



### Wilderness Care of Acute Traumatic Wounds Curriculum

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#### Abstract

**Introduction:** A comprehensive approach to wound care is critical when in the wilderness where definitive care may be hours, days or weeks away. The limitation of resources and the variety of acute traumatic wounds presents a management challenge. Resources for wilderness experiences with wound care are sparse. We developed an adaptable curriculum to teach participants of all levels how to appropriately manage wounds using established and improvised techniques.

**Methods:** The curriculum is an instructor-guided course designed to be an interactive presentation requiring two hours. It is presented in three parts. First, a brief description of a general approach to wounds highlighting pearls and pitfalls. Second, small groups rotate through four stations: wilderness closure techniques, a vascular damage wound model, water sterilization and wound irrigation strategies, and a case report discussion. A debriefing concludes the workshop.

**Results:** Participants are evaluated via direct observation, verbal feedback, and group discussion.

**Conclusion:** We were able to create an interactive, adaptable, and cost-effective curriculum to teach improvised wound care techniques.

#### Introduction

Acute traumatic wounds consistently rank in the top ten reasons for emergency room visits for adult males and pediatric patients under the age of 15 [1]. It has been estimated by Flores that the annual rate of outdoor recreational injuries is 72.1 per 100,000 population, with 14.8% being lacerations [2]. The National Outdoor Leadership School (NOLS) maintains an incident database; from 1998 to 2002 there were 1940 reported injuries, of which 31% were non athletic soft tissue injuries [3]. In the wilderness setting, a comprehensive approach to acute wound care is especially critical. Definitive treatment can be hours to weeks away. The limitation of available medical resources and the variety of acute traumatic wounds present a challenge. This instructional module presents an evidence-based approach to acute wound management, describes techniques that are applicable in remote and unclean environments, and provides a hands-on experience to adult learners. The information is applicable to learners of all backgrounds. Both medical professionals and laypeople are likely to be unfamiliar with treating wounds with limited resources; it is in the setting that small decisions may have

great impacts on clinical outcomes. We developed an adaptable curriculum to teach participants of all levels how to appropriately manage wounds using established and improvised techniques.

#### Methods

The “Wound Management in the Wilderness Workshop” is an instructor-guided, interactive presentation requiring approximately two hours. The intended audience is medical and allied health professionals. The workshop structure involves a brief introduction on pearls of wound management, four small group sessions, and a summary and participant evaluation. Four interactive stations are used for instruction: wound closures, water purification and wound irrigation, vascular damage and hemostasis, and a case review. Supplies used for each station are listed in table 1.

#### Station 1: Wound closure

Participants are instructed in wound closure using pig’s feet. Instruments, suture options, and proper technique should be demonstrated prior to participant practice of simple-interrupted sutures and knot tying. Direct observation of participants facilitates proper technique. While most people are unlikely to carry suture materials in the backcountry, practicing this technique may help with the understanding of improvised closure methods and the goals of wound closure. Improvised techniques are discussed as participants practice suturing. The techniques covered use materials easily carried in a first aid kit and include: duct tape steri-strips, wound adhesives, and the hair apposition technique (HAT) [4].

#### Station 2: Irrigation and foreign body management

Basic purification methods (boiling, pump/mechanical filters, UV

Table 1: Suggested supply list by station.

Wound Closure	Irrigation	Vascular Damage
suturing supplies / tools	pump filter (\$50-100)*	moulage arm (\$400-600)*
pig feet	UV filter pen (\$50)*	tourniquet (\$20-30)*
duct tape	filter syringe (\$20)*	bandanna
steri-strips	hydration bladder (\$20-30)*	belt
dermabond	iodine tabs (\$5-10)*	gauze
	basin / bed pan	
	syringes and angiocatheters	
	plastic bags	

\*Costs are estimated based on internet search. Many supplies were personally owned, borrowed, or available through our institution without additional cost.

