Chapter II:

The Wilderness Environment: Hazards, Safety, and Patient Care Implications

Wilderness EMS Institute

Appalachian Search and Rescue Conference
Center for Emergency Medicine of Western Pennsylvania

Wilderness EMT Textbook

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The ASRC-CEM Wilderness Emergency Medical Services Institute

The ASRC-CEM *Wilderness Emergency Medicial Services Institute*, previously named the *Wilderness Emergency Medicine Curriculum Development Project*, is devoted to developing curricula for wilderness EMS providers and medical control physicians, and fosters wilderness EMS research. It is a cooperative venture of the Appalachian Search and Rescue Conference and the Center for Emergency Medicine of Western Pennsylvania. The ASRC is a large, tightly-knit wilderness search and rescue organization with eight teams throughout the mid-Appalachian states. The Center for Emergency Medicine is an emergency medicine and prehospital care research and teaching organization. It provides a medical helicopter service, an emergency medicine residency, Emergency Medical Services for the city of Pittsburgh, and conducts a variety of related projects.

The WEMSI Wilderness EMT Curriculum

This chapter is one part of the ASRC-CEM Wilderness Emergency Medical Technician Textbook. In concert with the WEMT Curriculum, the Textbook has been in development since 1986, and took as its starting point a program Dr. Conover developed for the National Association for Search and Rescue in 1980. The Project has also drawn on many other sources in creating this Textbook. These include the Wilderness EMT program of SOLO (Stonehearth Open Learning Opportunities), the WEMT program developed by Wilderness Medical Associates, and the Winter Emergency Care Course of the National Ski Patrol. The Wilderness Medical Society's educational and research publications provide needed background for the Textbook. The National Association of EMS Physicians has developed and has published clinical guidelines for delayed/prolonged transport; WEMSI protocols are also available as a model.

With textbooks used by its EMT and SAR prerequisites, this Textbook provides all the training material needed to complete the Wilderness Prehospital Emergency Care curriculum established by the Wilderness Medical Society. (Indeed, early drafts of this textbook were a major resource for the WMS curriculum.) We assume that students have the knowledge and skills of an EMT-Basic or EMT-Paramedic. (The curriculum can accommodate both EMTs and paramedics in the same class.) We also assume that students have the knowledge and skills of the Virginia Ground Search and Rescue Field Team Member standards or better. (EMT standards are available from state EMS offices or the U.S. Department of Transportation. The Virginia GSAR standards and GSAR Manual are available from the Virginia Department of Emergency Services, 310 Turner Road, Richmond, VA 23225-6491.) The curriculum is competency-based rather than hours-based, but can be competed in roughly five intensive days. The curriculum also recommends clinical training, for which guidelines are available in the Curriculum.

WEMT Textbook Chapter Development

An outline for each of the twenty sections of the WEMT curriculum was created by a Task Group of five to twenty selected members, but draws on many published sources and consultants. A Task Group Leader guides the Task Group in reviewing and revising the section, and the Curriculum Coordinator supervises all aspects of curriculum development.

When the outline satisfies the Task Group, it goes to our **Editorial Board**; this includes officers of the ASRC and CEM. It also includes experts in emergency medicine, search and rescue, and education, and a State EMS director. Once acceptable to the Board, it is released to the public.

The Task Group Leader and Editor-in-Chief then produce a Textbook chapter based on the outline. Having a single editor provides a coherent, unified style. Basing chapters on the Task Group's Lesson Plans, as approved by the Editorial Board, ensures accuracy. Each chapter provides a glossary of terms new to a reader with basic EMT and SAR training. In the complete textbook, these glossaries will be merged and alphabetized. Each chapter also provides references to support its statements and for further reading. Background that need not be presented in a class based on the Curriculum appear *in this small, italic font.*

The textbook will be commercially published when completed. All profits will be used to support curriculum development. The textbook will be submitted for publication in 1994. Until then, preliminary versions of the chapters will be printed in this format. These preliminary versions are for use **only** at classes authorized by the Executive Director.

