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Evidence-Based Review of Wilderness First Aid Practices

Tod Schimelpfenig
National Outdoor Leadership School Wilderness Medicine Institute

David E. Johnson
Central Maine Medical Center

Grant S. Lipman
Stanford University School of Medicine

David H. McEvoy
Aerie Backcountry Medicine

Brad L. Bennett
Uniformed Services University of the Health Sciences

Abstract

Wilderness First Aid is a common certification for outdoor recreationists, educators, and trip leaders. A panel of educators, researchers, and clinicians evaluated 15 core and eight elective WFA practices for strength of recommendations based on the quality of supporting evidence and balance between the benefits and risks/burdens according to the methodology stipulated by the American College of Chest Physicians. The strength of the evidence for these 23 WFA practices varies widely because of scant published research to date. When no evidence existed, the panel based recommendations on a consensus of the panelists for risk/benefit and best practices. This review clearly points out the need for conducting greater research to strengthen the level of evidence in numerous WFA topics and for educational strategies that improve retention of core knowledge, as well as skill application for the lay first aid provider.

KEYWORDS: wilderness first aid; lay person; assessment; treatment; evacuation

People who live, work, travel, and recreate in remote locations should be prepared to provide first aid in challenging weather, with ineffective communication, delayed medical support, and limited equipment. Over the past 50 years, as outdoor recreation and education has grown in popularity, medical and outdoor specialists developed wilderness medicine courses to meet the needs of trip leaders and outdoor recreationists who were dissatisfied with urban-oriented first aid curriculums that were not practical or relevant for the wilderness (J. Gookin, personal communication, December 29, 2015). Annually thousands of laypeople take wilderness medicine courses offered by dozens of organizations in the United States. This paper focuses on the 16-hour Wilderness First Aid (WFA) course because of its popularity and because it shares a common curriculum with the majority of other layperson wilderness medicine courses.

In a 2013 consensus paper, a group of WFA course experts (Johnson et al., 2013) described the audience for a WFA course as nonmedical professionals for whom first aid delivery is a secondary responsibility. The intended context of practice is remote locations typically in but not limited to North America. Local emergency medical services (EMS)/search and rescue access is expected in less than 8 hr. These may be short trips relatively close to help, day trips/camps, stationary wilderness camps, weekend family activities, or front-country outdoor recreation.

First aid has been defined as "assessments or interventions that can be performed by the bystander (or by the victim) with minimal or no equipment" and as "immediate help provided to a sick and injured person" (Van de Velde et al., 2007, p. 241) consisting of "techniques requiring minimal or no equipment that can be taught to the general public in basic courses" (Markenson et al., 2010 p. S935). The focus of WFA is a basic patient assessment to identify obvious injuries or abnormalities; stabilize emergencies; initiate specific and appropriate medical treatments (e.g., basic splints, wound care, spine immobilization, managing heat and cold); and make conservative decisions on the need for, the urgency of, and the appropriate type of evacuation. Cardiopulmonary resuscitation (CPR) that includes instruction in positive pressure ventilation (mouth-to-mouth or mouth-to-mask) is a recommended additional skill for the WFA provider.

A WFA scope of practice has been published (Johnson et al., 2013) and is the source of the first aid procedures discussed in this review. The objective of this review is to evaluate the quality of evidence for the standardized WFA practices within the 23 curriculum (core and elective) topics described in that article and to provide key recommendations based on risks and benefits for patient management. Further, the intent of this review is to make recommendations and to provide supporting evidence that allows the WFA practitioner and course instructor to better understand the strength of evidence upon which the curriculum and practice is built rather than relying on anecdotes. Although supporting evidence for first aid procedures have been published for urban first aid (Markenson et al., 2010; Singletary et al., 2015), these recommendations and an evidence review process is currently absent in the WFA literature.

Method

In this era of evidence–based medicine, the grading of treatment recommendations is an increasingly common practice. A systematic approach to grading the strength of management recommendations can minimize bias, aid interpretation, and allow the clinician a deeper understanding of the rationale for treatment recommendations. The grading of the recommendations is based on quality of supporting evidence and consideration of benefits and risks/burdens for each modality. The panel used a grading system outlined by the American College of Chest Physicians (ACCP; Guyatt et al., 2006; Table 1).

Table 1
American College of Chest Physicians Classification Scheme for Grading Evidence and Recommendations in Clinical Guidelines

Grade	Grade description	Benefits vs. risks and burdens	Methodological quality of supporting evidence
1A	Strong recommendation, high quality evidence	Benefits clearly outweigh risks and burdens, or vice versa	Random controlled trials (RCT) without important limitations, or overwhelming evidence from observational studies
1B	Strong recommendation, moderate quality evidence	Benefits clearly outweigh risks and burdens, or vice versa	RCT with important limitations, or exceptionally strong evidence from observational studies
1C	Strong recommendation, low quality or very low quality evidence	Benefits clearly outweigh risks and burdens, or vice versa	Observational studies or case series
2A	Weak recommendation, high quality evidence	Benefits closely balanced with risks and burdens	RCT without important limitations, or overwhelming evidence from observational studies
2B	Weak recommendation, moderate quality evidence	Benefits closely balanced with risks and burdens	RCT with important limitations, or exceptionally strong evidence from observational studies
2C	Weak recommendation, low quality or very low quality evidence	Uncertainty in the estimates of benefits, risks, and burdens; benefits, risks, and burdens may be closely balanced	Observational studies or case series

Note. From "Grading Strength of Recommendations and Quality of Evidence in Clinical Guidelines: Report from an American College of Chest Physicians Task Force," by Guyatt et al., 2006, *Chest, 129,* 174–181.

The panel members were as follows:

- Tod Schimelpfenig, Wilderness Emergency Medical Technician (WEMT), Fellow of the Academy of Wilderness Medicine (FAWM), National Outdoor Leadership School (NOLS) Wilderness Medicine Institute
- David E. Johnson, MD, Fellow of the American College of Emergency Physicians (FACEP), Department of Emergency Medicine, Central Maine Medical Center
- Grant S. Lipman, MD, FACEP, FAWM, Department of Emergency Medicine, Stanford University School of Medicine
- David H. McEvoy, MS, Critical Care Emergency Medical Technician-Paramedic (CCEMT-P), Aerie Backcountry Medicine
- Brad L. Bennett, PhD, National Registry of Emergency Medical Technicians-Paramedic (NREMT-P), FAWM, Military & Emergency Medicine Department, F. Edward Hébert School of Medicine, Uniformed Services University of the Health Sciences

The panel included educators, instructors, and curriculum developers in the field of wilderness medicine from academic and private institutions. Three of the coauthors (DJ, DM, TS)

are either medical directors or curriculum directors for wilderness medicine programs and two others (BB, GL) are academic faculty in schools of medicine. Although all coauthors have no commercial conflicts of interest in the outcome of this study, the potential for bias cannot be ruled out and is a limitation of the review. To minimize bias, the panel members formed a joint writing group with initial two-person teams for the literature search, evaluation of the available manuscripts, and initial grading of the evidence. Each team selected between five and six WFA topics based on the 15 core and eight elective topics from Johnson et al. (2013; Table 2). Relevant articles were identified by a search of MEDLINE as the primary database, U.S. National Library of Medicine, and National Institutes of Health. Key search terms used were *wilderness, first aid, bandages, fractures, layperson, assessment, treatment,* and *evacuation* (see Table 2 for a complete list of search terms). Peer-reviewed studies related to WFA practices, observational studies, and case series were reviewed, and the level of evidence supporting the conclusions was assessed. Abstract-only studies were not included. Conclusions from review articles were not considered in the formulation of recommendations. Like urban first aid, many areas of WFA are lacking substantial research and thus recommendations were often based upon hospital or emergency medical services (EMS) studies.

The review process extended from June 2014 until June 2015. The group followed a modified Delphi process used in the medical literature to develop position papers. The group communicated by phone and e-mail. Each topic team independently developed an initial grading table (listing the topic, the reference, a brief description of the paper, comments on the methodological quality of the supporting evidence, and the panelist's grading) and then submitted the grading table to the larger group. A consensus approach—back and forth circulation of the grading tables—was used until group consensus was reached for each topic and a final grade was agreed upon. When no relevant studies were identified for any WFA practice, the recommendation was based on risk versus benefit perceptions derived from patient-care experience and an entry of No Grade (NG) was made. For example, the panel found no substantive evidence for the common advice to stabilize injuries to prevent further damage and blood loss in shock. The panel then came to a consensus opinion that the benefit from stabilizing injuries with simple first aid splinting outweighs the risk of exacerbating pain and possibly shock from patient movement during splinting.