filters, and chemical purification) are demonstrated after open-ended queries on standards for wound irrigant solutions. The principals of volume and force of irrigation with improvised wound irrigation systems are empirically challenged by experimenting with potential 'wilderness' irrigation devices. Participants test the subjective forces resulting from maximum compression of a water bottle with 14 gauge needle holes punctured in the cap, a sports-top water bottle, a 10 cc first aid kit syringe, a commercially available water filter cleaning syringe, a bladder-type hydration pack, and plastic zip top bags pierced with a 14 gauge angiocatheter. Wound foreign bodies are discussed via scenarios and photographs of contaminated wounds and participants were queried on optimal management options. Photographs are sourced from personal collections and published sources and include a figure from a case report of blunt carotid injury from a penetrating stick [5], a linear superficial injury with a clean kitchen knife, an abrasion with embedded granite, and a jagged laceration at point of impact from a fall on an outstretched hand (FOOSH).

### Station 3: Vascular damage

A commercial moulage model of a significant bleeding upper extremity wound is utilized to address critical actions to control bleeding. A clinical scenario of uncontrolled bleeding eventually requiring placement of a tourniquet proximal to the wound is repeated multiple times. First, participants are allowed to problem solve on their own after being told there is a large wound with bleeding that continues to soak through all dressings and interventions until some type of tourniquet is placed proximal to the injury. Materials (gauze, bandanas, belts, etc) are made available but no instruction is given. Participants then receive direct feedback on proper methods of wound packing and pressure dressing placement. Tourniquet application, using both commercial and improvised methods, is subsequently practiced in pairs first unaided and then followed by focused feedback and instruction. The scenario is practiced a final time without feedback to demonstrate learned critical interventions.

**Table 2:** Discussion questions for each station.

Discussion Questions	Possible answers
<b>Station 1: Wound Closure</b>	
Which provides the stronger wound closure: sutures or wound adhesive/tape?	Sutures provide stronger closure for high tension areas or highly mobile wound sites
What are drawbacks to suturing?	Introducing a foreign body into the wound (suture material); painful method; may trap contaminants unknowingly in wound (bacteria, foreign body); fatigable skill in non-practiced providers
Which seems stronger: improvised Duct tape® steri strips or simply covering the wound with a large piece of tape?	Variable responses
What are the steps of HAT (hair apposition technique) [4]?	<ol style="list-style-type: none"> <li>1. Perform wound irrigation and exam</li> <li>2. Twist together 3-7 strands of hair on each side of the wound.</li> <li>3. Interlock these two hair bundles in a 360-degree revolution. Do not tie a knot.</li> <li>4. Secure the bundles with tissue adhesive.</li> <li>5. Repeat to close the length of the laceration</li> <li>6. The hair will unravel on its own after a week</li> </ol>
Is wound adhesive and Super Glue® equivalent options for improvised wound closure? Why or why not?	No. Standard "superglue" is 100% ethyl cyanoacrylate. Medical grade wound adhesive is 2-octyl cyanoacrylate, a nearly identical molecule except with the addition of a 5 carbon "tail" attached. Due to this longer organic backbone, degradation and absorption of tissue adhesive is slowed, remaining below the threshold of tissue toxicity. Due to the potential toxicity issues of ethyl cyanoacrylate, the use of 2-octyl cyanoacrylate for closure is preferred.
<b>Station 2: Irrigation and Foreign Body Management</b>	
How clean does water need to be for irrigation?	Clean enough to drink
Rank the water treatment methods by time required to produce potable water.	Seconds: Water filter pump, Ultraviolet light pen Minutes: boiling Half-hour or more: Iodine tabs
Can the improvised irrigation devices provide the same irrigation force as the commercial device used in the Emergency department?	Variable responses. Most say yes. Items participants test include a 10cc syringe, a 50cc syringe, a water bottle with sports-top, a water bottle with 14 gauge holes punctured in the cap, a bladder hydration pack with tubing, and a Ziploc® punctured with a 14 gauge angiocatheter
When should you remove a foreign body?	Variable responses
When looking at the pictures provided, how would you manage the wound in terms of foreign bodies/contamination risk?	<ol style="list-style-type: none"> <li>1. Linear superficial injury with a clean kitchen knife: caution to not over-irrigate and devitalize tissue in low risk wound</li> <li>2. Abrasion with embedded granite: high infection risk due to foreign bodies, aggressive debridement</li> <li>3. Fall on outstretched hand with jagged laceration at point of impact: crushed tissue and site results in higher risk for infection, consider antibiotic prophylaxis after cleaning wound</li> <li>4. Impaled stick in the neck: stabilize and evacuate immediately, stroke like symptoms on presentation due to carotid injury [5].</li> </ol>
<b>Station 3: Vascular Damage</b>	
What is your experience with uncontrolled bleeding?	Variable responses
What is the most effective way to rapidly control bleeding from an arterial source?	Progression (linear or nonlinear) from interventions including direct pressure, packing a wound with gauze at sites of bleeding, pressure dressing, pressure to proximal arterial source, and application of a tourniquet should be discussed
Regarding hemostasis, does your practice/EMS system/prehospital wound management protocol reflect that thinking?	Variable responses
Are there other means of hemostasis that are safe and suitable for wilderness/remote environments?	Clotting powders can come up. Research current recommendations and products. Chemical burns to application area and systemic clots (remote from site of application) have been reported previously and cautions should be exercised in their use.
<b>Station 4: Case Review</b>	
What went wrong? Why did Brad have such a prolonged course/bad outcome?	Open discussion on choice of suturing, use of betadine in an acute traumatic wound, timing and choice of antibiotics, timing of evacuation plan
Is this wound contaminated?	Yes, all wounds in the wilderness should be considered contaminated
What would you have done differently?	Variable responses

