to be covered with skin grafts harvested with a dermatome from unburned areas at that time or at a later surgery. These grafts can be meshed and then expanded to obtain greater wound coverage [Figure 7].

Humby knife

A Weck:Goulian blade

A dermatome



A skin graft mesher

Humby knife (a) and Weck/Goulian blade (b) for the tangential excision of deep burns for large and small/ special areas respectively. A dermatome (c) for harvesting split skin grafts, and skin graft mesher (d) to enable expansion. The ridges on the derma-carrier or on the mesher itself, depending on the design, determine the mesh ratio.

Wherever possible, the wound should be healed or operated within three weeks, in order to reduce scar hypertrophy, contracture, as well as infection. For extensive burns with limited donor sites, cadaver skin is the most effective strategy for temporary coverage [Table 2] [Allorto, 2016].

Table 2. Major indications for deceased donor allograft skin in burn centre

Indication	Application
Extensive Burn	Staged application at time of excision and removal when autograft applied Over wide meshed autograft (3:1 or Meek)
Smaller burns	Burn involving special areas (hand / face) to improve sheet autograft take Management of burn wound infection
Necrotizing Soft Tissue Infection	'Test' of wound bed/ optimize general condition prior to definitive closure
Exfoliative Skin Condition	Avoid repeated painful and traumatic dressings (alternative to Biobrane)
Complex Wound	'Test' of wound bed / optimize general condition prior to definitive closure

PAIN CONTROL

Pain management is a prominent consideration throughout the course of treatment; the goal is to have a comfortable patient who is able to participate in rehabilitation and tolerate wound care and operative interventions [Shah, 2017; Pardesi, 2017]. Acetaminophen and non-steroidal anti-inflammatory drugs (NSAIDS) should be administered by the clock unless there are contraindications. One should make use of adjunctive agents to reduce the reliance of opioid analgesics; we use both long and short acting hydromorphone and avoid analgesics containing more than one active agent. Gabapentin and pregabalin are effective in managing neuropathic pain, especially associated with donor sites and pruritic healing wounds [Nieuwendijk, 2018]. The N-methyl-D-aspartate (NMDA) receptor agonist ketamine has both analgesic and dissociative effects and may be used for conscious sedation during dressing changes but can also be provided orally. Alpha-2 agonists, like oral clonidine or a Dexmedetomidine infusion, may be used in addition to or as an alternative to benzodiazepines to manage anxiety. Non-pharmacological methods, including virtual reality, are an important consideration for awake patients [Schmitt, 2011].

NUTRITIONAL SUPPORT

Patients should be regularly assessed by a dietitian to ensure that all caloric requirements are being met, and these may be corroborated by resting energy expenditure calculations [Rousseau, 2013]. For mechanically ventilated patients with extensive burns, continuous nutritional support is essential to obtain wound healing; volume-based feeding strategies compensate for any interruptions in enteral feeding over a 24-hour period, but feeds should generally not be withheld preoperatively and should be continued throughout surgical interventions [Sudenis, 2015]. Postpyloric feeding tubes may reduce the risk of aspiration safely facilitates continuous feeds. Many of the pharmacological strategies investigated in the area of burn care aim to suppress the hypermetabolic response to major burn injury, and the consumption of resources to sustain it, redirecting them towards anabolism and wound healing [Brown, 2016].

INFECTION

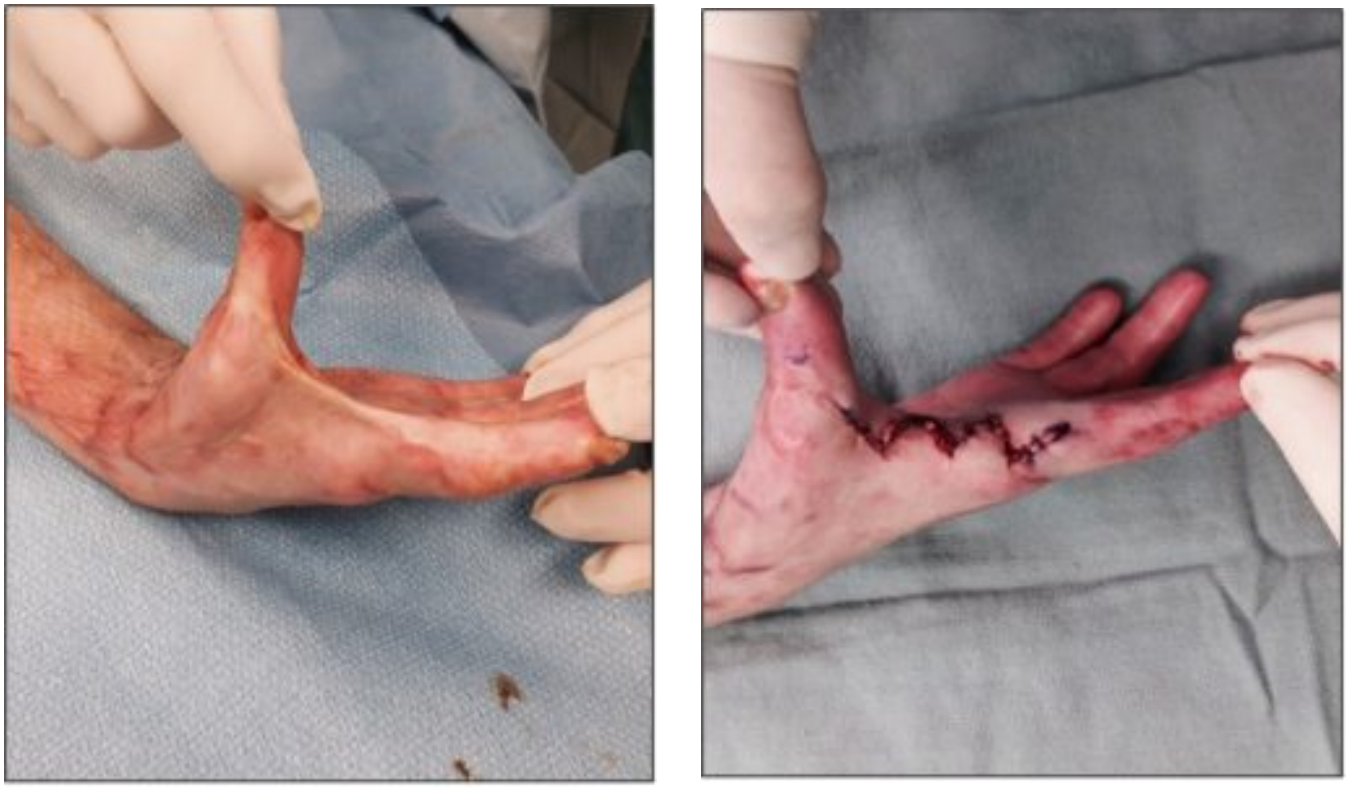
Infection remains the main cause of morbidity and mortality after burn injury. These include ventilator associated pneumonia, wound infection, and bloodstream infections associated with indwelling vascular lines, urinary catheters and endotracheal tubes necessary for their critical care [Rogers, 2014]. Infection prevention and control protocols, patient isolation, timely surgery, optimal antimicrobial dressing use and reduced duration of invasive devices, all contribute to limiting infection rates. Antibiotics are initiated empirically for systemic infection according to known resistance patterns, as well as the timing and location of infections, and adjusted subsequently based on cultures. A wide variety of topical antimicrobial dressings are in use for the management of burns and burn wound infections, and decisions should usually be made based on the dressing interface and the desired duration between dressing changes, in addition to the active antimicrobial agent.

REHABILITATION AND RECONSTRUCTION

Social workers play an integral role in coordinating important decisions and facilitating reintegration. Similarly, occupational and physical therapists help to prevent or decrease deconditioning, maintain function and joint range of motion, and reduce the negative sequelae of scarring. Splinting, pressure garment use, steroid injection and silicone gel sheeting are modalities that may reduce the need for burn reconstruction [Tredget, 2014] but laser

therapy offers a number of beneficial effects [Zuccaro, 2018]. Burn reconstruction surgery is sometimes required to address extensive burn scarring and contracture through reorienting, resurfacing and lengthening procedures [Friedstadt, 2014; Cartotto, 2014] [Figure 9].