Table 2
The 15 Core and Eight Elective Topics and Skills With Key Search Terms

Core topics and skills	Key search terms
Topics	
Patient Assessment System	basic life support, primary survey, secondary survey, disability, trauma, hemorrhage, patient assessment
Circulatory System: Shock	shock, first aid, Trendelenburg
Circulatory System: Acute Coronary Syndrome	acute coronary syndrome, chest pain, prehospital management, nitroglycerin, aspirin
Respiratory System	respiratory failure, upper airway, acute asthma, MDI, caregiver/education
Nervous System	oral glucose, recovery position, oral mucosa, hypoglycemia
Spine Injury	spinal injury, spinal trauma, spinal immobilization, cervical spine injury, cervical spine immobilization, cervical spine clearance

Table 2 (cont.)

Topics	Key search terms
Wounds	wound care, wound management, wound closure, wound infection, burn care, blister care, hemorrhage control, bleeding
Burns	burn first aid, cryotherapy
Musculoskeletal Injuries	splints, injury, cryotherapy, and ankle
Allergic Reaction and Anaphylaxis	anaphylaxis, treatment and epinephrine
Heat-Related Illness	heat stroke, heat exhaustion, heat illness, prevention, recognition, treatment
Hypothermia	accidental hypothermia, secondary hypothermia, trauma induced hypothermia, hypothermia, rewarming, resuscitation, wilderness medicine, avalanche, cold
Lightning Injury	lightning injury, lightning strike, prevention
Submersion	drowning, near drowning, immersion, submersion incident, respiratory distress, pulmonary edema
Common Medical Problems	abdominal pain; vomiting and diarrhea; cough and upper respiratory infection; urinary tract infection; ear, nose, throat; fever; poisoning; toxicity; ipecac; activated charcoal
Elective Topics and Skills	
Dislocation	dislocation, shoulder, treatment, reduction and radiography
Spine Injury Evaluation	NEXUS, Canadian C-spine rule, cervical fracture, spinal clearance, immobilization, prehospital
Frostbite and Non-Freezing Cold Injury	frostbite, frostbite prevention, hypothermia, rewarming, aloe vera, thrombolysis, trench foot, immersion foot
Altitude	high altitude, acute mountain sickness, high altitude pulmonary edema, high altitude cerebral edema, acetazolamide, dexamethasone
Poisoning	poisons, inducing vomiting, ipecac
Toxic: Snakebite	snakebites, arthropods, marine, envenomation, prehospital management
Toxic: Arthropods	
Toxic: Marine	

Note. From "Minimum Guidelines and Scope of Practice for Wilderness First Aid," by D. Johnson et al., 2013, *Wilderness and Environmental Medicine, 24,* 456–462.

Results

The core and elective WFA practices (Table 1) were examined within an evidence-based framework. To help the reader better understand and appreciate the strength of the evidence upon which the curriculum and practice is built, we first present the grading recommendation,

followed by comments to give context to the topic area as commonly taught on a WFA course. To avoid opinion and potential bias, the writing group avoided interpretation of the results in the framework of an educational strategy.

Patient Assessment System

Recommendation: Use a basic patient assessment system to identify obvious medical problems: NG

The WFA provider is taught a basic patient assessment system (e.g., airway-breathing-circulation, simple head-to-toe physical exam, elementary vital sign measurement, and medical history interview) that is patterned after but pared down from the assessment systems taught to professional providers. The WFA provider does not learn to measure blood pressure with a sphygmomanometer, to assess lung sounds or pupillary reaction, or to identify subtle physical signs or elicit nuanced symptoms. The patient assessment system, taught in both EMS and first aid courses, is based on tradition and expert opinion and consensus, although it is poorly supported by evidence of its efficacy. One study shows poor retention of patient assessment skills in WFA course participants (Schumann, Schimelpfenig, Sibthorp, & Collins, 2012).

Circulatory System: Shock

Recommendation:

Stabilize injuries to prevent further damage and blood loss: NG

Provide oral fluids if a patient can protect his or her airway: 1C

The WFA provider is taught to recognize signs and symptoms of shock and to differentiate these from an acute stress reaction. Treatment recommendations for volume shock (e.g., vomiting, diarrhea, bleeding) are bleeding control, stabilization of injury, oral fluids if tolerated, and protection from adverse environmental conditions during evacuation. Although oral fluids are not recommended in the urban first aid context where prompt transport to definitive care is anticipated, if the WFA provider has no other option, then oral fluids in patients who can protect their airway are logical and consistent with extensive experience in the context of diarrhea (Sack et al.,1970; Spandorfer, Alessandrini, Joffe, Localio, & Shaw, 2005).

Circulatory System: Acute Coronary Syndrome

Recommendation:

Evacuate the patient with cardiac chest pain and assist patients with their prescribed cardiac medications: 1B

In the case of chest pain (possible acute coronary syndrome), recommended prehospital practices include early symptom recognition, activity cessation, support of a patient with personal medications (e.g., aspirin, nitroglycerin), and evacuation to the health care system, and these are taught to lay WFA providers (Barbash et al., 2002).

Respiratory System

Recommendation:

Assist patients with their prescribed pulmonary medications: 1C

Use BLS techniques for airway management and positive pressure ventilation (mouth-to-mask or mouth-to-mouth): 1C

Recognition and management of respiratory distress is addressed through the basic life support (BLS) skills of opening and maintaining an airway with manual techniques and body position. Invasive or adjunct assisted (i.e., oropharyngeal airway) techniques are not appropriate for

lay WFA providers. The WFA provider is expected to support patients using their personal medications (i.e., prescribed inhaler) according to the patient's physician-prescribed treatment plan. It is unclear whether lay providers can effectively assist patients with their inhalers. Effective assistance would depend on adequate training (Simon, 1999; Clayton, Monroe, Magruder, & King, 2012).

Evacuation is recommended for high risk problems associated with respiratory compromise, worsening symptoms, and altered mental status. Protecting and clearing the airway are accepted BLS procedures.

The American Heart Association (AHA) teaches that unresponsiveness and ineffective breathing are the criteria for beginning chest compressions. Positive pressure ventilations are optional training (compression-only CPR) in the urban context (Kleinman et al., 2015). The AHA also acknowledges that compression-only CPR may not be as effective for children and recovered submersion patients because primary respiratory arrest is often the underlying etiology. (de Caen et al., 2015; Kyriacou, Arcinue, Peek, & Kraus, 1994). Because of this, CPR taught in conjunction with a WFA course should include positive pressure ventilation (mouth-to-mouth or mouth-to-mask) training.

Nervous System

Recommendation:

Use BLS techniques for airway management and positive pressure ventilation in a patient with altered mental status: 1C

Use sublingual glucose in patients with altered mental status: 1C

The WFA provider is trained to identify the most common causes of abnormal mental status (trauma, extremes of temperature, inadequate oxygen, low blood sugar, seizure) and to apply first aid treatment, which includes protecting the airway and spine, protecting the patient from environmental extremes (cooling heat-stroke patients and warming hypothermia patients), ventilating a hypoxic patient, and administering oral sugar. Evacuation is recommended for persistent altered mental status, decreased level of responsiveness, and lack of improvement despite appropriate treatment.

Protecting the airway for a patient with abnormal mental status and protecting the airway and spine for a patient with a head injury are logical layperson first aid measures (Blake, Stillman, Eizenberg, Briggs, & McMeeken, 2002). Provision of oral glucose, which is most likely absorbed in the stomach, not in the buccal mucosa, is controversial (Gunning & Garber, 1978; Squier, 1991). Concerns over airway obstruction exist, albeit in the absence of any evidence that this is a problem, and lead to the recommendation that oral glucose not be rubbed into the gums and only be given to patients who can swallow. In the absence of advanced life support, sublingual glucose in patients with altered mental status is safe and practical (Barennes, 2005).

Spine Injury

Recommendation:

Perform simple lifts, lift and slide, and rolls to facilitate patient examination and protection: 1C

Stabilize patients with suspected spine injury and initiate evacuation: 1C

Use of a selective spine immobilization protocol is inappropriate at the WFA level: 1C

WFA standard of practice is to protect the spine while contacting assistance for evacuation for all patients with a high risk mechanism of injury or signs and symptoms of spinal injury. The WFA provider is taught to identify high risk mechanisms for spinal injury (e.g., trauma with loss of responsiveness or from high velocity, falls greater than 1 meter, falls with axial loading; Stiell

et al., 2003) and to recognize signs and symptoms of possible spine injury (spine tenderness, impaired motor or sensory function, unresponsiveness, or abnormal mental state).

Initiation of spinal protection and simple lifts, lifts and slides, and rolls to facilitate patient examination, protection, and evacuation are part of the WFA skill set. Expert opinion supports the common and practical practice of carefully moving patients if necessary to protect the patient or the rescuer. A lifting technique may provide more stability to the spine than the log roll, but realistically the log roll is often used because the six to eight people needed to do an effective lift are not always available or the lift and slide technique may be impractical because of terrain or limited manpower (Boissy et al., 2011; Conrad, Horodyski, Wright, Ruetz, & Rechtine, 2007; Del Rossi et al., 2004; McGuire, Neville, Green, & Watts, 1987).