A Course Guide with information about Wilderness Emergency Medical Technician training and course scheduling, will also be available in late 1994; a checklist for recommended in-hospital training is available now. For a price list of available publications, write to: Center for Emergency Medicine, 320 McKee Place, Suite 500, Pittsburgh, PA 15213-4904, (412) 578-3203.

We actively solicit suggestions from anyone reading any of our Lesson Plans or Textbook chapters. Please send your comments to the Editor-in-Chief, as listed on the title page.

Educational Objectives

1. Define "wilderness," "wilderness EMT," and "wilderness EMS."
2. Discuss the importance of air and oxygen in respect to:
   a. its presence or absence in the wilderness environment;
   b. its quality in the wilderness environment; and
   c. the relationship between available oxygen, barometric pressure, and altitude.
3. List human compensations for altitude exposure and hypoxemia.
4. Discuss the role and importance of sun protection in the wilderness SAR environment.
5. List the types of sun protection and their advantages and disadvantages, citing specific examples of each.
6. Discuss the problems and dangers associated with wind in the wilderness environment.
7. Discuss the windchill effect and its importance to the wilderness EMT.
8. List the hazards associated with each type of precipitation.
9. Describe thunderstorm and lightning hazards to the wilderness EMT.
10. List six good safety rules for when lightning is imminent.
11. Define the term "ground current" as it relates to lightning strikes.
12. Discuss drinking water in the wilderness environment with respects to its:
    a. presence or absence;
    b. role in homeostasis;
    c. quality; and
    d. use for wound irrigation.
13. List five contaminants of drinking water in the wilderness environment.
14. Describe three methods of purifying (disinfecting) water, and the advantages and disadvantages of each.
15. Discuss the role and effects of water regarding:
    a. drowning;
    b. thermal conductivity; and
    c. force while moving.
16. Summarize the hazards presented by terrain as they relate to the following topics:
    a. vegetation dangers:
       (1) physical dangers, and
       (2) chemical dangers;
    b. animal dangers:
       (1) mammalian dangers,
       (2) reptilian dangers, and
       (3) dangers from insects and arachnids.
17. Discuss the prevention of insect bites and tick attachment.

Notes: *The Wilderness Environment*

All who read this chapter should have a basic understanding of wilderness travel and survival from experience or other reading. Thus, no basic survival material is presented here. *Search and Rescue Fundamentals* by Cooper, LaValla, and Stoffel is an excellent introduction. (Available from: Emergency Response Institute, 4537 Foxhall Drive, NE, Olympia, WA 98506; (206) 491-7785.)

This section sets the proper tone for the book. Our central precept is that we are teaching how to care for patients **in the wilderness**. We stress this idea here, then reinforce it in all chapters. In classes based on this book, we reinforce it strongly with practical exercises in a wild area (sometimes with heat, cold, wind, rain, or snow).

By reviewing environmental hazards, we also intruduce pertinent medical topics: hypothermia, heat exhaustion, envenomations, altitude illness, and trauma. Protection from the environment is one of the WEMT's few constants. **Everyone** in the field (including the WEMT) is always at risk for becoming a patient. This section helps to establish, at the outset, a wilderness environment theme persisting through the entire book.

18. Describe the recommended method of tick removal and explain why it is recommended.
19. List and explain five manmade hazards that might be found in the wilderness environment.
20. Discuss the role of subjective hazards as they relate to the wilderness SAR environment.
21. Describe the cave environment.
22. List five specific hazards of the cave environment.
23. List and differentiate the major components of "the wilderness ambulance."

Wilderness Definitions

Dictionary definitions of wilderness include:

* a tract or region uncultivated and uninhabited by human beings,
* an uninhabited region left in its natural condition, and
* something likened to a wild region in its bewildering vastness, perilousness, or unchecked profusion.

Terms we newly define for this course include the following.

* Wilderness EMT: A specially trained member of a well-organized, wilderness-oriented, physician-controlled system that provides medical care to patients in backcountry or wilderness situations.
* Wilderness EMS: A system capable of providing medical care and rescue beyond the means of routine or conventional EMS systems. This may require transport of equipment, personnel, and medications on team member's backs over rugged terrain to the patient, and during evacuation from the site to an entry point into the "normal" EMS system.