Figure 9: Surgical release of the right first web space burn contracture



Surgical release of the right first web space burn contracture nine months after autografting of a right-hand flame burn injury. The left picture depicts the hand prior to surgery, while the right picture depicts the hand after surgery. (Photos courtesy of Alan David Rogers)

AUTHOR

Alan David Rogers (MBChB, MMed, FC Plast Surg, FRCSI, MSc, FACS)
Ross Tilley Burn Centre, Sunnybrook Health Sciences Centre, Toronto, Canada; Division of Plastic and Reconstructive Surgery, Department of Surgery, University of Toronto, Canada. Email: alandavid.rogers@sunnybrook.ca

Conclusion & References

CONCLUSION

Fortunately, the vast majority of burn injuries can be managed with simple outpatient wound care and ambulatory clinic follow-up to ensure that all involved areas heal and do so without debilitating scarring. Selected patients require burn unit admission and surgical management, and this course requires a centralized infrastructure supported by a range of multi-professional experts.

REFERENCES

Allorto NL, Rogers AD, Rode H. 'Getting under our skin': Introducing allograft skin to burn surgery in South Africa. S Afr Med J 2016; 106(9): 865-866

Brown DA, Gibbons J, Honari S, Klein MB, Pham TN, Gibran NS. Propranolol Dosing Practices in Adult Burn Patients: Implications for Safety and Efficacy. J Burn Care Res. 2016 May-Jun;37(3):e218-26. doi: 10.1097/BCR.0000000000000240. PMID: 25882517.

Cartotto R, Cicuto BJ, Kiwanuka HN, Bueno EM, Pomahac B. Common postburn deformities and their management. Surg Clin North Am. 2014 Aug;94(4):817-37. doi: 10.1016/j.suc.2014.05.006. Epub 2014 Jun 16. PMID: 25085090.

Friedstat JS, Hultman CS. Hypertrophic burn scar management: What does the evidence show? A systematic review of randomized controlled trials. Ann Plast Surg. 2014;72:S198–S201.

Hansen JK, Voss J, Ganatra H, et al. Sedation and Analgesia During Pediatric Burn Dressing Change: A Survey of American Burn Association Centers. *J Burn Care Res*. 2019;40(3):287-293. doi:10.1093/jbcr/irz023

Hettiaratchy S, Dziewulski P. ABC of burns: pathophysiology and types of burns [published correction appears in BMJ. 2004 Jul 17;329(7458):148]. *BMJ*. 2004;328(7453):1427-1429. doi:10.1136/bmj.328.7453.1427

Hultman CS, Friedstat JS, Edkins RE, Cairns BA, Meyer AA. Laser resurfacing and remodeling of hypertrophic burn scars: The results of a large, prospective, before-after cohort study, with long-term follow-up. Ann Surg. 2014;260:519– 529; discussion 529–532.

Mason SA, Nathens AB, Finnerty CCet al Inflammation and the Host Response to Injury Collaborative Research Program. Hold the Pendulum: Rates of Acute Kidney Injury are Increased in Patients Who Receive Resuscitation Volumes Less than Predicted by the Parkland Equation. Ann Surg. 2016 Dec;264(6):1142-1147.PMID: 27828823

Nieuwendijk SMP, de Korte IJ, Pursad MM, van Dijk M, Rode H. Post burn pruritus in pediatric burn patients. *Burns*. 2018;44(5):1151-1158. doi:10.1016/j.burns.2018.02.022

Palmieri TL, Taylor S, Lawless M, Curri T, Sen S, Greenhalgh DG. Burn center volume makes a difference for burned children. *Pediatr Crit Care Med*. 2015;16(4):319-324. doi:10.1097/PCC.0000000000000366

Pardesi O, Fuzaylov G. Pain Management in Pediatric Burn Patients: Review of Recent Literature and Future Directions. *J Burn Care Res*. 2017;38(6):335-347. doi:10.1097/BCR.000000000000047

Rogers AD, Adams S, Rode H. The Introduction of a protocol for the use of Biobrane for facial burns in children. Plast Surg Int. 2011; 2011: 858093

Rogers AD, Deal C, Argent AC, Hudson DA, Rode H. Ventilator associated pneumonia in major paediatric burns. Burns. 2014 Sep; 40 (6): 1141-8

Rousseau AF, Losser MR, Ichai C, Berger MM. ESPEN endorsed recommendations: nutritional therapy in major burns [published correction appears in Clin Nutr. 2013 Dec;32(6):1083]. *Clin Nutr*. 2013;32(4):497-502. doi:10.1016/j.clnu.2013.02.012

Saffle JI. The phenomenon of "fluid creep" in acute burn resuscitation. J Burn Care Res. 2007;28:382–395.

Schmitt YS, Hoffman HG, Blough DK, et al. A randomized, controlled trial of immersive virtual reality analgesia, during physical therapy for pediatric burns. *Burns*. 2011;37(1):61-68. doi:10.1016/j.burns.2010.07.007

Shah AR, Liao LF. Pediatric Burn Care: Unique Considerations in Management. *Clin Plast Surg*. 2017;44(3):603-610. doi:10.1016/j.cps.2017.02.017

Snell JA, Loh NH, Mahambrey T, Shokrollahi K. Clinical review: the critical care management of the burn patient.Crit Care. 2013 Oct 7;17(5):241. doi: 10.1186/cc12706. Review. PMID: 24093225

Strobel AM, Fey R. Emergency Care of Pediatric Burns. *Emerg Med Clin North Am*. 2018;36(2):441-458. doi:10.1016/j.emc.2017.12.011

Sudenis T, Hall K, Cartotto R. Enteral nutrition: what the dietitian prescribes is not what the burn patient gets! J Burn Care Res. 2015 Mar-Apr;36(2):297-305. doi: 10.1097/BCR.0000000000000069. PMID: 24722665.

Tredget EE, Levi B, Donelan MB. Biology and principles of scar management and burn reconstruction. Surg Clin North Am. 2014;94:793–815.

Wasiak J, Cleland H, Campbell F, Spinks A. Dressings for superficial and partial thickness burns. Cochrane Database of Systematic Reviews 2013, Issue 3. Art. No.: CD002106. DOI: 10.1002/14651858.CD002106.pub4. Accessed 15 December 2021.

Zuccaro J, Muser I, Singh M, Yu J, Kelly C, Fish J. Laser Therapy for Pediatric Burn Scars: Focusing on a Combined Treatment Approach. J Burn Care Res. 2018 Apr 20;39(3):457-462. doi: 10.1093/jbcr/irx008. PMID: 29897540.

Self-Check

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://ecampusontario.pressbooks.pub/skinandwoundcare/?p=1206#h5p-9

CHAPTER 14

Chapter 14: Peristomal

Authors

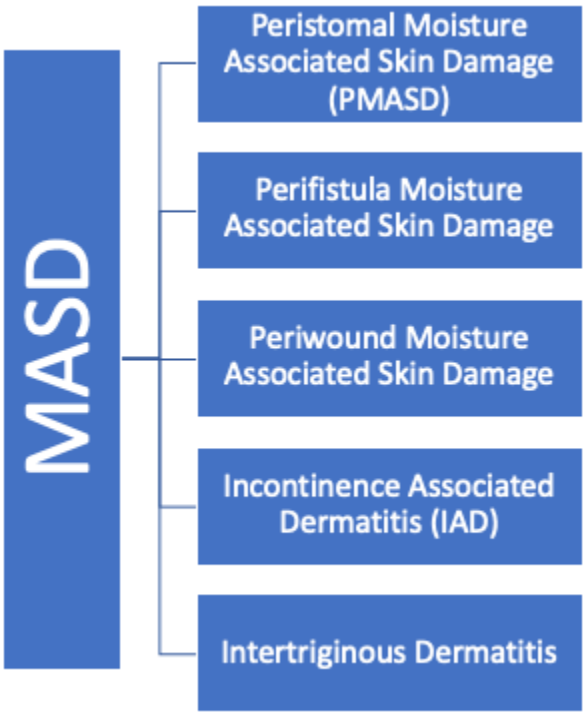
- Chabal & Ayello Ostomy

Learning Objectives

- Review assessment parameters of peristomal skin
- Identify common peristomal skin complications (PSC)
- Assess management options for selected peristomal skin complications (PSC)

Peristomal skin damage is considered one of the five types of moisture associated skin damage (MASD) (Black 2011, Gray 2011, NSWOCC, 2018).