The WFA skill set does not include immobilization on a litter or backboard or use of improvised litters or stretchers, because of the limited instructional time in this course and the fact that most outdoor recreationists do not travel with spine immobilization equipment. Expert opinion argues that selective spine immobilization protocols (e.g., NEXUS, Canadian C-Spine Rule; Bandiera et al., 2003; Hoffman, Mower, Wolfson, Todd, & Zucker, 2003) are inappropriate for the lay first aid provider without repeated practice until competency, memory aids/checklists, and/or supervision from higher trained personnel. The limited evidence supports this belief (Schumann et al., 2012).

Wounds

Recommendation:

If a wound is bleeding, apply direct manual pressure to the wound: 1B

Consider using clot enhancing dressing for severe bleeding control: 1B

Apply a tourniquet to an injured limb when no other bleeding control method is effective: 1A

WFA providers should not release a tourniquet in the field: NG

Irrigate wounds without significant active bleeding with potable water under pressure and/or with diluted povidone-iodine: 1B

Apply simple dressings and bandages to cover and protect wounds: 1B

Consider a commercial grade vented chest seal for all open chest wounds: 1B

Stabilize impaled objects: NG

Wound care for the WFA provider includes recognizing and controlling life-threatening bleeding with well-aimed direct pressure (Lehmann, Heath-Lange, & Ferris, 1999), pressure bandage, clot enhancing bandage (Kheirabadi, Scherer, Estep, Dubick, & Holcomb, 2009; Rall et al., 2013), or tourniquet (Kragh et al., 2009). There is strong evidence supporting a wide variety of hemorrhage control techniques that have been researched and implemented in the past decade in support of military requirements (Drew, Bennett, & Littlejohn, 2015; Littlejohn, Bennett, & Drew, 2015). Blood clot enhancing dressings and tourniquet use in field settings is beginning to transition into civilian emergency medical services. Furthermore, the AHA and American Red Cross support layperson education for the tourniquet as a bleeding control technique after a trial of direct pressure (Singletary et al., 2015).

The decision to release a tourniquet in the field is controversial and risks renewed bleeding and shock. Expert opinion is that releasing a tourniquet applied to control life-threatening hemorrhage is beyond the ability of a lay first aid provider and should be done only by an advanced life support provider or in the emergency department (Johnson et al., 2013).

WFA providers should recognize signs and symptoms of soft tissue infection and use hygiene and wound care to prevent infection. A focus on wound care and cleaning has been associated with reduced wound infection rates when used in the field by lay wilderness medicine

providers (Gentile, Morris, Schimelpfenig, & Auerbach, 1992). Wounds without significant active bleeding should be cleaned by removing debris and irrigating (e.g., potable water under pressure, diluted povidone-iodine solution; Dire & Welsh, 1990; Quinn et al., 2014; Valente, Forti, Freundlich, Zandieh, & Crain, 2003).

Simple dressings and bandages to cover and protect wounds are part of the WFA skill set. Evidence is lacking for the efficacy of an improvised three-sided occlusive dressing; therefore, open chest wounds should be covered with an occlusive dressing. The military recommends a commercial vented chest seal as superior to a nonvented or occlusive dressing to minimize the chance of developing a tension pneumothorax, although lay providers do not often carry these dressings (Butler et al., 2013; Kheirabadi et al., 2013; Kotora, Henao, Littlejohn, & Kircher, 2013). In the absence of evidence, expert opinion advises that impaled objects are immobilized in place except if they compromise the airway, cannot be stabilized, will easily fall out, prevent transport, or interfere with control of bleeding.

Blisters are caused by the friction that results from movement over inadequately protected skin. Strategies for prevention should be focused on moving the interface of friction off the skin and/or utilizing some form of protective bandage (Akers & Sulzberger, 1972). Once a blister has formed, it should be cleaned, drained, and covered with one of several types of bandages. If a blood blister breaks, it should be treated as a wound because there is increased risk of infection (Knapik, Reynolds, Duplantis, & Jones, 1995).

Burns

Recommendation:

Use water to cool burns: 1B

Avoid ice or snow application to burns: 1C

Protect the burned area with clean, nonadherent dressing: 1B

Evacuate all but simple, uncomplicated, localized burns and any high risk burns: NG

Burn first aid includes recognition of superficial versus deep burns and areas at high risk for complications: the palms and soles, face, airway, and genitals. Cooling may reduce pain, swelling, and depth of injury. Burns should initially be treated with cool water (not ice or snow), followed by an antibiotic cream or burn gel (hydrocolloid) to keep the surface moist (Cuttle, Kempf, Liu, Kravchuk, & Kimble, 2008; Ofeigsson, Mitchell, & Patrick, 1972).

Protect the burned area with clean, nonadherent dressing (Singer, Berrutti, Thode, & McClain, 1999). Evacuate all but simple, uncomplicated, localized burns. The decision to evacuate is often driven by lack of availability of appropriate dressing materials and/or inability to travel. Evacuation is recommended for high risk burns.

Musculoskeletal Injuries

Recommendation:

Apply RICE (rest, ice, compression, and elevation) principles to musculoskeletal injuries: 2B

Use bracing as needed for stable injuries: 1C

Use in-line repositioning of unstable injuries if there is impairment of neurovascular function: NG

Apply comfortable padded splints to unstable injuries: 1C

If trained in the procedure, the WFA provider can diagnose and reduce anterior shoulder dislocations with passive traction: 1C

The WFA provider is taught to differentiate musculoskeletal injuries on the basis of stable versus unstable. Stable injuries are treated using rest, ice, compression, elevation (RICE), and a brace or tape as needed (Tsang, Hertel, & Denegar, 2003). Unstable injuries are treated with gentle traction into position for angulated long bones when necessary to restore neurovascular function or facilitate splinting and are stabilized with simple padded splints (Ellerton, Tomazin, Brugger, & Paal, 2009). The WFA provider should identify high risk problems associated with musculoskeletal injuries (e.g., pelvic or femur fracture, open fracture, impaired circulation, sensation, and movement).

Dislocation reduction (i.e., anterior shoulder, patella, digits) is considered an elective topic because of concerns about achieving competency with limited practice time. The skill set should include an accurate assessment for mechanism of injury and physical exam and the reduction procedures themselves (Hendey, Chally, & Stewart, 2006; Reid, Liu, & Ortega, 2013). The anterior shoulder reduction described in Johnson et al. (2013), hanging arm or Stimson technique, is passive and theoretically with less risk and within the competence of a WFA provider (Ditty, Chisholm, Davis, & Estelle-Schmidt, 2010). The patella requires straightening the knee and often repositioning the patella. Digits require traction and repositioning.

Allergic Reactions and Anaphylaxis

Recommendation:

Provide assistance to victim to self-administer epinephrine administration by auto-injector for anaphylaxis: 1B

Signs and symptoms of allergic reactions span the spectrum from local and mild reactions to anaphylaxis. Initiation of treatment includes cool compresses and over-the-counter topical corticosteroid creams for local reactions and over-the-counter oral antihistamines for mild systemic reactions. The administration of epinephrine for anaphylaxis via auto-injector is a life-saving procedure (Gaudio, Lemery, & Johnson, 2010). Reliable recognition of anaphylaxis may be challenging (Pumphrey, 2004). WFA providers are trained to help a victim self-administer epinephrine administration via a prescribed auto-injector (Guerlain, Hugine, & Wang, 2010). Serious systemic adverse effects are rare, and improper auto-injection resulting in digital injection is low risk.

Heat-Related Illness

Recommendation:

Treat heat exhaustion patients with oral fluids, shade, and rest: 1C

Maintain body fluid balance (euhydration) with oral fluid ingestion: 1B

Treat heat stroke patients emergently with rapid cold water immersion: 1A

If cold water immersion for heat stroke is unavailable, remove excess clothing, wet down patient, and use continuous whole-body fanning: 1C

The WFA provider should recognize predisposing environmental conditions, as well as the signs and symptoms of moderate to severe dehydration, heat exhaustion, and heat stroke. Heat exhaustion and dehydration should be treated with oral fluids to maintain euhydration and with removal from all sources of heat stress (Anley, Noakes, Collins, & Schwellnus, 2010).

Heat stroke should be treated with the removal of excessive clothing layers and with aggressive and immediate whole-body cooling. Cold water immersion has been shown to be the most efficacious cooling strategy (Armstrong, Crago, Adams, Roberts, & Maresh, 1996; Hadad, Moran, & Epstein, 2004; Vicario, Okabajue, & Haltom, 1986). Practical considerations and available resources dictate that the WFA provider is familiar with cooling techniques such as wet

clothing and fanning. Any heat stroke victim and any heat exhaustion or dehydrated patients who cannot recover should be evacuated.

Hypothermia

Recommendation:

Treat mild hypothermia with protection from the elements and provide carbohydrate caloric intake to support shivering: 1B

Treat moderate and severe hypothermia with protection from the elements and with supplemental heat sources next to the torso: 1B

Generations of outdoor leaders have effectively treated mild hypothermia or cold stressed patients by moving the patient into a protected environment and then removing wet clothes and protecting the patient from cold, wind, and water with insulation and a windproof barrier along with food to help support heat production (i.e., shivering). When practical and available, active rewarming by the addition of supplemental heat sources to the patient is safe and beneficial, particularly when shivering ceases in the moderate to severe hypothermic patient (Allen, Salyer, Dubick, Holcomb, & Blackbourne, 2010; Henriksson, Lundgren, Kuklane, Holmér, & Bjornstig, 2009; Henriksson et al., 2015; Thomassen et al., 2011; Zafren et al., 2014).

