Expedition Wound Care

Introduction

Unfortunately, wounds are all too common on outdoor trips, with minor abrasions and full-thickness lacerations leading the list; that said, deeper wounds are not unheard of. The goal of wound care is to prevent infection and promote healing. Expedition settings bring challenges to wound management that are relatively rare in an urban environment and require a deeper understanding of the healing process and available dressing technology.

The Healing Process

The wound healing process has five continuous and overlapping phases:

1. Hemostasis Phase [5-15 min]. When the skin is broken during the creation of a full-thickness wound, blood vessels constrict to minimize bleeding. Seconds later, platelets aggregate and adhere to the inside of the damaged vessels as specialized protean strands [fibrin] create a mesh designed to trap platelets, form a clot, and stop the leak. In a dry wound environment, the clot develops into a scab.

2. Inflammatory Phase [0-3 days]. Inflammation leads to local vasodilation and increased vascular permeability that, in turn, permit phagocytes and other supplies to seep into the tissue and, together with the clotting proteins, form an internal barrier and external scab that help contain and destroy bacteria. Excess fluid and debris (pus or slough) not picked up by the lymphatic system or ingested by phagocytes drains through the scab. Inflammation is a natural part of the wound-healing process and is only problematic if prolonged or excessive.

3. Proliferation Phase [3-24 days]. During the proliferation phase, new tissue made up of collagen—secreted by fibroblasts—and extracellular matrix gradually rebuild the damaged tissue: Myofibroblasts contract and pull the wound edges together, new capillaries form and grow into red granulation tissue, and pink/white epithelial tissue migrates from wound edges towards the center. Healthy granulation tissue is relatively tough, with little to no drainage [exudate].

4. Epithelialization Phase [3-24 days]. At the end of the epithelialization phase, skin cells entirely cover the the granulation tissue. Epithelial cells form faster when the wound is kept warm and moist. Occlusive or semi-occlusive dressings applied within 48 hours of the injury and used throughout the healing process help maintain the necessary humidity for optimal epithelialization.

5. Maturation Phase [24+ days]. The initial collagen laid down during the proliferative and epithelization phases is disorganized, and the wound is thick. During the maturation phase, collagen reorganizes along stress lines and increases the tensile strength of the remodeled skin. Cells used to repair the wound are no longer needed and die [apoptosis]. Fully healed wounds are roughly 20% weaker than uninjured skin.

Individual characteristics that inhibit healing include:

- Age.
- Poor circulation, including vascular disease, diabetes, and obesity.
- Poor nutrition.
- Weakened immune response.
- Infection.
- Peripheral neuropathy.
- Stress.

Wound attributes that inhibit healing include:

- High risk of infection. Wounds that are contaminated, dirty, deep, or have ragged edges are at high risk of infection. High-risk wounds often require thorough and ongoing cleaning and topical or systemic antimicrobials to prevent infection and heal. Signs and symptoms of a local infection include increased redness and heat around the wound site with pus and a foul odor. Signs and symptoms of a systemic infection include fever, chills, malaise, and red streaks extending from the wound site toward the trunk.

- Scab/dry healing environment. Wounds exposed to air dry out, and a scab [eschar] forms. Epithelial cells — formed during phase four — need moisture to migrate across the surface of the wound bed. If a scab is present, the cells form in the moist layer under the scab, dramatically slowing the healing process. Moist wounds heal 50% faster than dry wounds. The clear serous fluid that leaks from the surrounding tissue [exudate] during the inflammatory phase contains the nutrients, proteins, glucose, and white blood cells necessary for the wound to heal; however, too much exudate can cause the skin to soften and break down [macerate], left untreated, maceration can lead to a bacterial or fungal skin infection. Maintaining the correct moisture content in the wound bed is critical for rapid healing.


Scab


Macerated Wound Edges

- Use of cytotoxic antiseptics. Chlorhexidine or povidine iodine are common topical antiseptics used to clean the skin around the wound to help prevent bacteria from migrating into the wound. If used directly on the wound, antiseptics destroy bacteria and healthy cells. While antiseptics may be warranted for an infected or high-risk wound, a risk/benefit analysis is required. Consider reducing the toxicity of a 10% PI solution by diluting it with water; solutions less than 1% do little damage to healthy cells but are still toxic to bacteria. Leave in place for at least three minutes.