Figure 1: The five types of moisture associated skin damage (MASD)



Despite surgical technique improvements and appliance innovation, peristomal complications remain high (up to 83%) (WCET IOG 2020). Early identification and management of peristomal skin complications (PSC) is supported by several professional guidelines and educational resources. (ASCN UK 2016, Chabal, Prentice, Ayello 2020, Johnson et al 2022, RNAO 2019, Stelton 2019, WCET 2016, WCET 2020, WOCN 2018). Patients often wait until the PSC becomes severe before seeking advice because:

- patients do not recognize the problems and/or do not wish to bother the nurse with specialized ostomy/stoma knowledge
- there is no nursing expertise available or specialized resources for them to contact.

A key strategy is to involve patients in their own care to screen, prevent and treat PSC when they occur (UOAA, 2022). Patients and families often need additional education and ongoing support as they navigate through stoma challenges.

Peristomal skin complications (PSC) can lead to leakage, pain, decreased quality of life, increased cost/financial hardships, and difficulty in adjusting to life with a stoma/ostomy (ASCN UK 2019, Hedegaard, Ajslev, Zeeberg & Hansen, 2020, McGrogan 2021, RNAO 2019, Russell, 2020, WCET IOG 2020, WOCN 2018). Scientific evidence supports preoperative stoma site marking by a qualified and skilled health care professional to decrease postoperative PSC. (ASCN UK 2016, RNAO 2019, WCET 2020, WOCN 2018, WOCN AUA and ASCRS 2021).

The abdominal location of the stoma is also important as it will impact the risk of skin issues (See figure 2, 3 and 4). Adequate circulation is necessary for the stoma mucosa to be pink, soft, warm and moist. The ileostomy stoma should be everted 2.5 to 3 cm above the skin surface and a colostomy is ideal 1 cm above the skin base. The proximal lumen should be at the apex of the stoma and its mucosa should be approximated to the skin (Steele 2020, Whitehead & Cataldo 2017).

Figure 2: Retracted stoma

Figure 3: Irritant Dermatitis in different Fitzpatrick skin tones

Figure 4: stoma

There are several tools available to assist the health care professional in describing PSC. Among these tools are the validated Ostomy Skin Tool (OST), the Peristomal Lesion Scale (PLS) and the Peristomal Skin assessment Score (SACS). Other tools include ABCD Stoma Care tool and the LSD Score. There is no single tool that are universally recognized as the gold standard for clinical practice. (WCET IOG 2020). Some peristomal skin characteristics that are included on these assessment tools include discoloration (changes in peristomal skin color from the person's usual skin tone), measurement as to the extent to which the peristomal skin is showing signs of damage, and if there is any yeast type of overgrowth on the tissue that is usually recognized as white cotton-like surface growths (WCET IOG 2020).

The remainder of this chapter will focus on commonly occurring PSC that health care professionals may encounter in their practice.

Irritant Dermatitis

Irritant contact dermatitis (See figure 5) is considered to be the most frequently occurring PSC. When skin comes into contact with stoma output from urine or stoo), the peristomal skin may show signs of irritation including maceration, erosions, color changes or blisters. The stoma output fluid is referred to as "effluent" and the pH is significantly different than normal skin due to the contents and source. Often the person has pain as a result of this peristomal skin irritation. The person may also experience skin barrier/pouch leakage or inability of the pouch to remain intact with decreased wear time. As with the wound bed preparation model, determining and treating the cause is an important step that determines why the ostomy effluent is able to come in contact with the peristomal skin.

Figure 5 Irritant Dermatitis

Management should consider the following principles (ASCN UK 2016, WOCN 2018, WCET 2016):

- Why is the skin barrier/pouch leaking?
    - Remeasure the stoma and assess the correct size for the skin barrier opening/pouch so that an adequate seal can be established. Having the right size skin barrier pouching system is imperative.
    - Is the patient waiting too long to empty the pouch? If so the weight of the ostomy content could be causing the leakage as a heavy pouch may pull downward and break the seal. If an opened ended pouch is being used, make sure the person has closed it correctly.
    - Remind the person that the size of their stoma may change over time. Stoma size needs to be measured to assess if the correct size of the skin barrier/pouch size opening is being used. Are they cutting the skin barrier opening too large? Some patients may want to switch to a pre-cut commercially available pouch rather than one that the patient cuts by themselves based on their own particular stoma size.
    - Are they correctly centering the skin barrier/pouch around their stoma? Can they see their stoma? Patient's ability to see their own stoma can change especially if person gains weigh and can no longer see their stoma, or the stoma is now in a skin fold that is causing leakage from the sides of the stomal skin interface.

- How should the peristomal skin be protected?
    - Consider applying protective stoma barrier product (powder, wipes/on a stick applicator) to the damaged peristomal skin prior to pouch application. "Sealing" the powder with a protective

barrier product (wipe or stick applicator) prior to reapplying the skin barrier/pouch can assist in fostering a better seal at the stoma skin/barrier pouch interface.

- Evaluate using ostomy accessories such as a protective ring/seal paste, or seal that surrounds the stoma (like corking around a leaking drafty window) to the damaged peristomal skin prior to pouch application.
- Contiplate using some of the newer skin barriers made with ceramide to protect and heal the peristomal skin.

Peristomal II

Allergic Dermatitis

- Skin discoloration around the stoma mirrors the size and shape of the product that is eliciting the allergic skin reaction. It presents as redness and may have surface exudate in lighter Fitzpatrick skin types or darker than usual skin color in persons of colour (brown, black Fitzpatrick classification system for types 5,6) (See figure 6 & 7).

Figure 6: Allergic Dermatitis

Figure 7: Allergic Dermatitis
Note that the skin immediately surrounding the stoma is not showing signs of PSC as it was protected by an ostomy skin product (paste or ring).

- Based on the wound bed preparation model, determine what specific product is causing the allergic

dermatitis. Consider a “repeat open application test” or ROAT patch test to see what is the offending substance that is the skin allergen, the source of the dermatitis. Some products contain colophony or it’s derivative Pentylin H as the adhesive in some ostomy products and/or dressings such as hydrocolloids can act as skin allergens. A repeat open application test is performed by drawing a circle the size of a coin on normal skin just below the forearm. Apply the substance (cream, ointment) to the circle twice a day for 2 days. A contact allergy is identified if the inside of the circle turns red or a darker colour post application. (See figure 8).

- Skin inflammation management can include topical steroid spray or lotions prior to reapplying an ostomy appliance. Avoid creams and ointments as they will interfere with the adhesive on the appliance. The skin surface should be dried (use a hairdryer on a cool or room temperature setting if required) prior to the reapplication of the appliance. Change to a different brand of ostomy skin barrier/pouch that does not contain the offending substance.

Figure 8: Open application test

Table 1: Common Allergens and Products

Common Allergens	Products
Epoxy resins	Plastics, used mainly as adhesives
Colophony	Adhesives, plasters, medicated creams, glue
Lanolin (derived from sheep)	Cosmetics, medical creams and bandages/strong allergen in persons with atopy
Fragrance mix, may cross-react with substances such as balsam of Peru	Moisturizing creams and ointments, air fresheners, washing powders, products may contain masking fragrances
Latex or rubber acetylators	Rubber, gloves, syringes, drains
Rubber accelators: mercapto mix/thiazoles, thiuram, carba mix	Rubber shoes, insoles, gloves and elastic products
Formaldehyde	Preservative frequently used in household/products, cosmetics, and shampoo
Neomycin	Topical antimicrobial creams, Neosporin, triple antibiotic creams/ointments, Bacitracin, Polumyyxin
Benzocaine is an **Ester** local anaesthetic	Many topical anaestetc creams; xylocaine is safer (**Amide** local anestetic cream)
Nickel	Keys, coins, zippers, buckles, batteries
Modified from Woo, Sibbald, Ayello, Coutts, Garde (2009). Peristomal Skin Complications and Management. Advances in Skin and Wound Care. 22(11): 522-32.	