The moderate to severe hypothermic patient should be managed with the same treatment principles as the mild hypothermic patient (dry windproof insulation) and the addition of gentle handling to prevent cardiovascular instability during evacuation. For these patients, prevention of further heat loss may be the only reasonably achievable goal in the field (Henriksson et al., 2012; Lundgren et al., 2009).

Lightning

Recommendation:

Use lightning prevention strategies to reduce risk: 1C

Treat injuries found and use prolonged BLS resuscitation procedures: 1C

The WFA provider focuses on prevention by recognizing high risk conditions and initiating effective risk management practices (Holle, Lopez, & Zimmermann, 1999). Preventive strategies include being vigilant about weather patterns and avoiding and escaping high risk areas as storms approach (e.g., tall objects, long conductive objects, open areas, mountain ridges, and openings such as cave openings). Although logical, the lightning position and mat protection is unproven. Lightning safety procedures are derived from physics and opinions (Duclos & Sanderson, 1990; Zimmermann, Cooper, & Holle, 2002).

Case reports suggest that treatment with standard first aid procedures makes the most sense. Of particular note is the potential for salvage from breathing cessation or cardiac arrest caused by a lightning strike by rescue breathing and CPR and the association of posttraumatic stress disorder with any lightning-related injury (Cooper, 1980; Pincus, Lathrop, Briones, Andrews, & Aurelius, 2015).

Submersion

Recommendation:

Use BLS techniques for airway management and positive pressure ventilation: 1B

As with lightning, the WFA provider identifies high risk conditions and preventive strategies with an emphasis on personal safety when planning rescue. First aid in the field consists of managing the conditions found with an emphasis on respiratory assistance, potential spine injury, and hypothermia (Venema, Groothoff, & Bierens, 2010). There is no need to clear as-

pirated water from the airway. Only a modest amount of water is aspirated by the majority of drowning victims, and this is rapidly absorbed and does not act as an airway obstruction (Oehmichen, Hennig, & Meissner, 2008). As noted in the section on respiratory problems, the AHA teaches that positive pressure ventilations are important in drowning victims. WFA BLS providers should be trained to provide ventilations as well as compressions for drowning victims (Szpilman, Joost, Bierens, Handley, & Orlowski, 2012; Vanden Hoek et al., 2010).

Common Medical Problems

Recommendation:

Use a red-flag-signs-and-symptoms approach to assessment and evacuation: NG

Medical topics are relevant to WFA providers. These could including exacerbations of pre-existing problems as well as new predictable and unpredictable problems arising as a result of the outdoor activity (e.g., abdominal pain, vomiting and diarrhea, cough and upper respiratory infection, urinary tract infection, ear, nose, throat, and fever). The challenge is how to approach this vast topic area in a manner that is practical for a layperson with limited training and experience. The WFA provider is taught to use conservative "red flags" (e.g., persistent abdominal pain, blood in urine, spiking fever) to trigger evacuation. Teaching preventive strategies (e.g., hand washing, kitchen sanitation, water disinfection) is an important primary goal (Boulware, 2004; McLaughlin, Gessner, & Bailey, 2005). Rather than focusing specifically on diagnoses, the WFA provider benefits more from learning to identify the red flag signs and symptoms of serious and life-threatening problems. Treatment options should be limited to those that represent reasonable and prudent measures for a WFA graduate, including appropriate and timely evacuations or calls for help.

Frostbite and Non-Freezing Cold Injury

Recommendation:

Warm unfrozen tissue with skin-to-skin contact: 1C

Thaw frozen tissue by immersion in a warm water bath: 1B

Protect thawed tissue from refreezing: 1B

The WFA provider learns to recognize predisposing conditions, signs, and symptoms of local cold injury, both freezing and nonfreezing, to evacuate promptly and, if warranted, to initiate field treatment with warm water baths or skin-to-skin warming while preventing refreeze. The WFA provider should take measures to prevent cold injury by avoiding exposure of the skin to the potential injurious combination of wind, moisture, and severe cold. Appropriate treatment of cold unfrozen skin includes rapid warming with passive warmth, which may be achieved by moving into a warm location or applying warm skin to the cold tissue. Frozen tissue is ideally thawed as soon as possible by immersion in a warm water bath 37–39 °C (99–102°F). In the field, skin-to-skin warming may be most practical. The use of radiant heat or massage should be avoided because any resulting thermal or mechanical damage may worsen the injury. Once thawed, the injury needs protected from refreeze. WFA providers should evacuate the patient if severe frostbite occurs, if blisters form, if patient is unable to use the injury, or if they cannot protect from refreeze (McIntosh et al., 2014; Mills, 1993).

Altitude Illness

Recommendation:

Use slow ascent to reduce risk of altitude illness: 1B

Stop ascent if symptomatic, descend if no improvement, descend immediately if concern for serious altitude illness: 1A

Prevention of altitude illness begins with cautious ascent when traveling above 3,000 m (10,000 ft) with an increase of no more than 500 m (1,650 ft) per night in sleeping altitude (Beidleman et al., 2009; Bloch et al., 2009). Recommendations on prophylactic and prescription medications are not part of the WFA course. First aid treatment of altitude illness begins with recognizing the signs and symptoms of acute mountain sickness (AMS) and serious altitude illness—high-altitude cerebral edema (HACE) and high-altitude pulmonary edema (HAPE). WFA treatment recommendations are to stop ascent if symptomatic, descend if no improvement in mild symptoms, and descend immediately in the presence of more severe symptoms of AMS, shortness of breath at rest (HAPE), and ataxia and/or mental status changes (HACE; Bärtsch & Swenson, 2013).

Poisoning

Recommendation:

Use supportive care and evacuation for ingested poisons: 1C

Do not induce vomiting for ingested poisons: 1C

See to scene safety and removal from exposure for inhaled poisons: 1C

The principles for the treatment of poisons at the WFA level are to identify the substance, to treat symptoms, and to maintain critical body functions. Administering an antidote is an inappropriate skill for a WFA provider. Removing a person from a toxic exposure is logical. Although "remove and dilute" is a logical approach, the induction of vomiting (i.e., use of syrup of ipecac) is likely both useless and potentially harmful (Pond, Lewis-Driver, Williams, Green, & Stevenson, 1995).

Snakebite

Recommendation:

Immobilize the snake-bitten limb while avoiding compression, constriction, and any unproven or discredited treatments (e.g., suction, tourniquets, electricity, ice): 1C

Snakebites caused by indigenous species are best treated in the field by immobilizing the affected part. Although walking is discouraged in an effort to slow systemic venom distribution, it may be necessary to evacuate the patient expeditiously to appropriate medical care. At the WFA level, any snakebite is evacuated, but threshold signs or symptoms are not used for an evacuation decision. Unproven and/or discredited techniques (e.g., suction, constriction bands, electricity, ice) are discouraged.

The use of a compression wrap is recommended in international consensus first aid guidelines for slowing lymph flow of neurotoxin venom. However, the evidence is primarily from animal model studies (German, Hack, Brewer, & Meggs, 2005; Howarth, Southee, & Whyte, 1994), and no clinical studies confirm these findings. It is controversial to use compression wraps to slow lymph venom flow from North American species, including for North American elapids (i.e., *M. fulvius*) and pit vipers, because they can potentially concentrate the venom in tissues, enhancing the localized cytotoxic effects. Furthermore, numerous studies report first aid providers have difficulty correctly applying the compression wrap technique to restrict lymph flow (Canale, Isbister, & Currie, 2009; Norris, Ngo, Nolan, & Hooker, 2005; Simpson, Tanwar, Andrade, Kochar, & Norris, 2008). Therefore, this technique should not be taught to WFA students in the United States.

Arthropods (i.e., Insects, Arachnids [e.g., Scorpions, Spiders])

Recommendation:

Use effective prevention strategies to minimize arthropod envenomation: NG

Evacuate early if local or systemic signs or symptoms present: 1C

The focus for WFA providers is prevention (e.g., clothing, netting, repellents, insecticides), symptomatic treatment, and early evacuation if rash, fever, or headache appear secondary to a bite or signs and symptoms of envenomation (Fradin & Day, 2002; Gupta et al., 1987).