Air

Patients with trauma or medical problems may be even more susceptible to wilderness air problems than healthy people.

The amount of air may be inadequate in swiftwater, avalanches, mud slides, natural or manmade pits, snow caves, natural caves or mines, tents with stoves (especially if snow-covered) and cars.

Air may also be of inadequate quality. It may have too much CO (carbon monoxide) or CO_2 (carbon dioxide; from stoves, catalytic heaters, cars). Air may contain other noxious gases or vapors. Volcanic mountains and hot springs may produce poisonous hydrogen sulfide or carbon monoxide. In one recent incident in South America, a nearly-dormant volcano "belched" enough CO_2 to suffocate an entire village.

Air may contain explosive gases. For instance, a cave rescue might occur in a cave near a filling station's underground gasoline tank that is leaking, or an underground gas pipeline. A caver's calcium carbide supply may become wet and fill his or her cave pack with explosive acetylene gas, ready to explode in the caver's face. Decomposition of trash and other organic material in mines and caves may produce explosive methane gas. After an explosion, the air may still contain enough gas for a second explosion, and may be filled with poisonous gases.

Particulate matter may fill the air, as in a western dust storm or smoke from a forest fire.

Air may contain infectious agents. In areas with a large bat population, especially certain caves, rabies virus particles may be in the air. It is possible (though not at all likely) to get rabies simply from breathing such air. (Rabies is discussed further in the chapter on *Wilderness Medical Problems*). In the same way, the air of certain caves harbors the infectious agent of histoplasmosis, a lung infection.[1,2]

Air may not have enough O_2 (oxygen). In confined spaces, such as a crevice rescue, the

Effective $\%O_2$	Partial Pressure O_2, mm Hg	Altitude	Physiological Effects of Acute Exposure
21%	160	Sea Level	• Normal physiology
17%	130	5,000 feet	• Impaired night vision • Increased repiratory rate or depth
14%	110	10,000 feet	• Lightheadedness • Dizzyness • Headache • Rapid fatigue
12%	90	15,000 feet	• Acute Mountain Sickness • Pulmonary edema • Cerebral edema
9%	70	21,500 feet	• Loss of consciousness

Table 1: Physiology, Hypoxia, and Altitude

large number of rescuers may use up available O_2. A large mass of rescuers may also produce enough CO_2 to pool in the crevice and displace O_2. Lower barometric pressure decreases the amount of O_2 available via the law of partial pressures. (EMT-P texts contain a description of the law of partial pressures.)*

Your reactions to altitude depend on the speed at which you reach altitude (the degree of acclimatization), your cardiovascular fitness, and your particular constitution. Excellent cardiovascular fitness is, unfortunately, no safeguard against altitude illness. Though high altitudes are not found in the East, some Eastern WEMTs may be recreational climbers and need to know about altitude effects. Air transport via helicopter or fixed-wing aircraft will also increase the patient's altitude. Table 1 summarizes the direct effects of sudden exposure to altitude. Details of altitude-related illness that might develop later (acute mountain sickness, high altitude cerebral edema, and high altitude pulmonary edema), and acclimatization to altitude, are covered in the chapter on *Altitude Illness.*

Human compensations for altitude or hypoxia include the following.[3]

- ⁕ Increased respiration (depth, rate, or both) is an acute adaptation that persists indefinitely.
- ⁕ An the mass of red blood cells increases over time, which allows more efficient carrying of oxygen.
- ⁕ Some enzymes in red blood cells change to increase their O_2 carrying ability; this also occurs over time.
- ⁕ With exercise at altitude, you develop increased general cardiovascular fitness.

* Normal barometric pressure is 760 mmHg (29.92 inches) at sea level. For practical purposes, barometric pressure decreases .01 inch for every 10 foot increase in elevation.