Peristomal Hernia

These lesions present as a slight to large protruding bulge around the stoma (See figure 9). Assess if the stoma is viable and that there is no compromise as to blood supply (such as in a necrotic stoma illustrated in figure 10) or bowel obstruction. Is stool or urine still able to exit the stoma or is there a bowel obstruction? Flexible convex skin barrier/pouch that fits over the bulge is a management option as well as the addition of a support/hernia belt. Be careful that the belt is not too tight and is a proper fit.

Figure 9: Parastomal Hernia in 2 different Fitzpatrick Skin Classification types

Pyoderma Gangrenosum (PG)

Pyoderma gangrenosum (PG) can occur around a stoma especially in person with inflammatory bowel disease (IBD) as well as other conditions without a stoma including rheumatoid arthritis and myeloproliferative disorders (leukemia, lymphoma). Not all cases of PG are associated with an underlying cause. PG is usually painful and features rolled edges when lesions are active. It often has a violaceous or purple edges. It usually can be treated with oral topical or intralesional corticosteroid therapy. One of the stoma care challenges is to atraumatically apply and secure the appliance post local treatment. Debridement is contraindicated during active disease as it may increasing the pathergy (trauma leads to extension of the lesion) and activate the PG to spread outwards increasing the size of the lesion. After involvement on the legs, peristomal pyoderma gangrenosum is the second most common site. (See figure 10)

Figure 10: Necrotic stoma
This stoma is necrotic and requires consultation with the surgeon.

References

ASCN UK. Association of Stoma Care Nurses UK. ASCN Stoma Care National Clinical Guidelines. Nurses Clinical Practice Guideline. ASCN UK, 2016.

Berger, A, Inglese G, Skountrianos G, Croce D, Oguz M. Budget impact of ceramide-infused skin barriers versus standard of care skin barriers for new ostomates: a six-country analysis. WCET Journal. 41(2)):22-31, 2021.

Black JM, Gray M, Bliss D, et al. MASD part 2: incontinence-associated dermatitis and intertriginous dermatitis. J Wound Ostomy Continence Nurs. 2011;38(4):359-70.

Chabal LO, Prentice JL, Ayello EA. Practice implications from the WCET® International Ostomy Guideline 2020. Advances in Skin and Wound Care. 34(6):293-300, 2020.

Gray M, Black JM, Baharestani MM, et al. Moisture-associated skin damage: overview and pathophysiology. J Wound Ostomy Continence Nurs. 38(3):233-41, 2011.

Hedegaard C, Ajslev TA, Zeeberg R, Hansen AS. (2020). Leakage and peristomal skin complications influences user comfort and confidence and are associated with reduced quality of life in people with a stoma. WCET Journal, 40(4):23-29. 2020.

Johnston at al. Canadian Urinary Diversions Position Statement: Collaboration of Canadian Urological Association, Nurses Specialized in Wound, Ostomy and Continence Canada & Urology Nurses of Canada. (1st ed.). 2022.

McGrogan M. (2021). How holistic assessment and appropriate product selection will enhance quality of life for ostomates with cognitive impairment. WCET Journal. 41(1):33-35, 2021.

Nurses Specialized in Wound, Ostomy and Continence Canada (NSWOCC). Nursing Best Practice Recommendations: Enterocutaneous Fistulas (ECF) and Enteroatmospheric Fistulas (EAF). 2nd Ed. Ottawa: Nurses Specialized in Wound, Ostomy and Continence Canada; 2018.

RNAO. Registered Nurses' Association of Ontario. Best Practice Guideline. Supporting Adults who Anticipate or Live with an Ostomy. 2nd ed. Toronto (ON): Registered Nurses' Association of Ontario. 2019.

Russell S. Parastomal hernia: Improving quality of life, restoring confidence and reducing the fear. The importance of the role of the stoma nurse specialist. WCET Journal. 40(4):36-39. 2020.

Steele et al. The ASCRS Textbook of Colon and Rectal Surgery. ASCRS (American Society of Colon and Rectal Surgeons) 4d edition, 2020.

Stelton S. Stoma and peristomal skin care: A clinical review. AJN, 119(6): 38-45, 2019.

WCET. WCET International Ostomy Guideline (WCET® IOG 2020). Chabal LO, Prentice JL & Ayello EA (Eds.). Perth Australia: WCET. 2020

WCET. WCET Ostomy Pocket Guide: Stoma and Peristomal Problem Solving. Ayello EA & Stelton (Eds). Perth, Australia: WCET, 2016.

Whitehead A, Cataldo PA. technical considerations in stoma creation. Clin Colon Rectal Surg. 30(3):162-171, 2017.

WOCN. Wound Ostomy and Continence Nurses Society Guideline Development Task Force. Management of the Adult patient with a fecal or urinary ostomy- An Executive summary. JWOCN. 45(1):50-58; January/February2018.

WOCN. Basic Ostomy Skin Care: A guide for Patients and Health Care Providers. WOCN® Society, 2018.

WOCN, AUA and ASCRS. WOCN Society, AUA, and ASCRS position statement on preoperative stoma site marking for patients undergoing ostomy surgery. JWOCN. 48(6):533-536, 2021.

Woo, Sibbald, Ayello, Coutts, Garde (2009). Peristomal Skin Complications and Management.

Advances in Skin and Wound Care. 22(11): 522-32

Self-check

CHAPTER 15

Chapter 15: The Edge Effect in Chronic Wound Care

EDGE EFFECT AND ADJUNCTIVE THERAPIES

Authors:

- Haya Homsi
- Muskaan Sachdeva
- Asfandyar Mufti
- Gary Sibbald

Learning Objectives

1. Define edge effect in chronic wounds
2. Explore different adjunctive therapies for wound care

INTRODUCTION

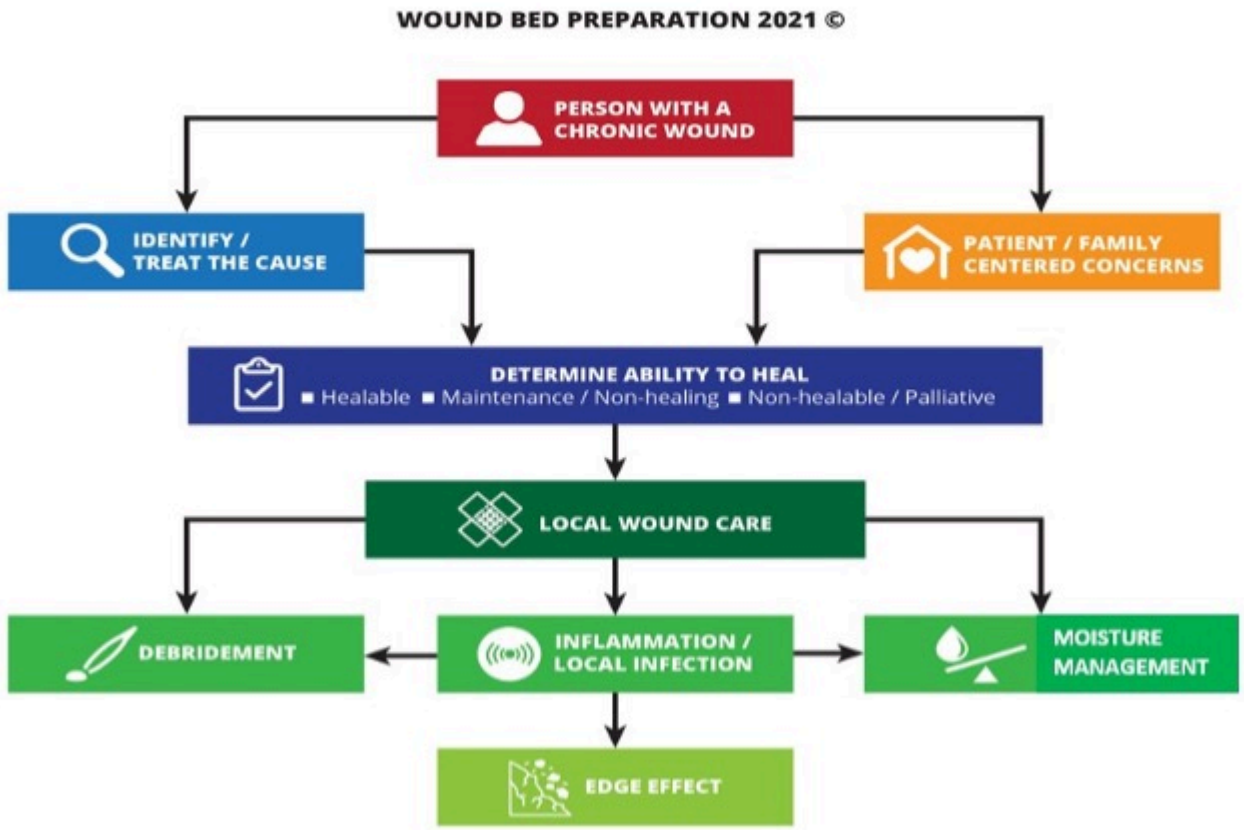
This chapter focuses on the edge effect as it relates to chronic wound care within the Wound Bed Preparation paradigm. Wounds that are present for six weeks or more are considered chronic. When wounds are determined to be healable but stalled, this is an opportune time for adjunctive therapy considerations. Patients and their circle of care engagement will improve treatment decisions for edge effect. The geographical practice setting and resources will impact the availability of edge effect interventions. Often, adjunctive therapies with excellent scientific data may not have cost effective application for everyday practice.