Marine Injury

Recommendation:

Immerse nematocyst stings by unknown species in hot water: 1B

Rinse known box jellyfish (Cubozoa) stings in vinegar; otherwise, use vinegar cautiously: 1B

Immerse marine spine envenomations in hot water: 1B

Avoid using baking soda, alcohol, and papain for marine envenomations: 2C

In the context of nematocyst injury (e.g., jellyfish, corals, anemones) in North America and Hawaii, the WFA provider is taught to use a saltwater rinse to remove loose nematocysts and then scrape off remaining nematocysts. Treating nematocyst (e.g., jellyfish, corals, anemones) injuries by immersion in hot water is supported by the literature (Bowra, Gillet, & Morgan, 2002; Loten et al., 2006). Vinegar is useful for box jellyfish (class Cubozoa), but may worsen other envenomations (Nomura et al., 2002). Additionally, no other substances studied (e.g., baking soda, papain, urine) have had consistently proven efficacy (Thomas, Scott, Gaanis, & Goto, 2001).

In the context of a marine spine injury, the WFA provider is taught to soak the injury in hot water (45 °C) for 30–90 min or until pain relief, followed by standard wound care. The literature supports the use of immersing an extremity impaled by a marine spine in hot water (Trestrail & Al-Mahasneh, 1989).

Conclusion

WFA courses are popular with outdoor recreationists and have become an expected minimum training for many trip leaders. This paper reviewed the medical evidence supporting 54 practices commonly taught in the WFA course with the intent of highlighting, for the practitioner and the educator, the strength of evidence upon which these practices are based and future directions for potential research.

The paucity of high quality studies in first aid in general, let alone in the wilderness environment, is evident in the grading of the evidence (see Table 3). Of the 54 practices graded for level of evidence only, three (5%) were graded at 1A, the strongest supporting recommendation that requires high quality supporting evidence, random controlled trials without significant limitations, or strong observational studies. The bulk of the recommendations derive from random controlled trials or observational and case studies, all with significant limitations and moderate to poor supporting evidence, resulting in 1B or 1C grades, for which the panelists' recommendations reflect that benefits from these techniques outweigh the risks of harm to the patient.

Seven (13%) of the recommendations did not receive a grade, because there were no relevant studies upon which to base a recommendation and the practice is therefore opinion based. One example is the guideline of using red flag signs and symptoms to make an evacuation decision in the context of abdominal pain. The red flag concept makes intuitive sense, but there is only unpublished provider experience to suggest that a lay first aid provider can use these guidelines effectively.

This lack of high quality evidence is often the case with first aid procedures. Direct study of a layperson applying a first aid procedure is lacking in the medical literature outside of BLS (Cummins, Schubach, Litwin, & Hearne, 1989). Despite the limitations of the available evidence, practice recommendations must be made because first responders want to help and they expect guidance from the medical profession. This guidance in the form of best available evidence often uses first aid practices based on urban or advanced provider studies that are then generalized to the WFA arena or in some cases relegated to expert opinion based on group experience.

Table 3
Recommendations Grouped by Rating

1A*:* Strong recommendation, high quality evidence. Benefits clearly outweigh risks and burdens, or vice versa. Random controlled trials (RCTs) without important limitations, or overwhelming evidence from observational studies.
• Apply a tourniquet to an injured limb when no other bleeding control method is effective • Treat heat stroke patients emergently with rapid cold water immersion • Stop ascent if symptomatic, descend if no improvement, descend immediately if concern for serious altitude illness
1B*:* Strong recommendation, moderate quality evidence. Benefits clearly outweigh risks and burdens, or vice versa. RCTs with important limitations, or exceptionally strong evidence from observational studies.
• Irrigate wounds without significant active bleeding with potable water under pressure and/or with diluted povidone-iodine • Consider a commercial grade vented chest seal for all open chest wounds • Protect the burned area with clean, nonadherent dressing • Maintain body fluid balance (euhydration) with oral fluid ingestion • Immerse nematocyst stings by unknown species in hot water • Rinse known box jellyfish (Cubozoa) stings in vinegar; otherwise, use vinegar cautiously • Immerse marine spine envenomations in hot water • Thaw frozen tissue by immersion in a warm water bath • Protect thawed tissue from refreezing • Use slow ascent to reduce risk of altitude illness • Use BLS techniques for airway management and positive pressure ventilation • Treat moderate and severe hypothermia with protection from the elements and with supplemental heat sources next to the torso • Treat mild hypothermia with protection from the elements and provide carbohydrate caloric intake to support shivering • Provide assistance to victim to self-administer epinephrine administration by auto-injector for anaphylaxis • Evacuate cardiac chest pain and assist patients with their prescribed cardiac medications • If a wound is bleeding, apply direct manual pressure to the wound • Consider using clot enhancing dressing for severe bleeding control • Apply simple dressings and bandages to cover and protect wounds • Use water to cool burns

Table 3 (cont.)

1C: Strong recommendation, low quality or very low quality evidence. Benefits clearly outweigh risks and burdens, or vice versa. Observational studies or case series.

- Treat heat exhaustion patients with oral fluids, shade, and rest
- Provide oral fluids if a patient can protect his or her airway
- Assist patients with their prescribed pulmonary medications
- Use BLS techniques for airway management and positive pressure ventilation (mouth-to-mask or mouth-to-mouth)
- Use BLS techniques for airway management and positive pressure ventilation in a patient with altered mental status
- Use sublingual glucose in patients with altered mental status
- Perform simple lifts, lift and slide, and rolls to facilitate patient examination and protection
- Stabilize patients with suspected spine injury and initiate evacuation
- Use of a selective spine immobilization protocol is inappropriate at the WFA level
- Avoid ice or snow application to burns
- Apply comfortable padded splints to unstable injuries
- Use bracing as needed for stable injuries
- Use in-line repositioning of unstable injuries if there is impairment of neurovascular function
- If trained in the procedure, the WFA provider can diagnose and reduce anterior shoulder dislocations with passive traction
- Warm unfrozen tissue with skin-to-skin contact
- Use supportive care and evacuation for ingested poisons
- Do not induce vomiting for ingested poisons
- See to scene safety and removal from exposure for inhaled poisons
- Immobilize the snake-bitten limb while avoiding compression, constriction, and any unproven or discredited treatments (e.g., suction, tourniquets, electricity, ice)
- Evacuate early if local or systemic signs or symptoms present
- If cold water immersion for heat stroke is unavailable, remove excess clothing, wet down patient, and use continuous whole-body fanning
- Use lightning prevention strategies to reduce risk
- Treat injuries found and use prolonged BLS resuscitation procedures

2B: Weak recommendation, moderate quality evidence. Benefits closely balanced with risks and burdens. RCTs with important limitations, or exceptionally strong evidence from observational studies.

- Apply RICE principles to musculoskeletal injuries

2C: Weak recommendation, low quality or very low quality evidence. Uncertainty in the estimates of benefits, risks, and burdens; benefits, risks, and burdens may be closely balanced. Observational studies or case series.

- Avoid using baking soda, alcohol, and papain for marine envenomations
- NG: No relevant studies. Recommendation based on risk versus benefit perceptions derived from patient-care experience.
- Use the basic patient assessment to identify obvious medical problems
- Stabilize injuries to prevent further damage and blood loss
- WFA providers should not release a tourniquet in the field
- Stabilize impaled objects
- Use a red-flag-signs-and-symptoms approach to assessment and evacuation
- Use effective prevention strategies to minimize arthropod envenomation
- Evacuate all but simple, uncomplicated, localized burns and any high risk burn

Recommendations

The WFA curriculum, originally based on opinion on what was relevant and practical for the lay provider, has evolved over time based on evidence as well as teaching and field experience. Practices such as "cut and suck" for snakebites have been abandoned based on the evidence that this technique has no benefit and much risk of harm. Practices such as descent for altitude illness and tourniquets for life-threatening bleeding are recommended based on experience and evidence of their efficacy.

The future evolution of the WFA course would be aided by a better understanding of what first aid practices are safe and effective in the hands of a lay provider and how best to teach these skills. Many areas need support in evidence of efficacy of a skill as well as in the teaching of that skill. The authors suggest direction for future study in areas that are currently the focus of a changing paradigm in the EMS and first aid community, where the risk of harm of a traditional intervention may outweigh the benefits, such as spine injury management, or where a simple procedure may provide substantial benefits, such as layperson use of medications for anaphylaxis and asthma.

While not a focus of this review, only Schumann et al. (2012) examined skill and knowledge retention from a WFA course. There is a growing body of literature on how well the lay public learns and retains first aid skills and on the ability of laypeople to perform first aid techniques (Berden et al., 1994). Both Schumann et al. and Berden et al. (1994) found poor skill retention and suggest the need for reduced complexity in training programs while increasing the frequency of recertification. This is an important area for research attention with implications on the educational structure of the WFA course and retraining schedules for outdoor program leaders and the public.

