WILDERNESS & ENVIRONMENTAL MEDICINE, **27,** 519–525 (2016)

REVIEW ARTICLE

Management of Burn Injuries in the Wilderness: Lessons from Low-Resource Settings

Cindy C. Bitter, MD, MA, MPH; Timothy B. Erickson, MD

From the Department of Surgery, Division of Emergency Medicine and the College of Public Health and Social Justice, Saint Louis University, St. Louis, MO (Dr Bitter); and the Department of Emergency Medicine, Division of Toxicology, Brigham & Women's Hospital, Harvard Medical School, Harvard Humanitarian Initiative, Boston MA (Dr Erickson).

Burns are a common source of injuries worldwide, with a high burden of disease in low- and middle-income countries. Burns also account for 2%−8% of wilderness injuries. Although many are minor, the potential for serious morbidity and mortality exists, and standard treatments used in high-resource settings are not readily available in the backcountry. A literature review was performed to find evidence from low-resource settings that supports alternative or improvised therapies that may be adapted to care of burns in the wilderness. There is good evidence for use of oral rehydration to support volume status in burn patients. There is moderate evidence to support cold therapy as first aid and adjunct for pain control. Some evidence supports use of alternative dressings such as boiled potato peel, banana leaf, aloe vera, honey, sugar paste, and papaya when standard therapies are not available.

Key words: thermal injury, wilderness, alternative treatments

Introduction

Multiple large studies of wilderness trauma show burns account for 2%−8% of injuries.[1–6] Recreational areas with geothermal features have higher rates of severe injuries.[7] The primary mechanisms of burn in the wilderness setting are scalds from hot liquids and thermal burns from direct contact with hot objects such as stoves, lanterns, and coals from campfires. Injuries from direct contact with flames are less common. Campfire burns are recognized as a worldwide problem, as evidenced by case series from San Diego,[8,9] Arizona,[10] Australia,[11] Saudi Arabia,[12] and South Africa.[13] These injuries frequently involve the hands and feet, with a high potential for long-term morbidity.

Burn injuries are also a leading cause of trauma globally, with 85% of injuries occurring in low- and middle-income countries, where therapeutic options are limited by resource constraints.[14] Up to 17.5 million burns occur in children in sub-Saharan Africa annually.[15] India has an estimated 600,000–700,000 admissions to burn units per year.[16] Morbidity and mortality are higher for a given injury in low- and middle-income countries.[15] Currently, the burn size associated with a 50% case fatality in high-income countries is between 60% and 70% total body surface area (TBSA).[17] In Nepal, burns between 20%−30% TBSA carried a 50% mortality rate, and no patient survived burns of more than 40% TBSA.[18] We hypothesize that treatments used in low-resource settings can be adapted to back-country care of burn injuries.

Most burns occur in males during the working years of life. Although scalds are the most common burns in children less than 5 years of age, burns due to exposure to fire or flame predominate in all other age groups. The majority of burns are relatively small with only 2% covering 40% TBSA or more.[19]

Corresponding author: Cindy Bitter, MD, MA, MPH, 3635 Vista Ave, Desloge Tower, 1st floor, St. Louis MO 63110 (e-mail: bittercc@slu.edu).

Submitted for publication May 2016.
Accepted for publication September 2016.

Case report

Three days into a 14-day backpacking trip in the rural mountainous region of Nepal, an otherwise healthy 26-year-old man sustained scald burns from a pot of boiling water. He had partial thickness burns to the dorsal aspect of the left forearm and anterior thighs totaling 15% TBSA. First aid consisted of rinsing the areas with cool water from a nearby stream. He was seen at the health post of a nearby village, where large blisters were sharply

debrided and the wounds were dressed with honey and boiled potato peel dressings. Pain control was adequate with cold therapy and nonsteroidal anti-inflammatory medications. He completed the trip and was seen for wound check when he returned to Kathmandu. A hydrocolloid dressing was used on the remaining open area on the left thigh. His burns healed with acceptable cosmetic outcome.