It should be emphasized that the following steps need to be completed prior to the use of adjunctive therapies:

- Accurate identification and treatment of the wound cause
- Determination of healable wound that is stalled
- Optimization of patient-centered concerns
- Appropriate steps for optimal Debridement, Infection/Inflammation, Moisture management (DIM)

If all the factors are corrected in a healable wound, active adjunctive therapies may be considered. This edge effect is an important last step of the Wound Bed Preparation (WBP) paradigm. See Figure 1.

Figure 1. Wound Bed Preparation Algorithm 2021



Courtesy of Sharon Baranoski

EDGE EFFECT

Wound healing involves the advancing of the purple-pink epithelium at the wound periphery into the mature granulation base that forms a tapered edge, with the goal of ultimately covering the wound with a new epithelial layer (Woo, Ayello, and Sibbald 2007). A healing wound with tapered edges like the shore of a sandy beach. Edge effect refers to the steep cliff-like epidermal edge that occurs due to the failure of the epithelial migration across a firm, pink and level granulation base that would result in delayed wound healing (Figure 2; (Woo, Ayello, and Sibbald 2007).

Many ***edge–effect*** therapies support the addition of missing components including growth factors, fibroblasts, epithelial cells or matrix components. There are several adjunctive therapies available for chronic stalled but healable wounds that are discussed in this chapter.

Figure 2: Edge Effect (Woo, Ayello, and Sibbald 2007)

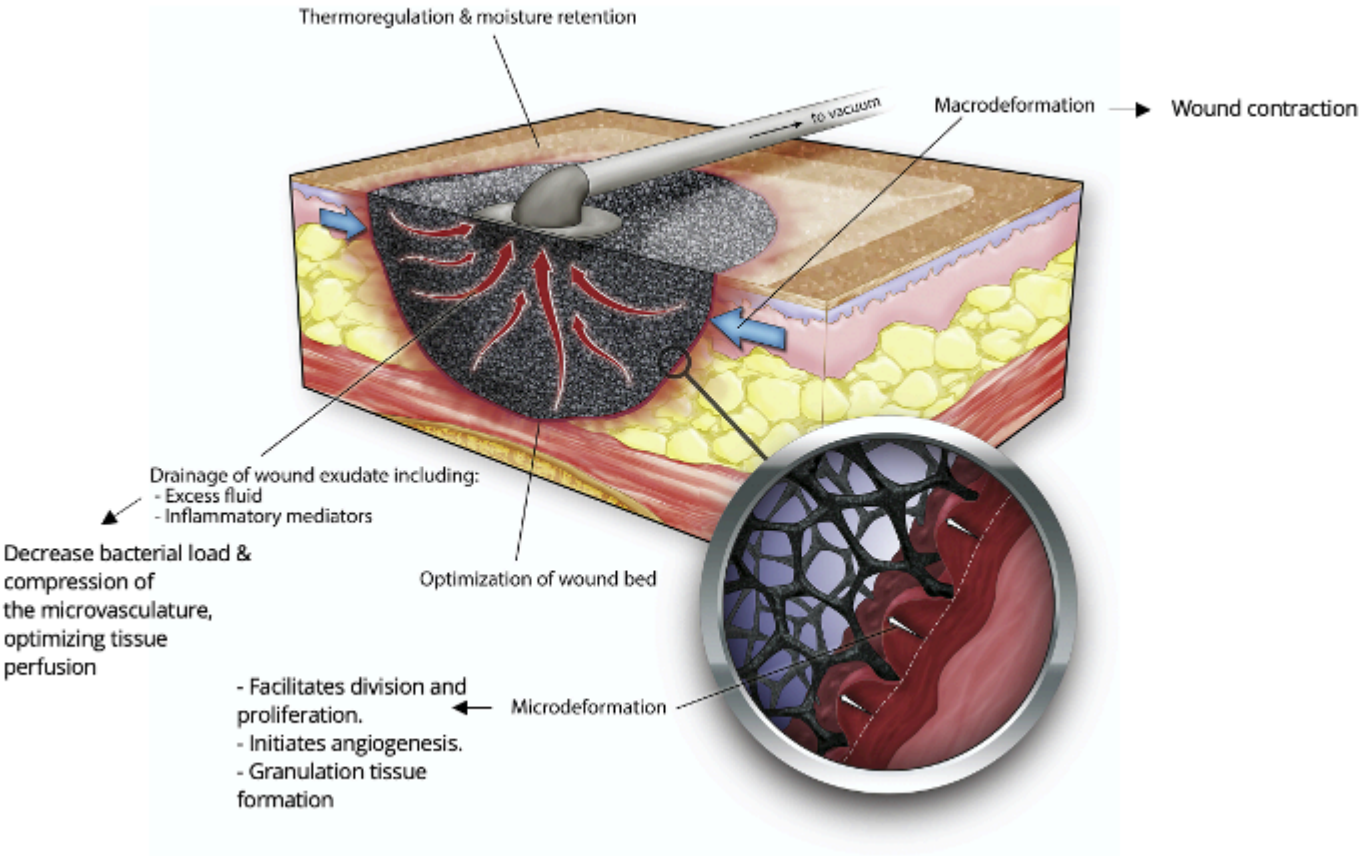
This picture illustrates a wound with a cliff-like edge. There is surface yellow eschar, red friable tissue and slough that will contribute to the lack of healthy granulation tissue that has not reached the surrounding edges of the skin. The process of re-epithelialization is delayed.

Negative-Pressure Wound Therapy

Negative-Pressure Wound Therapy (NPWT)

NPWT is an adjunctive therapy that promotes wound healing. It is a sealed wound-care system that delivers a controlled suction across the surface of the wound bed. Figure 2 demonstrates NPWT primary mechanisms of action and their associated secondary effects (C. Huang et al. 2014; Orgill and Bayer 2013). Braakenburg et al. (2006) demonstrated that NPWT offers more comfort for patients and the treating team because of the fewer dressing changes and less leakage and odour. Because of faster healing, NPWT may not result in overall higher costs despite the expenses of the pumping device and specialized accessories. However, the available data on the efficacy of NPWT has significant heterogeneity in the type of wounds treated as well as clinical indicators assessed (Brassard and Tardif 2015). It is difficult to generalize results and favour NPWT over standard treatment for all wounds. Higher quality evidence assessing NPWT efficacy is required for an accurate cost-effectiveness analysis (Canadian Agency for Drugs and Technologies, 2014).

Figure 2: Negative pressure wound therapy: A sponge is placed into the wound and covered by an adhesive sheet, within which a suction tube is placed.



Adapted from: (C. Huang et al. 2014)

When Negative Pressure Wound Therapy (NPWT) is initiated and the wound has an occlusive seal, there are 4 primary mechanisms of action:

1. Macrodeformation (macrostrain)

2. Microdeformation (microstrain)

3. Fluid / exudate removal into the tubing.

4. Changes in the wound environment

When negative pressure is initiated and applied to the wound, there is a collapse of the sponge. The wound edges are pulled together (macrostrain). The small circular image shows the black foam with the open reticulated cells (pores). With the negative pressure "pull" between the black foam and wound bed cell layer, the top layer of the wound bed is drawn up into each of the black foam cells causing microstrain. This is what promotes the granulation tissue to proliferate at a faster than normal rate – due to the strain. This is unique action that only occurs with NPWT. Interstitial fluid is pulled into the tubing and canister. Edema is reduced. There are many changes in the wound environment. Growth factors and antibiotics can now get to this previously edematous area. The dressing is occlusive (air tight) and this promotes moist wound healing at an optimal rate.