References

Akers, W. A., & Sulzberger, M. B. (1972). The friction blister. *Military Medicine,* 137, 1–7. https://doi.org/10.1097/00006534-197207000-00049

Allen, P. B., Salyer, S. W., Dubick, M. A., Holcomb, J. B., & Blackbourne, L. H. (2010). Preventing hypothermia: Comparison of current devices used by the US Army in an in vitro warmed fluid model. *Journal of Trauma Injury, Infection, & Critical Care, 69*(Suppl. 1), S154–S161. https://doi.org/10.1097/ta.0b013e3181e45ba5

Anley, C., Noakes, T., Collins, M., & Schwellnus, M. P. (2010). A comparison of two treatment protocols in the management of exercise-associated postural hypotension: A randomised clinical trial. *British Journal of Sports Medicine, 45*(14). https://doi.org/10.1136/bjsm.2010.071951

Armstrong, L. E., Crago, A. E., Adams, R., Roberts, W. O., & Maresh, C. M. (1996). Whole-body cooling of hyperthermic runners: Comparison of two field strategies. *American Journal of Emergency Medicine, 14,* 355–358. https://doi.org/10.1016/S0735-6757(96)90048-0

Bandiera, G., Stiell, I. G., Wells, G. A., Clement, C., De Maio, V., Vandemheen, K., . . . Worthington, J. (2003). Canadian C-Spine and CT Head Study Group, The Canadian C-spine rule performs better than unstructured physician judgment. *Annals of Emergency Medicine, 42,* 395–402. https://doi.org/10.1016/S0196-0644(03)00422-0

Barbash, I. M., Freimark, D., Gottlieb, S., Hod, H., Hasin, Y., Battler, A., . . . Leor, J. (2002). Outcome of myocardial infarction in patients treated with aspirin is enhanced by pre-hospital administration. *Cardiology, 98,* 141–147. https://doi.org/10.1159/000066324

Barennes, H. (2005). Sublingual sugar administration as an alternative to intravenous dextrose administration to correct hypoglycemia among children in the tropics. *Pediatrics, 116,* e648–e653. https://doi.org/10.1542/peds.2004-22188

Bärtsch, P., & Swenson, E. R. (2013). Acute high-altitude illnesses. *New England Journal of Medicine, 368,* 2294–2302. https://doi.org/10.1056/NEJMcp1214870

Beidleman, B. A., Fulco, C. S., Muza, S. R., Rock, P., Stabb, J., Forte, V., . . . Cymerman, A. (2009). Effect of six days of staging on physiologic adjustments and acute mountain sickness during ascent to 4300 meters. *High Altitude Medicine & Biology, 10,* 253–260. https://doi.org/10.1089/ham.2009.1004

Berden, H., Bierens, J., Willems, F., Hendrick, J., Pijls, N., & Knape, J. (1994). Resuscitation skills of lay public after recent training. *Annals of Internal Medicine, 23,* 1003–1008. https://doi.org/10.1016/s0196-0644(94)70094-x

Blake, W. E., Stillman, B. C., Eizenberg, N., Briggs, C., & McMeeken, J. M. (2002). The position of the spine in the recovery position: An experimental comparison between the lateral recovery position and the modified HAINES position. *Resuscitation, 53,* 289–294. https://doi.org/10.1016/S0300-9572(02)00037-0

Bloch, K. E., Turk, A. J., Maggiorini, M., Hess, T., Merz, T., Bosch, M., Barthelemes, D., . . . Schoch, O. (2009). Effect of ascent protocol on acute mountain sickness and success at Muztagh Ata, 7546 m. *High Altitude Medicine & Biology, 10*, 25–32. https://doi.org/10.1089/ham.2008.1043

Boissy, P., Shrier, I., Brière, S., Mellete, J., Fecteau, L., & Matheson, G. O., . . . Steele, R. (2011). Effectiveness of cervical spine stabilization techniques. *Clinical Journal of Sport Medicine, 21,* 80–88. https://doi.org/10.1097/JSM.0b013e31820f8ad5

Boulware, D. R. (2004). Influence of hygiene on gastrointestinal illness among wilderness backpackers. *Journal of Travel Medicine, 11,* 27–33. https://doi.org/10.2310/7060.2004.13621

Bowra, J., Gillet, M., & Morgan, J. (2002). A trial comparing hot showers and icepack in the treatment of physalia envenomation. *Emergency Medicine Journal, 14,* A22.

Butler, F. K., Dubose, J. J., Otten, E. J., Bennett, B., Gerhardt, R., Kheirabadi, B., . . . Bailey, J. (2013). Management of open pneumothorax in tactical combat casualty care: TCCC guidelines change 13-02. *Journal of Special Operations Medicine, 13*(3), 81–86. https://doi.org/10.1007/978-3-642-29613-0_403

Canale, E., Isbister, G. K., & Currie, B. J. (2009). Investigating pressure bandaging for snakebite in a simulated setting: Bandage type, training, and the effect of transport. *Emergency Medicine Australasia, 21,* 184–190. https://doi.org/10.1111/j.1742-6723.2009.01180.x

Clayton, K., Monroe, K., Magruder, T., & King, W. (2012). Inappropriate home albuterol use during an acute asthma exacerbation. *Annals of Allergy, Asthma, and Immunology, 109,* 416–419. https://doi.org/10.1016/j.anai.2012.09.013

Conrad, B. P., Horodyski, M., Wright, J., Ruetz, P., & Rechtine, G. R. (2007). Log-rolling technique producing unacceptable motion during body position changes in patients with traumatic spinal cord injury. *Journal of Neurosurgery: Spine, 6,* 540–543. https://doi.org/10.3171/spi.2007.6.6.4

Cooper, M. (1980). Lightning injuries: Prognostic signs for death. *Annals of Emergency Medicine, 9,* 134–138. https://doi.org/10.1016/S0196-0644(80)80268-X

Cummins, R. O., Schubach, J. A., Litwin, P. E., & Hearne, T. R. (1989). Training lay persons to use automatic external defibrillators: Success of initial training and one-year retention of skills. *American Journal of Emergency Medicine, 7,* 143–149. https://doi.org/10.1016/0735-6757(89)90126-5

Cuttle, L., Kempf, M., Liu, P., Kravchuk, O., & Kimble, R. (2008). The optimal temperature of first aid treatment for partial thickness burn injuries. *Wound Repair and Regeneration,16,* 626–634. https://doi.org/10.1111/j.1524-475X.2008.00413.x

de Caen, A., Maconochie, I., Aickin, R., Atkins, D., Biarent, D., Guerguerian, A. M., . . . Veliz Pintos, R. (2015). Part 6: Pediatric basic life support and pediatric advanced life support 2015 international consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. *Circulation, 132,* S177–S203. https://doi.org/10.1161/CIR.0000000000000275

Del Rossi, G., Horodyski, M., Heffernan, T. P., Powers, M. E., Siders, R., Brunt, D., & Rechtine, G. R. (2004). Spine-board transfer techniques and the unstable cervical spine. *Spine, 29*(7), 134–138. https://doi.org/10.1097/01.BRS.0000116986.48166.D0

Dire, D. J., & Welsh, A. P. (1990). A comparison of wound irrigation solutions used in the emergency department. *Annals of Emergency Medicine, 19,* 704–708. https://doi.org/10.1016/S0196-0644(05)82484-9

Ditty, J., Chisholm, D., Davis, S. M., & Estelle-Schmidt, M. (2010). Safety and efficacy of attempts to reduce shoulder dislocations by non-medical personnel in the wilderness setting. *Wilderness & Environmental Medicine, 21,* 357–361. https://doi.org/10.1016/j.wem.2010.06.010

Drew, B., Bennett, B., & Littlejohn, L. (2015). Review of hemorrhage control principles in austere environments: Part 2. *Wilderness & Environmental Medicine, 26,* 246–252. https://doi.org/10.1016/j.wem.2014.08.018.

Duclos, P., & Sanderson, L. (1990). An epidemiological description of lightning-related injuries in the United States. *International Journal of Epidemiology, 19,* 673–679. https://doi.org/10.1093/ije/19.3.673

Ellerton, J., Tomazin, I., Brugger, H., & Paal, P. (2009). Immobilization and splinting in mountain rescue: Official recommendations of the International Commission for Mountain Emergency Medicine, ICAR MEDCOM, intended for mountain rescue first responders, physicians, and rescue organizations. *High Altitude Medicine & Biology, 10,* 337–342. https://doi.org/10.1089/ham.2009.1038

Fradin, M. S., & Day, J. (2002). Comparative efficacy of insect repellents. *New England Journal of Medicine, 347,* 13–18. https://doi.org/10.1056/NEJMoa011699

Gaudio, F., Lemery, J., & Johnson, D. (2010). Recommendations on the use of epinephrine in outdoor education and wilderness settings: Round table report. *Wilderness & Environmental Medicine, 21,* 185–187. https://doi.org/10.1016/j.wem.2010.06.004

Gentile, D., Morris, J., Schimelpfenig, T., & Auerbach, P. (1992). Wilderness injuries and illness. *Annals of Emergency Medicine, 21,* 853–861. https://doi.org/10.1016/S0196-0644(05)81034-0

German, B. T., Hack, J. B., Brewer, K., & Meggs, W. J. (2005). Pressure-immobilization bandages delay toxicity in a porcine model of eastern coral snake (Micrurus fulvius fulvius) envenomation. *Annals of Emergency Medicine, 45,* 603–608. https://doi.org/10.1016/j.annemergmed.2004.11.025