Moist Slough

- Slough. Slough comprises dead white blood cells, tissue debris, bacteria, and fibrin. A small amount of slough is expected during the inflammatory phase of healing as the immune system works to kill bacteria within the wound; the amount of slough should decrease after the first day or two. Increasing slough indicates bacterial growth that will delay healing and may lead to a local infection. Slough is initially moist and soft but, over time, gradually dries into a leather-like consistency that may require surgical removal.

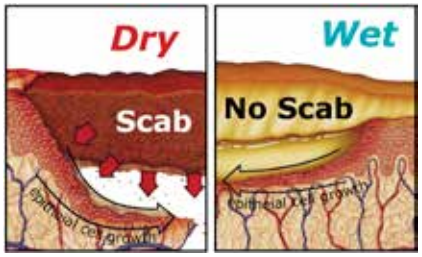

Dry Slough

- Biofilm growth. A biofilm is a microbial colony that can attach to a wound surface. The colony is encased in a thick, protective layer of sugars and proteins that shields the microorganisms from the patient's immune system and many antimicrobial agents, including antibiotics and topical treatments, making them difficult to remove. Biofilm colonies are microscopic and must be confirmed by biopsy. To the naked eye, they appear as a shiny covering over the wound bed; they prolong inflammation, compromise skin integrity, and delay healing.

Dressings

Characteristics of Ideal Expedition Dressings

- easy to use
- low cost
- works well for multiple wound types and across multiple healing phases
- hypoallergenic
- easy to remove
- conform to the wound bed and promote healing
- maintain a consistent moist environment to eliminate scab [eschar] formation, promote healing, and reduce scarring
- minimize micro-trash



Dressing Options

Six categories of wound dressings are discussed below. Recommendations are based on the ideal characteristics discussed above for healthy individuals with no local or systemic wound infection. Infected wounds and those slow to heal should be evacuated for assessment and treatment by a physician or wound care specialist.

1. Transparent film dressings are permeable to water vapor but not liquids. They help maintain a moist environment for full-thickness wounds with little exudate and abrasions. Because they are transparent, you can watch the wound heal through them. If clear fluid [serious exudide] builds under the film, switch to a foam dressing to prevent skin maceration. Alternatively, add a non-adherent gauze dressing ± additional gauze under the film to absorb excess fluid. You can also add an antimicrobial directly to the wound bed if the wound is at risk for infection. They are often the best choice for wet expedition environments and can be layered with other dressings to manage exudate. Transparent film dressings are recommended for minimal or low exudate wounds or medium to high exudate wounds in a wet expedition environment when combined with a foam dressing.
2. Foam dressings are effective for all wound types. They adhere to the wound's surface and absorb excess exudate while maintaining a warm, moist wound bed; they can be left in place for multiple days. Generally, the thicker the foam, the more exudate it can absorb and hold. Some foam dressings come with

a perimeter adhesive, while others require flexible medical tape to keep them in place. Foam dressings without perimeter adhesive can be cut to size but require fixation. If the wound is at risk for a local infection, you can apply an antibacterial ointment under the foam. Foam dressings can also degrade moist slough on the wound surface. Foam dressings without a perimeter adhesive are recommended for medium to high exudate wounds and secured with a transparent film dressing or flexible medical tape. Flexible medical tape permits moisture to evaporate through the dressing and is water-resistent.