Studies on neurotrophic diabetic foot ulcers (DFUs) with adequate blood supply to heal suggest that NPWT is associated with increased proportion of healed DFUs, reduced time to wound closure and decreased secondary amputations (Brassard and Tardif, 2015; Canadian Agency for Drugs and Technologies, 2014). In addition, NPWT

has been found to increase split-thickness skin graft survival rate following surgical cover. The Canadian Agency for Drugs and Technologies in Health (2015) recommends the use of NWPT in acute and chronic wounds as an adjunctive therapy since it accelerates wound healing. For surgical wounds, NPWT may decrease the rate of surgical site infection in comparison to standard therapy (Webster et al. 2019).

Candidates for NPWT should be appropriately selected according to their clinical situation, wound-related factors, patient preferences, healthcare settings and available resources (Brassard and Tardif 2015) (Table 1). High-quality randomized controlled trials are needed to explore the co-use of NPWT with instilled materials (e.g., antiseptics, other antimicrobials) and parameters of application to determine optimal use of NPWT.

Table 1: NPWT indications, contraindications, precautions for use, and discontinuation criteria

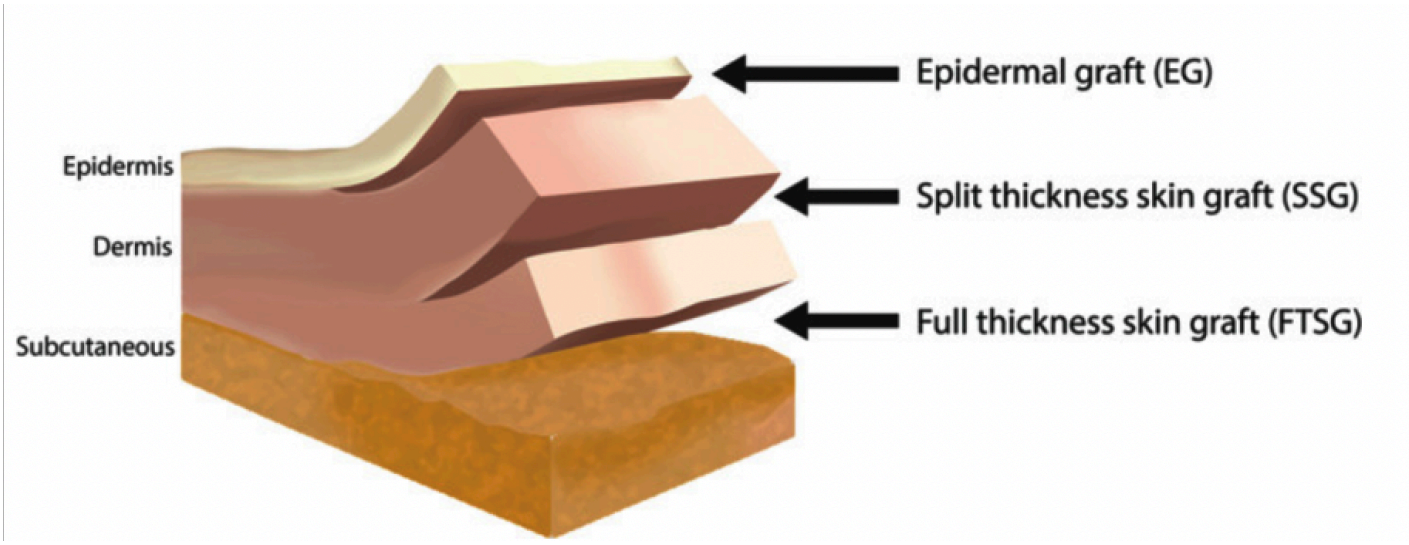
Indications		Contraindications	Precautions for use	Discontinuation Criteria
Chronic Wound Closure (secondary intention	• Non-ischemic diabetic foot ulcer associated with significant loss of tissue (after debridement) • Arterial or mixed ulcer after an assessment of the potential for revascularization • Stage III or stage IV pressure injury (after off-loading pressure and other contributing factors corrected)	• Malignancy in the wound • Untreated osteomyelitis • Non-enteric and unexplored fistulas • Necrotic tissue with eschar present • Allergy to any of the material required for the procedure • Uncontrolled wound infection • Exposed vital organs or blood vessels	• Setting clear clinical objectives &Patient counseling prior to NPWT start • Wound debridement and cleansing prior to NPWT • Documenting the number of dressing pieces inserted and removed at each dressing change (only one piece into a single wound is preferred) • Avoid interrupting NPWT- Laparotomy: avoiding contact between the digestive tract and the NPWT system to prevent the creation of a gastrointestinal fistula • Infection control measures • Pain management	• Formation of healthy granulation tissue • Achieving the clinical objective of NPWT (e.g., reduce wound size, wound closures, etc.) • If the healing trajectory has not been met after two weeks • The occurrence of necrotic tissue, hyper-granulation or stagnation • If moderately severe adverse events occur: • — excessive bleeding • — severe wound or peri-wound infection • — intense pain • — an allergic reaction following application
Acute Wound Closure	• Secondary Intention • Tissue removal associated with significant deep tissue loss • Wound dehiscence of an extensive surgical wound • Traumatic wound that cannot / should not be sutured • Primary or Tertiary Intention • Open wound of the abdomen or thorax • Surgical wound with a high risk of dehiscence			
Stabilize skin graft or flap				

Skin Grafting and CTPs

Skin Grafting

Skin grafting, where skin or a skin substitute is transplanted over a wound, may be a useful and effective adjunctive therapy for stalled healable wounds (Serra et al. 2017). A skin graft provides the wound with the keratinocytes needed for epithelization along with mechanical stability and resistance to infection and fluid loss (Hierner et al. 2005). Skin grafts are indicated in a variety of clinical situations, such as chronic traumatic and burn wounds (Elseth and Lopez 2021; Serra et al. 2017). Classification of skin grafts is based on the thickness of the harvested skin: full-thickness skin graft (FTSG), split-thickness skin graft (SSG) and epidermal graft (EG) (Figure 3; (Kanapathy et al. 2017)). FTSG offers the best cosmetic outcome, while SSGs are frequently used for functional repair in wounds such as venous or arterial ulcers as they require less blood supply. Evidence suggests high success rates with skin grafts in chronic venous leg ulcers (VLUs) compared to chronic arterial ulcers and DFUs (Serra et al. 2017).

Figure 3: Skin Grafts Depth (Kanapathy et al. 2017)



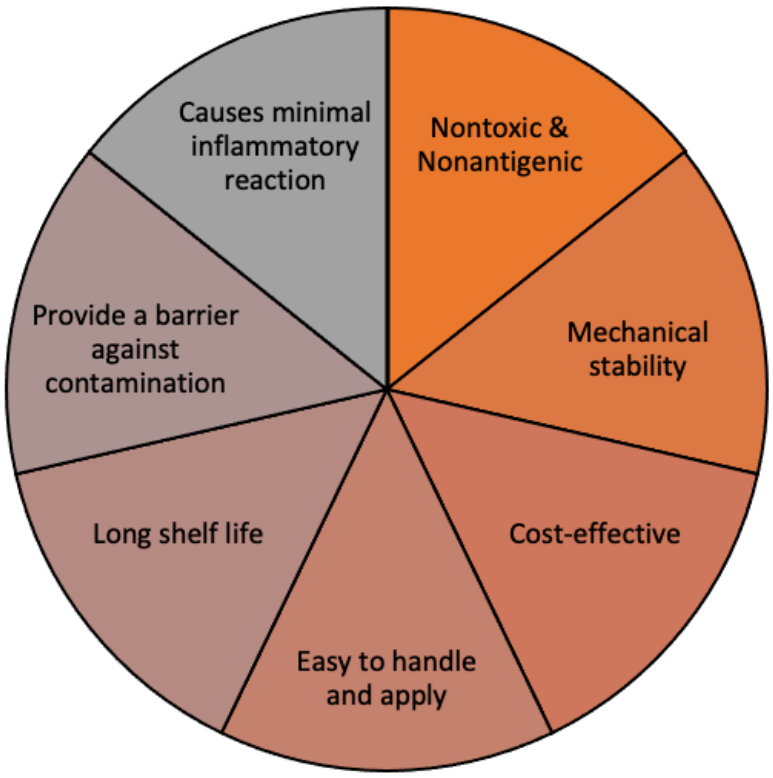
Both FTSG and SSG require hospital admission, a trained surgeon, operating room and anaesthesia. They are associated with a significant burden to the donor by creating a painful wound at the harvesting site (Herskovitz et al. 2016). In contrast, EG can be done in an outpatient setting without donor site morbidity. EG also stimulates wound healing differently from FTSG and SSG, likely through providing the wound with growth factors and cytokines (Herskovitz et al. 2016). A systematic review concluded that EG is associated with a wound healing rate of over 70% and a mean healing time of 5 weeks (Kanapathy et al. 2017). The healing rate varied by wound etiology; DFUs, burn wounds, and SSG donor site wounds achieved complete healing with EG, while wounds such