Guerlain, S., Hugine, A., & Wang, L. A. (2010). Comparison of 4 epinephrine autoinjector delivery systems: Usability and patient preference. *Annals of Allergy, Asthma, & Immunology, 104,* 172–177. https://doi.org/10.1016/j.anai.2009.11.023

Gunning, R. R., & Garber, A. J. (1978.) Bioactivity of instant glucose. Failure of absorption through oral mucosa. *JAMA, 240,* 1611–1612. https://doi.org/10.1001/jama.1978.03290150057025

Gupta, R. K., Sweeney, A. W., Rutledge, L. C., Cooper, R. D., Frances, S. P., & Westrom, D. R. (1987). Effectiveness of controlled-release personal-use arthropod repellents and permethrin-impregnated clothing in the field. *Journal of the American Mosquito Control Association, 3,* 556–560. https://doi.org/10.1603/0022-2585-37.1.182

Guyatt, G., Gutterman, D., Baumann, M., Addrizzo-Harris, D., Hylek, E., Phillips, B., . . . Schunemann, H. (2006). Grading strength of recommendations and quality of evidence in clinical guidelines: Report from an American College of Chest Physicians task force. *Chest, 129,* 174–181. https://doi.org/10.1378/chest.129.1.174

Hadad, E., Moran, D. S., & Epstein, Y. (2004). Cooling heat stroke patients by available field measures. *Intensive Care Medicine, 30,* 338. https://doi.org/10.1007/s00134-003-2084-5

Hendey, G., Chally, M., & Stewart, V. (2006). Selective radiography in 100 patients with suspected shoulder dislocation. *Journal of Emergency Medicine, 31,* 23–28. https://doi.org/10.1016/j.jemermed.2005.09.006

Henriksson, O., Lundgren, P., Kuklane, K., Holmér, I., & Bjornstig, U. (2009). Protection against cold in prehospital care—Thermal insulation properties of blankets and rescue bags in different wind conditions. *Prehospital and Disaster Medicine, 24,* 408–415. https://doi.org/10.1017/S1049023X00007238

Henriksson, O., Lundgren, P., Kuklane, K., Holmér, I., Bjornstig, U., Giesbrecht, G., & Naredi, P. (2015). Protection against cold in prehospital care: Wet clothing removal or addition of a vapor barrier. *Wilderness & Environmental Medicine, 26,* 11–20. https://doi.org/10.1016/j.wem.2014.07.001

Henriksson, O., Lundgren, P., Kuklane, K., Holmér, I., Naredi, P., & Bjornstig, U. (2012). Protection against cold in prehospital care: Evaporative heat loss reduction by wet clothing removal or the addition of a vapor barrier—A thermal manikin study. *Prehospital and Disaster Medicine, 27,* 53–58. https://doi.org/10.1017/S1049023X12000210

Hoffman, J. R., Mower, W. R., Wolfson, A. B., Todd, K. H., & Zucker, M. I. (2003). National Emergency X-Radiography Utilization Study Group: Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. *New England Journal of Medicine, 343,* 94–99. https://doi.org/10.1056/NEJM200007133430203

Holle, R. L., Lopez, R. E., & Zimmermann, C. (1999). Updated recommendations for lightning safety. *Bulletin of the American Meteorological Society, 80,* 2035–2041. https://doi.org/10.1175/1520-0477(1999)080<2035:URFLS>2.0.CO;2

Howarth, D. M., Southee, A. E., & Whyte, I. M. (1994). Lymphatic flow rates and first-aid in simulated peripheral snake or spider envenomation. *The Medical Journal of Australia, 161,* 695–700. https://doi.org/10.1016/s0965-2302(02)00189-3

Johnson, D., Schimelpfenig, T., Hubbell, F., Frizzel, L., Nicolozzo, P., McEvoy, D., . . . Weil, C. (2013). Minimum guidelines and scope of practice for wilderness first aid. *Wilderness and Environmental Medicine, 24,* 456–462. https://doi.org/10.1016/j.wem.2013.05.003

Kheirabadi, B. S., Scherer, M. R., Estep, J. S., Dubick, M. A., & Holcomb, J. B. (2009). Determination of efficacy of new hemostatic dressings in a model of extremity arterial hemorrhage in swine. *Journal of Trauma Injury, Infection, & Critical Care, 67,* 450–459. https://doi.org/10.1097/TA.0b013e3181ac0c99

Kheirabadi, B. S., Terrazas, I. B., Koller, A., Allen, P. B., Klemcke, H. G., Convertino, V. A., & Blackbourne, L. H. (2013). Vented vs. unvented chest seals for treatment of pneumothorax (PTx) and prevention of tension PTx in a swine model. *Journal of Trauma and Acute Care Surgery, 75,* 150–156. https://doi.org/10.1097/TA.0b013e3182988afe

Kleinman, E., Brennan, E., Goldberger, Z., Swor, R., Terry, M., Bobrow, B., . . . Rea, T. (2015). Part 5: Adult basic life support and cardiopulmonary resuscitation quality—2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation, 132,* S414–S435. https://doi.org/10.1161/CIR.0000000000002599

Kotora, J. G. Jr., Henao, J., Littlejohn, L. F., & Kircher, S. (2013). Vented chest seals for prevention of tension pneumothorax in a communicating pneumothorax. *Journal of Emergency Medicine, 45,* 686–694. https://doi.org/10.1016/j.jemermed.2013.05.011

Knapik, J. J., Reynolds, K. L., Duplantis, K. L., & Jones, B. H. (1995). Friction blisters: Pathophysiology, prevention, and treatment. *Sports Medicine, 20,* 136–147. https://doi.org/10.2165/00007256-199520030-00002

Kragh, J. F., Jr., Walters, T. J., Baer, D. G., Fox, C. J., Wade, C. E., Salinas, J., & Holcomb, J. B. (2009). Survival with emergency tourniquet use to stop bleeding in major limb trauma. *Annals of Surgery, 249,* 1–7. https://doi.org/10.1097/SLA.0b013e31818842ba

Kyriacou, D. N., Arcinue, E. L., Peek, C., & Kraus, J. F. (1994). Effect of immediate resuscitation on children with submersion injury. *Pediatrics, 94*(Pt. 1), 137–142. https://doi.org/10.1016/0300-9572(95)99671-v

Lehmann, K., Heath-Lange, S. J., & Ferris, S. T. (1999). Randomized comparison of hemostasis techniques after invasive cardiovascular procedures. *American Heart Journal, 138*(Pt. 1), 1118–1125. https://doi.org/10.1016/S0002-8703(99)70078-5

Littlejohn, L., Bennett, B., & Drew, B. (2015). Review of hemorrhage control principles in austere environments: Part 1. *Wilderness and Environmental Medicine, 26,* 236–245. https://doi.org/10.1016/j.wem.2014.08.016

Loten, C., Stokes, B., Worsley, D., Seymour, J. E., Jiang, S., & Ibsbister, G. K. (2006). A randomised controlled trial of hot water (45C) immersion versus ice packs for pain relief in bluebottle stings. *The Medical Journal of Australia, 184,* 329–333. https://doi.org/10.3390/toxins8040097

Lundgren, J. P., Henriksson, O., Pretorius, T., Cahill, F., Bristow, G., Chochinov, A., . . . Giesbrecht, G. (2009). Field torso-warming modalities: A comparative study using a human model. *Prehospital Emergency Care, 13,* 371–378. https://doi.org/10.1080/10903120902935348

Markenson, D., Ferguson, J., Chameides, L., Cassan, P., Chung, K., Epstein, J., . . . Singer, A. (2010). Part 13: First aid: 2010 American Heart Association and American Red Cross international consensus on first aid science with treatment recommendations. *Circulation, 122,* S394–S946. https://doi.org/10.1161/circulationaha.110.971168

McGuire, R. A., Neville, S., Green, B. A., & Watts, C. (1987). Spinal instability and the log-rolling maneuver. *Journal of Trauma Injury, Infection, & Critical Care, 27,* 525–531. https://doi.org/10.1097/00005373-198705000-00012

McIntosh, S., Opacic, M., Freer, L., Grissom, C., Auerbach, P., Rodway, G., Cochran, A., . . . Hackett, P. (2014). Wilderness Medical Society practice guidelines for the prevention and treatment of frostbite: 2014 update. *Wilderness & Environmental Medicine, 25,* S43–S54. https://doi.org/10.1016/j.wem.2014.09.001

McLaughlin, J., Gessner, B., & Bailey, A. M. (2005). Gastroenteritis outbreak among mountaineers climbing the West Buttress route of Denali—Denali National Park, Alaska, June 2002. *Wilderness & Environmental Medicine, 16,* 92–96. https://doi.org/10.1580/1080-6032(2005)16[92:GOAMCT]2.0.CO;2

Mills, W. J., Jr. (1993). Frostbite: A discussion of the problem and a review of the Alaskan experience. 1973. *Alaska Medicine, 35,* 29–40.