Weather

*Weather patterns**[4]

Weather patterns vary from area to area, and each WEMT must know the local patterns. However, some general principles apply. Sudden changes in barometric pressure (e.g., as shown by sudden changes in altimeter readings) correlate with sudden changes in weather. High pressure areas correlate with dry, clearing weather. Low pressure areas correlate with lingering and heavy precipitation. Cold fronts are vertical and thus are accompanied by sudden, severe changes in weather, and with severe storms. Warm fronts bring gradually lowering skies and drizzle or other precipitation, but rarely cause severe storms.

In most of the continental U.S., the weather comes from the west. Dry Canadian air coming from the northwest brings cool, dry weather. Warm, moist air coming from the southwest brings precipitation.

In much of the country, there is a common summertime thunderstorm weather cycle. For weeks, no new air masses come from the west. The weather is clear each morning, but, each afternoon, the sun's heat causes moist air to rise, and thunderstorms develop.

Tips:

Watch for sudden changes in your altimeter.

Watch for new cloud buildup.

Watch for sudden sustained shifts in wind direction.

Check the weather forecasts.

Sun

Blue skies and bright sun are enjoyed by all wilderness travelers. However, bright sun has harmful effects on our immediate wilderness environment and on wilderness travelers themselves.

Bright sun may melt frozen snow and ice leaving mountain slopes prone to avalanche. By midmorning or early afternoon, travel is hazardous on such slopes.[5]

Sun and the Eye: Bright light and reflections off water, snow, or sand make protective eyewear necessary. Protective eyewear should reduce the total visible and ultraviolet light to safe levels. Ultraviolet (UV), with a lesser contribution from infrared, causes snowblindness. (Snowblindness is a UV "sunburn" of the cornea.) Most manufacturers of sunglasses are careful to point out that their sunglasses block 98%, 99%, or 100% of UV light. UV light is also a probable cause of cataracts, which are opacities that develop in the lens of the eye.

Sunglasses come with four different types of lens material:

* Acrylic: is inexpensive, but may melt in the heat, scratches easily, and breaks easily on impact;
* CR-39 plastic: is a bit more expensive, and is fairly strong against impact;
* Polycarbonate plastic: scratches easily, but usually has an anti-scratch coating, and is very strong against impact. Bollé manufactures polycarbonate sunglass lenses, and a subsidiary (Yarrow) can provide prescription polycarbonate lenses;
* Glass: is very strong when totally unscratched, yet fractures easily once scratched. It doesn't scratch as easily as any plastic.

Color choice for sunglasses is very subjective; pick a color that gives a very similar color spectrum compared with "normal," and is personally pleasing. Some suggestions that "blue-blocking" sunglasses give superior protection or

* This material (in small italics) is not currently covered in adequate detail in most search and rescue training. However, as it does not relate directly to medical concerns of the WEMT, it will not be covered in classes nor form part of the educational objectives.

improved vision have no good evidence to support them.

Mirror coatings reflect some infrared (heat), but scratch easily. They also reflect light onto your nose and cause increased sunburn there, though this can be blocked by a leather or plastic nose guard.

Side guards are important for protection against solar keratitis (snowblindness). You can improvise them from duct tape, if necessary.*

Sun and the Skin: The sun's effect on skin may be debilitating at any altitude. Sun is particularly dangerous when you are at higher altitudes; there is less atmosphere to protect against the sun's burning rays.

UV light can be divided into different frequency ranges. UVB is responsible for sunburns and suntans, and is what is produced by most tanning lamps. UVA, though it causes little sunburn or tanning, is known to cause damage to the skin and the lens of the eye (cataracts)[6,7]

The UVB light flux increases about 4% for every thousand feet of elevation, so sunburn becomes progressively more of a problem with altitude. Clouds absorb only about 30% of UVB, so a cloudy day is little protection against sunburn, especially at altitude.

Besides "regular" sunburn caused by UVB, those who are taking certain medications may develop photodermatitis from UVA. Photodermatitis is slightly different from sunburn, but the differences are unimportant to anyone suffering from it. Certain common wilderness medical kit drugs cause photodermatitis: nonsteroidal antiinflammatory drugs such as ibuprofen, and tetracycline antibiotics, especially doxycycline.

Wind is well-known to increase the skin's susceptibility to sunburn. "Windburn" is really sunburn caused by exposure to both wind and ultraviolet, even on cloudy days.