First aid

Cold therapy such as use of cool running water or cold compresses has been shown to limit the depth and size of burns[20] and is an important adjunct for pain control. In 1 study in Nigeria, patients treated with cool water lavage had a lower complication rate than those treated with other forms of first aid.[21] Optimal temperature and duration of cold therapy have not been extensively studied,[22] but use of ice water and direct application of ice has been shown to worsen burn healing.[23,24] Loss of skin integrity from burns impairs the body's ability to thermoregulate, but prehospital use of cold therapy was not associated with hypothermia in one study.[25] The authors suggested that clinically important hypothermia would only be a concern for extensive burns, 70% TBSA or greater.

The burn wound should be gently cleansed to remove debris. There is a paucity of evidence to guide management of blisters, and clinical controversy persists. Citing concerns about inflammatory mediators in blister fluid and infection risk with the presence of devitalized tissue in the wound, some authors recommend debridement of nonintact blisters, blisters over joints, and blisters larger than 6 mm.[26] Leaving the blisters intact is advocated by 1 review, which found enhanced patient comfort and lower risk of infection with conservative management than with aspiration or debridement.[27]

After cleansing and possibly debridement of blisters, the wound should be evaluated to determine the location, size, and depth. Burn size is estimated using the "rule of nines" or a pediatric modification. For smaller areas, the palmar surface of the patient's hand represents 1% TBSA. Unlike most traumatic injuries, burns are dynamic and tend to progress over time; thus, it may be difficult to accurately assess burn depth immediately after injury.[28] The initial estimate will guide fluid therapy and suggest need for evacuation. Serial assessments may be required to determine the most appropriate therapeutic plan.

Fluid therapy

Given insensible losses and leakage of intravascular fluid into the soft tissues, maintaining adequate circulating volume is crucial. Patients with deep burns covering larger body surface areas will require fluid resuscitation to support vital organ perfusion and ensure adequate urine output. When intravenous access is available, the Parkland formula is the most common method used to calculate fluid requirements.[29–31] It calls for 4 mL/kg/% TBSA of Ringer's lactate solution over the first 24 hours; half of the fluid is given within the first 8 hours after injury and the other half is given over the next 16 hours.

Concern that excess fluid administration contributes to burn edema and lung injury have led to multiple modifications of resuscitation protocols.[32] The Modified Brooke formula calls for 2 mg/kg/%TBSA in adults and 3 mg/kg/%TBSA in children in the first 24 hours. The United States Armed Forces Institute of Surgical Research has recently proposed a simplified formula, the "rule of 10" in which patients are administered 10 mL Ringer's lactate solution for every %TBSA per hour, with hourly adjustments based on clinical response and urine output.[33] The rule of 10 has acceptable predictive value for adult patients but has not been validated for pediatric patients.[34] The target urine output is 0.5 mg/kg/h for adults and 1 mg/kg/h for pediatric patients.

In low-resource settings, oral rehydration therapy is routinely used for burns of less than 20% TBSA and has been successful in treating burns up to 40% TBSA.[35–37] Frequent small sips of fluid are better tolerated than larger boluses. Oral rehydration therapy salts can be purchased or improvised according to several recipes (Table 1), or locally available substitutes such as salted rice water or lassi may be used.[38] If patients are unable to tolerate large volumes of fluid orally, rectal infusion therapy (proctoclysis) can be implemented with oral rehydration therapy solution. A urethral catheter is inserted into the rectum, and fluids are instilled according to the patient's clinical condition and tolerance of the infusion.[39]

Pain management

Adequate pain control is thought to reduce long-term psychological sequelae after burns.[40] For decades, cold therapy has been advocated to control burn pain,[41,42] but recent data to support its use is limited.[43] Narcotic analgesics, often in high doses, are the mainstay of

Table 1. Formulas to prepare oral rehydration solution

World Health Organization	*Simple*
3/8 teaspoon salt	6 teaspoons sugar
1/4 teaspoon salt substitute (KCl)	1/2 teaspoon salt
1/2 teaspoon baking soda	1 L clean water
6 teaspoons sugar	
1 L clean water	

KCl, potassium chloride.