#### Station 4: Case review

A case discussion station centers on an article, "They had me in stitches: a Grand Canyon river guide's case report and a review of wilderness wound management literature" [6]. The article presents a real life example of a simple wound sustained on a rafting trip, common pitfalls of wilderness wound management, and the potential serious sequelae of even simple wounds that are not aggressively and appropriately managed. Complications including poor wound healing, infections, and hemorrhage are specifically emphasized during the discussion as the risk of these can be reduced with the techniques covered in the course.

Each of the stations are directly proctored and discussion questions that are appropriate for each station and sample answers can be found in table 2. Since groups can be lead by different proctors and experiences differ slightly, these questions are reviewed with key take home points reinforced at the debriefing at the conclusion of the station activity. Direct feedback on strengths and weaknesses of the activity are solicited prior to the conclusion of the course.

#### Results

The Wounds in the Wilderness curriculum has been used to teach multi-specialty practicing physicians, undergraduate and graduate students, medical residents, and the general public. Workshops can be tailored to specific audiences and each session may be unique given a variety of backgrounds and experiences that are shared through the interactive experience.

Total equipment costs for the workshop is estimated at \$800-900 with the most expensive item being a durable, re-usable wound model. A cost per participant has not been established as we have so far taught it on a volunteer basis. Wound models are available through online retailers at varying costs. Some items used in our workshop (water filters) were personal items owned by instructors and many were common supplies available through our residency program's teaching resources, which limited our actual overall cost.

Informal feedback from participants during and at the conclusion of the workshop has been consistently overwhelmingly positive. A limitation of this curriculum is the lack of formal testing to objectively measure retention of knowledge; however, direct observation in the application of skills taught demonstrated skill competence in participants by the end of the sessions. Participants across an array of educational and experiential backgrounds leave the course with skills that they may be of practical utility in real wilderness emergencies. Another limitation of the curriculum is the lack of follow up to determine if there is skill fatigue (from lack of use) in learners who do not regularly manage wounds as part of their professional setting.

There may be more skill retention with a longer course. Although, our two hour course focuses on crucial, basic techniques which are repeatedly practiced.

#### Conclusion

Wounds in the Wilderness is an interactive, adaptable, cost-effective model for engaging our community and teaching basic wound care with real world application. We hope this curriculum inspires others to share their knowledge and to learn more about wilderness medicine, and we will continue to refine the material and expand our audiences for a richer learning experience.

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None to disclose

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