The best treatment for sunburn is prevention. There are two main ways to prevent sunburn: physically or chemically. You can physically protect against the sun's harmful effects by using clothing, including the hats, sunglasses with side shields, and clothing covering all your extremities. Note that thin clothing may offer little protection against the sun, especially when wet. For instance, a plain white Hanes™ brand T-shirt has a sun protection factor of only five.**

You can use chemical protection against the sun's harmful rays by using commercially available sunscreens. For the wilderness, use sunscreens with sun protection factors greater than 15. A waterproof sunscreen is virtually a necessity for the wilderness. "Clear sunscreens" act by selectively absorbing ultraviolet light. Older sunscreens block UVB, but newer sunscreens also block UVA to different degrees. The most common blocking agent used to be PABA (para-aminobenzoic acid). However, people sensitive to sulfa drugs should avoid using sunscreens containing this agent and opt for a PABA-free sunscreen (e.g., a benzophenone- or cinnimate-based sunscreen).

When using a sunscreen, be sure to replace it often if it is washed, abraded, or sweated off. Some dermatologists believe that some PABA is absorbed into the outer layers of skin, particularly after a bath or shower. (Others disagree, saying there is no significant absorption). Simple sun blocking agents include the opaque white zinc oxide and titanium dioxide found in many glacier creams. These provide absolute protection at the cost of a bizarre appearance

* More information on eye protection may be found in Dr. Donner's section on eye protection in the proceedings of the 1990 meeting of the Wilderness Medical Society.

** Sun protection factor (SPF) is the minimum dose of ultraviolet light to provide skin erythema with the sunscreen, divided by the minimum erythema dose without the sunscreen. Thus, with a SPF of 2, you can stay out in the sun 2 hours and get the same burn you'd get in 1 hour with no sunscreen.

that tends to frighten small animals along the trail.

Many treatments recommended for sunburn protection have been found to be useless. Oral PABA does not protect against sunburn. Commercial "bronzers" make the skin darker. They cause no harm, but the darker coloration they provide does nothing to decrease sunburn. Commercial "tanning accelerators" seem to do nothing at all.[6]

Equipment is also affected by the sun. Materials such as nylon are degraded by continuous exposure to the sun's rays, particularly at altitude. The sun's thermal energy may heat equipment to the point of failure if the equipment is exposed for long periods of time.

Medications may also be affected by light or extremes of temperature. (See the chapter on *Pharmacology* for medications that can and cannot survive freezing.)

Just as sunlight may degrade items frequently used in the wilderness EMS environment, sunscreens may make clothing and equipment deteriorate even more rapidly. The presence of sunscreen on hardware collects dirt causing premature wear and possibly jamming when moving parts are involved.

Heat and Cold

This textbook assumes that you have experience or training in search and rescue. Therefore, we will not review the principles of clothing protection from heat and cold, such as the dangers of cotton and the need for warm-when-wet clothing.*

The medical consequences of exposure to heat and cold are covered in the chapters on *Thermal Regulation*, *Heat-Related Disorders*, and *Cold-Related Disorders*.

Recent literature suggests many common emergency drugs are safe for use after being frozen and thawed, though some may not be.[8,9,10] A list appears in the chapter on *Pharmacology*.

Wind

Wind noise may make it hard for rope team and litter team to hear each other. Deadfall from trees may endanger both you and your patients; you must look up as well as down when picking a place to set a litter down. Windborne particles commonly cause eye injury (especially around helicopter landing zones).

The **wind chill temperature**, sometimes incorrectly quoted in weather forecasts as the "wind chill factor," is a calculated temperature. It expresses the chilling effect of the current temperature and wind **on exposed flesh**, in terms of an equivalent temperature without any wind. Wind will also increase evaporative losses from wet clothing or flesh.[11]

Precipitation

Snow, rain, sleet, and hail may:

- make hazardous footing for the litter team,
- decrease visibility,
- increase the need for belays for the litter,
- increase the risk of dangerous flooding (especially in drainage areas and caves), and
- predispose patient and litter team to hypothermia.