3. While dry gauze should never be used directly on a wound bed before the wound has completely closed, it can be impregnated with medical honey or Vaseline to create a moist environment to promote healing or added as a secondary dressing to hold excess exudate or provide protective padding. Vaseline-impregnated gauze dressings are inexpensive and work well for dry or low exudate wounds when combined with flexible medical tape or transparent film dressing. Vaseline-impregnated gauze dressings are recommended as the initial dressing for most wounds in healthy individuals. Dry gauze dressings are also used to protect fully closed wounds during the maturation phase.
4. Hydrogel dressings are primarily used for dry wounds or wounds with minimal exudate. They reduce pain, promote healing, and can be used with infected wounds. Once the lid has been removed, they are commonly used to relieve pain and promote healing with friction blisters. They can also degrade slough on the wound surface. While hydrogel dressings work well for treating friction blisters, they are not recommended for full-thickness wounds in an expedition setting as foam dressings are more versatile in an expedition setting.
5. Hydrocolloid dressings use gel to create an impenetrable protective barrier that prevents bacteria from entering the wound bed and maintains a moist environment. Like hydrogel dressings, they are used with dry wounds or wounds with minimal exudate; however, they should not be used with infected wounds or wounds at risk of infection because they are occlusive and can trap bacteria. Hydrocolloid dressings are not recommended in an expedition setting as foam dressings are more versatile.
6. Calcium alginate dressings are used with wounds with moderate to severe exudate. They form a soft gel when in contact with exudate and conform to the contours of the wound to provide a micro-environment that helps break down dead tissue and encourage new skin cell growth. They can be used to pack deep wounds. They require a secondary dressing and fixation. Calcium alginate dressings are not recommended in an expedition setting as foam dressings are more versatile and easier to use, and medical honey can be used to fill a deep wound and promote healing.

Antimicrobials

Recommendations for antimicrobials used in treating wounds in a remote setting are for healthy individuals and designed to prevent a local or systemic wound infection. Infected wounds and those slow to heal should be evacuated for assessment and treatment by a physician or wound care specialist.

- Use soap and water to gently wash the wound bed and surrounding skin and pat dry at each dressing change. Apply chlorhexidine or povidone-iodine solution to the skin surrounding the wound to reduce the chance of bacteria reaching the wound bed. If the risk or consequences of local infection are high, dilute a 10% povidone-iodine solution to less than 1% and wash the wound before applying the primary dressing. 10% povidone-iodine solution is recommended over chlorhexidine because it can be used full-strength to clean skin around the wound and diluted to less than 1% for use in deep wounds or directly on a wound bed. While chlorhexidine is faster and better than povidone-iodine in reducing bacterial migration, due to its toxicity it should not be used in deep wounds.
- Medical honey has proven more effective than antibacterial ointments in preventing infection and promoting healing. It can be used to fill a deep wound, applied to the wound's surface, or impregnated into a gauze dressing. Medical honey is recommended for the prevention of local infections and the treatment of biofilms.
- Antiseptics like chlorhexidine or povidone-iodine solutions are excellent for cleaning the skin around a wound but cytotoxic when used inside or directly on a wound bed. Dilute a 10% povidone-iodine solution with clean water to less than 1% to flush or pack a high-risk wound or use it directly on a wound bed or dressing. A 10% povidone-iodine solution is recommended for removing bacteria from the skin around the wound site; a less than 1% povidone-iodine solution is recommended for flushing and packing high-risk wounds, cleansing a high-risk wound bed or saturating a gauze dressing to treat or prevent a local infection.
- Antibacterial ointments or creams—e.g., Bacitracin, Neosporin, Polysporin, or mupirocin—to prevent wound infection are controversial. They are not recommended for treating or preventing local infection infections in an expedition setting, as medical honey is more effective and versatile in promoting healing and does not lead to allergic dermatitis or bacterial resistance.

Refer to the graphic below for treatment objectives, dressing options, and changes for each phase of the healing process.

Wound Care in an Expedition Setting

INJURY	HEMOSTASIS	INFLAMMATORY	PROLIFERATION	EPITHELIZATION	MATURATION
Stages of Wound Healing	*0-15 Minutes* Full-thickness wound ± moderate to heavy bleeding; sutures are not required to repair deep structures or close wound.	*0-3 Days* Initial healing and natural wound cleaning starts. Exudate — dead nutrafils and other debris [pus] — forms.	*3-24 Days* Beginning of reconstruction & repair. Granulation tissue fills the wound from the bottom up.	*3-24 Days* Delicate new skin [epithial cells] migrate from the wound edges and covers granulation tissue.	*24+ Days* The wound is closed but not fully healed.
					