Nomura, J. T., Sato, R. L., Ahern, R. M., Snow, J. L., Kuwaye, T. T., & Yamamoto, L. G. (2002). A randomized paired comparison trial of cutaneous treatments for acute jellyfish (Carybdea alata) stings. *American Journal of Emergency Medicine, 20,* 624–626. https://doi.org/10.1053/ajem.2002.35710

Norris, R. L., Ngo, J., Nolan, K., & Hooker, G. (2005). Physicians and lay people are unable to apply pressure immobilization properly in a simulated snakebite scenario. *Wilderness & Environmental Medicine, 16,* 16–21. https://doi.org/10.1580/PR12-04.1

Oehmichen, M., Hennig, R., & Meissner, C. (2008). Near-drowning and clinical laboratory changes. *Legal Medicine, 10*(1), 1–5. https://doi.org/10.1016/j.legalmed.2007.05.007

Ofeigsson, O. J., Mitchell, R., & Patrick, R. S. (1972). Observations on the cold water treatment of cutaneous burns. *The Journal of Pathology, 108,* 145–150. https://doi.org/10.1002/path.1711080208

Pincus, J., Lathrop, S., Briones, A., Andrews, S., & Aurelius, M. (2015). Lightning deaths: A retrospective review of New Mexico's cases, 1977–2009. *Journal of Forensic Sciences, 60*(1), 66–71. https://doi.org/10.1111/1556-4029.12546

Pond, S., Lewis-Driver, D., Williams, G., Green, A., & Stevenson, N. (1995). Gastric emptying in acute overdose: A prospective randomized controlled trial. *The Medical Journal of Australia, 163,* 345–349.

Pumphrey, R. (2004). Anaphylaxis: Can we tell who is at risk of a fatal reaction? *Current Opinion in Allergy and Clinical Immunology, 4,* 285–290. https://doi.org/10.1097/01.all.0000136762.89313.0b

Quinn, R., Wedmore, I., Johnson, E., Islas, A., Anglim, A., Zafren, K., . . . Mazzorana, V. (2014). Wilderness Medical Society practice guidelines for basic wound management in the austere environment: 2014 update. *Wilderness and Environmental Medicine, 25,* S118–S133. https://doi.org/10.1016/j.wem.2014.04.005

Rall, J. M., Cox, J. M., Songer, A. G., Comeaux, J., Estep, J., Cestero, R., & Ross, J. (2013). Comparison of novel hemostatic gauzes to QuikClot Combat Gauze in a standardized swine model of uncontrolled hemorrhage. *Journal of Trauma and Acute Care Surgery, 75*(2 Suppl. 2), S150–S156. https://doi.org/10.1097/TA.0b013e318299d909

Reid, S., Liu, M., & Ortega, H. (2013). Anterior shoulder dislocation in pediatric patients: Are routine prereduction radiographs necessary? *Pediatric Emergency Care, 29,* 39–42. https://doi.org/10.1097/pec.0b013e31827b52a7

Sack, R. B., Cassells, J., Mitra, R., Merritt, C., Butler, T., Thomas, J., . . . Mondal, A. (1970). The use of oral replacement solutions in the treatment of cholera and other severe diarrhoeal disorders. *Bulletin of the World Health Organization, 43,* 35–360. https://doi.org/10.1056/nejm197711172972007

Schumann, S. A., Schimelpfenig, T., Sibthorp, J., & Collins, R. H. (2012). An examination of wilderness first aid knowledge, self-efficacy, and skill retention. *Wilderness and Environmental Medicine, 23,* 281–287. https://doi.org/10.1016/j.wem.2012.04.005

Simon, H. (1999). Caregiver knowledge and delivery of a commonly prescribed medication (albuterol) for children. *Archives of Pediatrics and Adolescent Medicine, 153,* 615–618. https://doi.org/10.1001/archpedi.153.6.615

Simpson, I. D., Tanwar, P. D., Andrade, C., Kochar, D. K., & Norris, R. L. (2008). The Ebbinghaus retention curve: Training does not increase the ability to apply pressure immobilization in simulated snake bite—Implications for snake bite first aid in the developing world. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 102,* 451–459. https://doi.org/10.1016/j.trstmh.2008.01.014

Singer, A. J., Berrutti, L., Thode, H. C., Jr., & McClain, S. A. (1999). Octylcyanoacrylate for the treatment of partial-thickness burns in swine: A randomized, controlled experiment. *Academic Emergency Medicine, 6,* 688–692. https://doi.org/10.1111/j.1553-2712.1999.tb00436.x

Singletary, E., Charlton, N., Epstein, J., Ferguson, J., Jensen, J., MacPherson, A., . . . Zideman, D. (2015). Part 15: First aid: 2015 American Heart Association and American Red Cross guidelines update for first aid. *Circulation, 132,* S574–S589. https://doi.org/10.1161/CIR.0000000000000269

Spandorfer, P. R., Alessandrini, E. A., Joffe, M. D., Localio, R., & Shaw, K. N. (2005). Oral versus intravenous rehydration of moderately dehydrated children: A randomized, controlled trial. *Pediatrics, 115,* 295–301. https://doi.org/10.1542/peds.2004-0245

Squier, C. A. (1991). The permeability of oral mucosa. *Critical Reviews in Oral Biology & Medicine, 2*(1), 13–32. https://doi.org/10.1177/10454411910020010301

Stiell, I., Clement, R., McKnight, R., Brison, R., Schull, M., Rowe, B., . . . Wells, G. (2003). The Canadian C-spine rule versus the NEXUS low-risk criteria in patients with trauma. *New England Journal of Medicine, 26,* 349–352. https://doi.org/10.1056/nejmoa031375

Szpilman, D., Joost, J., Bierens, M., Handley, A., & Orlowski, J. (2012). Drowning: Current concepts. *New England Journal of Medicine, 366,* 2102–2110. https://doi.org/10.1056/NEJMra1013317

Thomas, C. S., Scott, S. A., Gaanis, D. J., & Goto, R. S. (2001). The analgesic effect of Sting-Aid Adolph's meat tenderizer and fresh water on their stings: A double blinded, randomised, placebo controlled clinical trial. *Hawaii Medical Journal, 60*(8), 205–210.

Thomassen, Ø., Færevik, H., Østerås, Ø., Sunde, G., Zakariassen, E., Sandsund, M., . . . Bratteb, G. (2011). Comparison of three different prehospital wrapping methods for preventing hypothermia—A crossover study in humans. *Scandinavian Journal of Trauma, Resuscitation, and Emergency Medicine, 19,* 1–7. https://doi.org/10.1186/1757-7241-19-41

Trestrail, J. H., & Al-Mahasneh, Q. M. (1989). Lionfish string experiences of an inland poison center: A retrospective study of 23 cases. *Veterinary and Human Toxicology, 31,* 173–175.

Tsang, K., Hertel, J., & Denegar, C. (2003). Volume decrease after elevation and intermittent compression of postacute ankle sprains are negated by gravity-dependent positioning. *Journal of Athletic Training, 38,* 320–324.

Valente, J. H., Forti, R. J., Freundlich, L. F., Zandieh, S. O., & Crain E. F. (2003). Wound irrigation in children: Saline solution or tap water? *Annals of Emergency Medicine, 41,* 609–616. https://doi.org/10.1067/mem.2003.137

Vanden Hoek, T. L., Morrison, L. J., Shuster, M., Donnino, M., Sinz, E., Lavonas, E., . . . Gabrieli, A. (2010). Part 12: Cardiac arrest in special situations: Drowning: 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation, 122*(Suppl. 3), S847–S848. https://doi.org/10.1161/CIRCULATIONAHA.110.971069

Van de Velde, S., Broos, P., Van Bouwelen, M., De Win, R., Sermon, A., Verduyct, J., . . . Aertgeerts, B. (2007). European first aid guidelines. *Resuscitation, 72,* 240–251. https://doi.org/10.1016/j.resuscitation.2006.10.023

Venema, A. M., Groothoff, J. W., & Bierens, J. J. (2010). The role of bystanders during rescue and resuscitation of drowning victims. *Resuscitation, 81,* 434–439. https://doi.org/10.1016/j.resuscitation.2010.01.005

Vicario, S. J., Okabajue, R., & Haltom, T. (1986). Rapid cooling in classic heatstroke: Effect on mortality rates. *American Journal of Emergency Medicine, 4,* 394–398. https://doi.org/10.1016/0735-6757(86)90185-3

Zafren, K., Giesbrecht, G., Danzl, D., Brugger, H., Sagalyn, E., Walpoth, B., . . . Grissom, C. (2014). Wilderness Medical Society practice guidelines for the out-of-hospital evaluation and treatment of accidental hypothermia: 2014 update. *Wilderness and Environmental Medicine, 25,* S66–S85. https://doi.org/10.1016/j.wem.2014.09.002

Zimmermann, C., Cooper, M., & Holle, R. (2002). Lightning safety guidelines. *Annals of Emergency Medicine, 39,* 660–664. https://doi.org/10.1067/mem.2002.124439