* If do not have a search and rescue background, we recommend that you read a text such as *Search and Rescue Fundamentals* by Cooper, LaValla, and Stoffel, available from Emergency Response Institute, 4537 Foxhall Drive, NE, Olympia, WA 98506; (206) 491-7785.

Hail may cause direct damage to WEMTs, patients, or equipment. Hail comes from large thunderstorms. Hailstones as large as a pound and a half (0.7 kg) have been documented, and people have been killed by hailstorms.[12] Snow may present avalanche dangers, even in the Appalachians. A small avalanche, while not enough to kill or bury anyone, can still wreak havoc on your litter team when in the bottom of a ravine.

Thunderstorms and Lightning

Thunderstorms and lightning are severe hazards to patients and rescuers alike, especially on exposed, rocky ridges. Thunderstorms may occur as part of the summertime afternoon shower cycle, or may be associated with a cold front. You can estimate the lightning's distance by counting the seconds from flash to thunderclap. Divide the number of seconds by five to get the approximate distance in miles. This may help you estimate how long until the storm arrives.

Lightning injuries, while rare, are not extremely rare: 250 people are injured every year, and 150 people are killed each year.[13]

Lightning is particularly likely to strike you:

* in open fields, on open water, or anywhere where you are the highest object around; or,
* standing next to a single protruding object in the middle of a clearing (i.e., a lone tree), or
* near a large metal object such as a Stokes litter.

The danger of injury from lightning for WEMTs is small but significant. For a patient tied into a steel basket on the end of a wet rope suspended on an exposed cliff, the danger is immediate.

Some places are likely to have a large, dangerous ground current arcing across during a lightning strike: any shallow depression such as a small shelter cave. (Deep caves are safe except near the entrance.)

When lightning is an imminent danger, observe the following rules:

* avoid open water;
* avoid open ground;
* avoid tall objects;
* avoid being the highest point;
* avoid sheltering in moist areas and depressions;
* span as small a distance as possible;
* insulate yourself from the ground;
* divest yourself of any metal objects;
* if on a face, tie in with horizontal lines, as for a traverse, to avoid vertical current flows.
* If a strike is imminent, as shown by St. Elmo's fire, or hair "standing on end," get away from a metal litter, and crouch down to present as small a target as possible.[14]

Water

Water Quantity

You should be able to estimate drinking water amounts for the team. Daily requirements for each person range from few to many liters. Thirst is primarily an indicator of **hypernatremia** (increase in salt level in blood) rather than lack of fluid volume. (Hypernatremia may occur with greater water than salt loss, as occurs with profuse sweating.) Therefore, as a WEMT, you must serve as a medical educator to team members, and urge adequate drinking to keep team members from becoming patients.[15] If you suspect dehydration in a team member, you should ask the member to urinate. Judge the state of hydration by the amount and color of urine.*

Water Quality

You must understand the principles governing water quality for drinking and for irrigation. There are several types of contaminants in water:

* bacteria, including enteropathogenic bacteria (ones that cause gastroenteritis), e.g., *Salmonella, Shigella, Campylobacter*, and certain types of *E. coli*, and wound pathogens *(e.g., Staphylococcus, Streptococcus, Pseudomonas*, and *Clostridium tetani*);
* viruses, including viruses that cause diarrhea, such as the *Norwalk agent* and the *rotaviruses*, and the *Hepatitis A* and one of the *non-A, non-B hepatitis* viruses;
* mineral and heavy metal contaminants including pesticides, mine residue, and industrial waste;
* microscopic parasites (e.g., tapeworm, *Giardia lamblia*); and
* gross organic material and dirt.

Water for drinking and water for wound irrigation have different requirements. For drinking water, we only need to remove or kill organisms that cause disease when they are ingested. For sterile irrigation water, we need to kill the spores of bacteria that may cause wound infections. Spores are much more resistant to killing than enteric bacteria and other pathogens, including viruses. However, irrigating a grossly-contaminated wound with water containing only a few spores is going to reduce the bacterial count and probably do more good than harm.

Water Purification and Disinfection

Water purification and disinfection methods include the following.