	• Wound is clean • Bleeding has stopped [blood has clotted and formed a platelet plug]	• Surrounding skin is typically red, warm > hot, and swollen • White/yellow pus forms • Minimal/moderate exudate	• Red granulation tissue forms in the wound bed • As the wound fills with granulation tissue, pink/white epithelial tissue migrates from the wound edges • Minimal or no exudate	• Pink/white epithelial tissue forms and covers the wound • Very delicate • No exudate • No slough	• The skin is still delicate and there is a risk of reopening of the scar.
Treatment Objectives	• Cover & protect • Shallow full-thickness wounds can be closed with steristrips • Absorb any remaining blood • Moist wound healing	• Cover & protect • Manage exudate • Manage bacteria • Aid removal of dead tissue • Moist wound healing	• Cover & protect new tissue • Absorb exudate • Moist wound healing • Remove slough as necessary	• Cover & protect if there is a risk of new damage	• Cover & protect if there is a risk of new damage
Recommended Dressing Options	• Transparent film dressing ± non-adhesive gauze pad ***or*** Vaseline-impregnated gauze • Non-adherent gauze pad ***or*** Vaseline-impregnated gauze with flexible medical tape • Tincture of Benzoin may be used to protect undamaged skin and enhance fixation	• Foam dressing, Vaseline-impregnated gauze, ***or*** non-adherent gauze pad with flexible medical tape or transparent film dressing • If the wound is at high risk of local infection: wash wound bed with < 1% povidine-iodine • Consider medical honey • Tincture of Benzoin may be used to protect undamaged skin and enhance fixation	• If slough is present, use a foam dressing with flexible medical tape **or** transparent film dressing • Consider Vaseline-impregnated gauze, ***or*** non-adherent gauze pad with flexible medical tape **or** transparent film dressing if there is minimal minimal exudate and no slough. • If the wound is at high risk of local infection or slough is present: wash wound bed with < 1% povidine-iodine • Consider medical honey • Tincture of Benzoin may be used to protect undamaged skin and enhance fixation	• Non-adherent gauze pad ± secondary dry gauze for additional padding with flexible medical tape ***or*** transparent film dressing • Tincture of Benzoin may be used to protect undamaged skin and enhance fixation	• Non-adherent gauze pad ± secondary dry gauze for additional padding with flexible medical tape ***or*** transparent film dressing • Tincture of Benzoin may be used to protect undamaged skin and enhance fixation
Timing of Dressing Change	• Monitor healing daily: Reclean wound & reevaluate. Change dressing if exudate increases after 24 hrs; add foam, non-adherent pad, or antimicrobial as necessary.	• Monitor, reclean and change dressing based on exudate and risk of infection.	• Reclean and change dressing every 5-7 days	• Reevaluate wound when dressing starts to fall off.	• Reevaluate wound and the on-going need for protection when dressing starts to fall off.
Wet expedition environment [rain, water sports, etc.]	• Transparent film dressing ± foam dressing, Vaseline-impregnated gauze, ***or*** non-adherent gauze pad	• Transparent film dressing ± foam dressing, Vaseline-impregnated gauze, ***or*** non-adherent gauze pad	• Transparent film dressing + foam dressing	• Transparent film dressing with non-adherent gauze pad ± secondary dry gauze for additional padding	• Transparent film dressing with non-adherent gauze pad ± secondary dry gauze for additional padding
Problems that Delay Healing	• High risk wound [deep, ragged edges, dirty, contains organic material]	• Scab [eschar] formation • Local infection may lead to a systemic infection; oral Rx antibiotics are typically required • Use of cytotoxic antimicrobials — chlorhexidine ***or*** povidine iodine — requires a risk/benefit analysis. Consider reducing the toxicity of a 10% PI solution by diluting it with water to < 1%.	• Continued or increased exudate production • Continued or increased slough production • Biofilm develops and covers wound surface • Use of cytotoxic antimicrobials	• New Damage	• New Damage