as lymphedema and pyoderma granulosum failed to heal with EG. Finally, it is imperative to optimize the recipient wound bed to avoid skin grafts failure (Herskovitz et al. 2016).

Cellular and/or tissue-based products (CTPs)

Previously developed to treat burns and traumatic wounds, CTPs may also improve wound healing in DFUs and VLUs (Liu et al. 2019). The synthetic material of skin substitutes mimics normal skin, providing a moisture coverage and a bacterial barrier. CTPs help replace lost tissue to restore normal function by providing a template for host's cells to use for healing (Ho et al. 2005). Different types of skin substitutes are available with varying wound indications, effectiveness in diverse chronic wounds and evidence for their use (Nicholas and Yeung 2017). For example, acellular dermal substitutes involve materials similar to the extracellular matrix present in skin that provide a scaffold for wound healing without causing immune reactions (Abdo and Ortman 2020). Their effect has been studied on DFUs and showed shorter healing times (Nicholas and Yeung 2017). On the other hand, cellular dermal substitutes include fibroblasts and/or keratinocytes that secrete cytokines and growth factors to replace tissue loss but are at risk for immunogenicity (Abdo and Ortman 2020; Nicholas and Yeung 2017). To overcome this, cells from amniotic membrane and neonatal foreskin have been employed to avoid immune rejections. Cellular-based CTPs have been proven to promote wound healing in both DFUs and VLUs and may potentially offer economic net savings (Liu et al. 2019). In the upcoming years, CTPs will involve the development of an ideal skin substitute (Figure 4) as well as the replacement of other skin components, such as hair follicles and sebaceous glands (Liu et al. 2019; Nicholas and Yeung 2017).

Figure 4: Ideal properties for skin substitutes (Shores et al., 2007)



Other Therapies and Treatments

Hyperbaric oxygen therapy (HBOT)

Oxygen plays an important role in the wound healing process. While tissue hypoxia labels the initial phase of wound healing and signals for angiogenesis and growth factors, a wound that is chronically depleted from oxygen will have impaired healing (Kranke et al. 2015). HBOT is a systematic oxygen supplementation in which a patient is sealed within a chamber filled with 100% oxygen at a pressure greater than sea level atmospheric pressure (Jirangkul et al. 2021). As HBOT raises the oxygen's concentration in blood, more oxygen will reach the wound that has a higher metabolic demand (E. Huang, Heyboer, and Savaser 2019). The availability of oxygen will induce the synthesis of Nitric Oxide, promoting angiogenesis and increase the production of energy needed for tissue growth, cell recruitment, re-epithelization, and immune defense against bacteria (de Smet et al. 2017). Generally, HBOT is a lengthy therapy associated with few adverse events, including oxygen toxicity, anxiety and barotrauma such as rupture of ear membrane (Health Quality Ontario 2017). According to de Smet et al. (2017), HBOT results in faster wound closure and improved vascular perfusion. Specifically with skin grafts in carefully selected patients, HBOT is associated with better graft survival and less infection. The use of HBOT in the treatment of stalled but healable DFUs has shown to reduce frequency of surgical procedures and minimize the risk and extent of amputations (E. Huang, Heyboer, and Savaser 2019; Jirangkul et al. 2021). Additionally, Health Quality Ontario (2017) stated that HBOT may provide lower costs and better outcomes when compared to standard wound therapies. Nevertheless, additional studies are needed to properly select patients who are most likely to benefit from HBOT (E. Huang, Heyboer, and Savaser 2019). There is also a considerable cost that may not be covered by many health care systems except in cases with specialized criteria.

Electrical stimulation (ES)

Electrical Stimulation is considered an adjunctive treatment modality for chronic wound healing due to its effects on cutaneous perfusion, cell proliferation and migration, and bacterial growth (Thakral et al. 2013). It involves placing electrodes directly to the wound bed that delivers electrical charges that mimic the physiological electrical potentials proven to accelerate wound healing (Rajendran et al. 2021). Clinician training and experience within their scope of practice is a factor for consideration. ES is painless and safe to use; however, it is contraindicated in pregnancy and patients with osteomyelitis, cancer, skin conditions, blood clots or implanted electronic devices (Ontario Health Technology Advisory Committee 2017; Rajendran et al. 2021). According to Khouri et al. (2017), ES is shown to be more effective on pressure injuries than DFUs and VLUs with better outcomes linked to smaller wounds. Although ES has been found to significantly reduce wound surface area in chronic wounds compared to standard wound care, the evidence is uncertain for routine clinical use. This is due to variation in wound types, patient characteristics, ES parameters, and standard wound care evaluated across the studies (Ontario Health Technology Advisory Committee 2017; Rajendran et al. 2021).

Ultrasound (US)

Low-frequency US (20-40 kHz) is one of the most recent treatment methods used for debridement, bactericidal effect and healing of chronic wounds (Alkahtani et al. 2017; Kavros et al. 2008). As opposed to high-frequency US, that triggers mechanical and thermal effects reaching deep tissue layers, low-frequency US only creates a mechanical pressure wave reflected in the wound surface (Yadollahpour, Jalilifar, and Rashidi 2014). These mechanical effects include

1. surface cavitation: generating and dissipating microbubbles in tissue
2. acoustic streaming: movement of fluids across membranes

Both of these effects increase cellular activity as well as vascular permeability (Voigt et al. 2011).

Mechanical stimulation can also activate the Rac1 protein in fibroblasts, accelerating wound healing (Lyu et al. 2021). Low-frequency US can be delivered directly to the wound, known as high-intensity contact US, or indirectly via saline or water, known as low-intensity noncontact US (Voigt et al. 2011). Despite the low quality of evidence, low-frequency US has demonstrated better healing and smaller wound size for VLUs and DFUs. In comparison to sharp debridement, US was found to be relatively painless (Ruby Chang, Perry, and Cross 2017; Voigt et al. 2011). Lyu et al. (2021) proposed designing flexible US patches that can conform better to the wound surface for effect wound treatment. Larger, well-designed and well-conducted trials are needed to evaluate dose-response efficacy of US in different types of wounds before conclusions can be drawn (Jalilifar, Yadollahpour, and Rashidi 2015).

Conclusion and References

CONCLUSION

The clinical use of any of the aforementioned adjunctive therapies depends on the healability potential, expected outcome, and risk-benefit ratio. However, it is important to note that many of these therapies lack sufficient scientific evidence assessing their efficacy and cost-effectiveness (Sibbald et al. 2021). Therefore, adjunctive therapies should be considered after an interprofessional comprehensive patient assessment, correctable factors have been addressed and regular evaluations of the wound (Sibbald et al. 2021).

REFERENCES

Abdo, James, and Holly Ortman. 2020. "Biologic and Synthetic Cellular and/or Tissue-Based Products and Smart Wound Dressings/Coverings." *Surgical Clinics of North America* 100(4): 741–56.

Alkahtani, Saad Ahmed et al. 2017. "Ultrasound-Based Techniques as Alternative Treatments for Chronic Wounds: A Comprehensive Review of Clinical Applications." *Cureus* 9(12). /pmc/articles/PMC5814295/.