Filtering: You can use coffee filters, cheesecloth, or a clean shirt-tail to strain out large-size particles. This is especially effective you first "flocculate" the water with a pinch of the chemical alum.*

You can use micropore filters (e.g., the Katadyn®, First Need®, and Mountain Safety Research "Water Works Total Filtration System" filters**) to remove organisms. However, such filtration systems do not remove all viruses such as those that cause hepatitis or diarrhea. Filters such as those listed will produce water suitable for "sterile" irrigation, because the remaining viruses are unlikely to cause infection when used for irrigation. Larger-pore filters designed solely to remove *Giardia* will not provide water suitable for irrigation.

Boiling kills most pathogenic organisms. However, some bacterial spores resist boiling even for extended periods, and even boiled water may not be "sterile." At sea level, 10 minutes of boiling will kill most spores that may cause wound infections.

Nearly all enteric pathogens (ones that cause disease when you drink them) are killed by just bringing water to a boil (at sea level). The time required to bring to a boil is also working toward disinfection.

Halogens (iodine or **chlorine** tablets, crystals, or solutions) disinfect water based on the concentration of halogen, the duration of contact, and the temperature of the water. Iodine-containing tablets are still the U.S. Army choice for field disinfection of water, and are effective against almost all enteric pathogens when used

*** This is similar to **uromancy**, the art of divining medical problems by urine, practiced by British doctors in the late middle ages and even since.

* You can reportedly get a similar effect from a pinch of the fine white ash from a campfire.

** The size of the pores in the First Need® filter are larger than those in the Katadyn filter, but the design seems to trap all bacteria in tests.

as directed. (Iodine is superior to chlorine, as it kills more pathogens.) True iodine allergy is very rare, and ill effects from normal occasional use of iodine-purified water should be exceptionally rare. However, the strong iodine taste is objectionable to some. Some systems use chemicals or absorbents to remove the iodine after it has done its work.

A new filter technology uses an iodine-containing resin. Organisms are exposed to very high concentrations of iodine when passing through the filter, but little or no of the iodine passes through into the water coming out of the filter. This system is effective against all pathogens. It is probably best to let water sit for 15 minutes after filtering with such a system, to let iodine attached to pathogens finish killing them.

The resin method has been approved by the U.S. Food and Drug Administration. Two manufacturers provide devices using this technology.*

The best for SAR use is probably the PUR Scout. This device combines a 1-micron filter to remove larger elements such as Giardia cysts with a second filter with iodine resin to kill bacteria and viruses. It weighs twelve ounces, is nine inches long and two and a quarter inches in diameter, and will fit easily in a pack's side pocket. An optional add-on charcoal filter will remove many organic contaminants such as pesticides and herbicides.

For routine drinking water disinfection in wilderness and disaster situations, we recommend (1) an iodine-resin filter with a charcoal filter such as the PUR Scout, or (2) iodine, either tablets or another method such as crystals. If water is very cloudy, flocculate first and filter through filter paper. For wound irrigation, we recommend water from a filter such as the Katadyn® or PUR Scout filter systems. If you don't have a filter, use water treated with a standard iodine method. You can also use povadone-iodine (e.g., Betadine) solution from your medical kit to disinfect water: use eight drops per liter of water for half an hour; use more povadone-iodine or longer contact time if the water is very cold or if the water is very dirty.

Urine: A question often arises in WEMT classes: if you expect a prolonged transport, and a wound is grossly contaminated, and the only irrigant available is urine, should you use it? While this is indeed a sticky question, a tentative answer is to use only male urine. (Female urine has a higher bacterial count.) Should anyone actually have occasion to use this technique, we would expect careful follow-up and a paper to be presented at the annual meeting of the Wilderness Medical Society.