Boersema, Geertien C. et al. 2021. "Management of Nonhealable and Maintenance Wounds: A Systematic Integrative Review and Referral Pathway." *Advances in Skin and Wound Care* 34(1): 11–22.

Braakenburg, Assa et al. 2006. "The Clinical Efficacy and Cost Effectiveness of the Vacuum-Assisted Closure Technique in the Management of Acute and Chronic Wounds: A Randomized Controlled Trial." *Plastic and Reconstructive Surgery* 118(2): 390–97.

Brassard, Joelle, and Melanie Tardif. 2015. *Toward the Optimal Use of Negative Pressure Wound Therapy for the Treatment of Complex Wounds*. https://www.cadth.ca/sites/default/files/pdf/INESSS_TPN_Rapport_ETS_final_e.pdf.

Elseth, Anna, and Omar Nunez Lopez. 2021. StatPearls *Wound Grafts*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK564382/.

Health Quality Ontario. 2017. "Hyperbaric Oxygen Therapy for the Treatment of Diabetic Foot Ulcers: A Health Technology Assessment." *Ontario Health Technology Assessment Series* 17(5): 1. /pmc/articles/PMC5448854/.

Herskovitz, Ingrid et al. 2016. "Epidermal Skin Grafting." *International Wound Journal* 13(S3): 52–56. https://onlinelibrary.wiley.com/doi/full/10.1111/iwj.12631.

Hierner, Robert et al. 2005. "Skin Grafting and Wound Healing—the 'Dermato-Plastic Team Approach.'" *Clinics in Dermatology* 23(4): 343–52.

Ho, Chuong et al. 2005. *Artificial Skin Grafts in Chronic Wound Care: A Meta-Analysis of Clinical Efficacy and a Review of Cost-Effectiveness*. Ottawa. http://www.ccohta.ca.

Huang, Chenyu, Tripp Leavitt, Lauren R. Bayer, and Dennis P. Orgill. 2014. "Effect of Negative Pressure Wound Therapy on Wound Healing." *Current problems in surgery* 51(7): 301–31. https://pubmed.ncbi.nlm.nih.gov/24935079/.

Huang, Enoch, Marvin Heyboer, and Davut J Savaser. 2019. "Hyperbaric Oxygen Therapy for the Management

of Chronic Wounds: Patient Selection and Perspectives." *Chronic Wound Care Management and Research* 6: 27–37. http://doi.org/10.2147/CWCMR.S175721.

Jalilifar, Mostafa, Ali Yadollahpour, and Samaneh Rashidi. 2015. "Electromagnetic Fields and Ultrasound Waves in Wound Treatment: A Comparative Review of Therapeutic Outcomes Neuromodulation in Neuropsychiatric Disorders View Project Non-Ionizing Radiation for Wound Healing View Project." *Article in Biosciences Biotechnology Research Asia*. http://dx.doi.org/10.13005/bbra/1622.

Jirangkul, Puripun, Sopon Baisopon, Danai Pandaeng, and Phutsapong Srisawat. 2021. "Hyperbaric Oxygen Adjuvant Therapy in Severe Mangled Extremities." *Injury* (xxxx). https://doi.org/10.1016/j.injury.2021.06.033.

Kanapathy, Muholan et al. 2017. "Systematic Review and Meta‐analysis of the Efficacy of Epidermal Grafting for Wound Healing." *International Wound Journal* 14(6): 921. /pmc/articles/PMC7950096/.

Kavros, Steven J. et al. 2008. "Expedited Wound Healing with Noncontact, Low-Frequency Ultrasound Therapy in Chronic Wounds: A Retrospective Analysis." *Advances in skin & wound care* 21(9): 416–23. https://journals.lww.com/aswcjournal/Fulltext/2008/09000/Expedited_Wound_Healing_with_Noncontact,.6.aspx.

Khouri, Charles et al. 2017. "Hierarchical Evaluation of Electrical Stimulation Protocols for Chronic Wound Healing: An Effect Size Meta-Analysis." *Wound Repair and Regeneration* 25(5): 883–91. https://onlinelibrary.wiley.com/doi/full/10.1111/wrr.12594.

Kranke, Peter et al. 2015. "Hyperbaric Oxygen Therapy for Chronic Wounds." *The Cochrane Database of Systematic Reviews* 2015(6). /pmc/articles/PMC7055586/.

Liu, Yukun, Adriana C. Panayi, Lauren R. Bayer, and Dennis P. Orgill. 2019. "Current Available Cellular and Tissue-Based Products for Treatment of Skin Defects." *Advances in Skin and Wound Care* 32(1): 19–25.

Lyu, Wenhan et al. 2021. "Flexible Ultrasonic Patch for Accelerating Chronic Wound Healing." *Advanced Healthcare Materials* 10(19): 2100785. https://onlinelibrary.wiley.com/doi/full/10.1002/adhm.202100785.

Nicholas, Mathew N., and Jensen Yeung. 2017. "Current Status and Future of Skin Substitutes for Chronic Wound Healing." *Journal of Cutaneous Medicine and Surgery* 21(1): 23–30.

Ontario Health Technology Advisory Committee. 2017. "Electrical Stimulation for Pressure Injuries: A Health Technology Assessment." 17(14): 1. /pmc/articles/PMC5700239/ .

Orgill, Dennis P, and Lauren R Bayer. 2013. "Negative Pressure Wound Therapy: Past, Present and Future." *International Wound Journal* 10(s1): 15–19. https://onlinelibrary.wiley.com/doi/full/10.1111/iwj.12170.

Rajendran, Saranya B., Kirsty Challen, Karen L. Wright, and John G. Hardy. 2021. "Electrical Stimulation to Enhance Wound Healing." *Journal of Functional Biomaterials* 12(2).

Rhee, Susan M. et al. 2015. "Negative Pressure Wound Therapy Technologies for Chronic Wound Care in the Home Setting: A Systematic Review." *Wound Repair and Regeneration* 23(4): 506–17.

Ruby Chang, Ying Ju, Julie Perry, and Karen Cross. 2017. "Low-Frequency Ultrasound Debridement in Chronic Wound Healing: A Systematic Review of Current Evidence." *Plastic Surgery* 25(1): 21. /pmc/articles/PMC5626185/.

Serra, Raffaele et al. 2017. "Skin Grafting for the Treatment of Chronic Leg Ulcers – a Systematic Review in Evidence‐based Medicine." *International Wound Journal* 14(1): 149. /pmc/articles/PMC7949524/.

Sibbald, R. Gary et al. 2021. "Wound Bed Preparation 2021." *Advances in skin & wound care* 34(4): 183–95.

de Smet, Gijs H.J. et al. 2017. "Oxygen Therapies and Their Effects on Wound Healing." *Wound Repair and Regeneration* 25(4): 591–608.

Shores JT, Gabriel A, Gupta S. Skin substitutes and alternatives: a review. *Adv Skin Wound Care.* 2007;20:493–508

Thakral, Gaurav et al. 2013. "Electrical Stimulation to Accelerate Wound Healing Electrical Stimulation to Accelerate Wound Healing."

Voigt, Jeffrey, Martin Wendelken, Vickie Driver, and Oscar M. Alvarez. 2011. "Low-Frequency Ultrasound (20-40 KHz) as an Adjunctive Therapy for Chronic Wound Healing: A Systematic Review of the Literature and Meta-Analysis of Eight Randomized Controlled Trials." *International Journal of Lower Extremity Wounds* 10(4): 190–99.

Webster, J et al. 2019. "Webster J, Liu Z, Norman G, Dumville JC, Chiverton L, Scu Ham P, Stankiewicz M,

Chaboyer WP." *Cochrane Database of Systematic Reviews* (3): 151. https://www.cochranelibrary.com/es/cdsr/doi/10.1002/14651858.CD009261.pub4/full/es.

Woo, Kevin, Elizabeth A. Ayello, and R. Gary Sibbald. 2007. "The Edge Effect: Current Therapeutic Options to Advance the Wound Edge." *Advances in skin & wound care* 20(2): 99–117.

Yadollahpour, Ali, Mostafa Jalilifar, and Samaneh Rashidi. 2014. "Ultrasound Therapy for Wound Healing: A Review of Current Techniques and Mechanisms of Action." *Article in Journal of Pure and Applied Microbiology*. https://www.researchgate.net/publication/267926830.

This is where you can add appendices or other back matter.