Disasters: If you are in a disaster setting, and you need to disinfect large amounts of water, your best bet is to find a bottle of chlorine bleach (e.g., Clorox® bleach.) Such household bleach is a solution of sodium hypochlorite (Clorox® is 5.25%), which releases chlorine. The amount you need to use depends on the condition of the water. The cloudier the water, the more organic material therefore to "soak up" chlorine, and therefore you must add more bleach. For cold water, you need more chlorine. Finally, time is very important; if you can leave the water for an hour or more, you can use lower levels of chlorine. A simple rule, reliable for nearly all situations, is: add two drops of 5% bleach (ten drops if you have 1% bleach) to each liter (quart) of water, and leave overnight. This is the same as 4cc of 5% bleach (Clorox®) for every 40 liters=10 gallons** If you need to use the water

* Water Technologies Corporation, 14405 21st Ave. N., Suite 120, Plymouth, MN 55447, (800) 637-1244, (612) 473-1625; and PUR, a Division of Recovery Engineering, Inc., 2229 Edgewood Avenue South; Minneapolis, MN 55426; (800) 845-7873; PUR products are available by mail from a variety of providers, including Travel Medicine, Inc., 351 Pleasant St., Suite 312, Northampton, MA 01060, (800) 872-8633.

right away, double the amount of bleach and leave for an hour.[16*]

Other miscellaneous water considerations for WEMTs include the following.

For near-drowning, the treatment is the same in the city and in the mountains. Swiftwater and low-head dams are significant hazards, especially for team members burdened with rescue gear, or for patients strapped into a Stokes litter. The strength of the current in a rain-swollen creek is easy to underestimate.

The thermal conductivity of water is much higher than air (and thus wet clothes suck out heat much faster than dry). Cotton and down clothes lose most of their insulation value when wet.

Water is well known to cause failure of radios, especially when they are immersed. Water also absorbs radio energy; the range of VHF-FM radios decreases markedly in a downpour.

Terrain

Gravity

People slipping or falling, or things falling on people, are common causes of wilderness injury. A patient strapped into a Stokes, and litter team members hanging onto a litter, are not at liberty to move away from falling objects. Therefore, protection is essential (helmets and packs for litter team members, helmet and face shield for patient).

Plant hazards

Twig in the eye: Eye protection is essential for night operations.

Deadfalls: WEMTs must wear helmets when they are attached to the litter or otherwise unable to dodge falling limbs.

Sticks/logs: Sticks and logs may injure the legs and feet of litter bearers who are limited in ability to choose their path or to see their feet; this is also common in those who have been running through woods lost.

Thorns: Thorns may cause serious lacerations, especially when the evacuation route is through brambles.

Generalized allergy: Hay fever is a misery for all who suffer it; no more need be said.

Skin irritation: Direct irritation (e.g., stinging nettles) and skin allergy (poison ivy and other plants) are covered in the *Wilderness Medical Problems* chapter.

Animal hazards

Animal bites are discussed in the chapter on *Wilderness Surgical Problems.*

Mammals:

- **Rabid animals:** Rabies and rapid animals are discussed in the chapter on *Wilderness Medical Problems.* Any unusually friendly or bizarre behavior of a wild mammal should make you suspicious of rabies.
- **Bears:** Bears are vastly overrated as a hazard. Black bears (the only kind in the east) are generally dangerous only if cornered, wounded, or protecting their

*** one drop= 0.05cc; 4 liters=1 gallon (roughly)

* Information on water purification methods has been revised based on information presented by Howard Backer, M.D., at the Eighth Annual Scientific Meeting of the Wilderness Medical Society, September 1992; proceedings available from: Wilderness Medical Society, P.O. Box 2463, Indianapolis, IN 46206, (415) 663-9107

young. (Brown and cinnamon bears are merely different colored black bears.) Only the polar bear and grizzly bear are reported to stalk humans. Climbing a tree may be an adequate defense against an older grizzly, but grizzly cubs and black bears can climb trees. Bear attacks may be based on dominance behavior, and in certain situations, submissive behavior (i.e., playing dead) can be an effective deterrent to further attacks. Those interested in further reading on this fascinating topic are referred to Stephen Herrero's work on the topic.[17]

* **Feral dogs:** If you are confronted by a person bitten by a feral dog, you must leave the wound open, will generally treat with antibiotics if far from a medical facility, and depending on the location of the bite, must consider an evacuation for immediate rabies immunization, or at least arrange for evaluation for rabies immunization on return to civilization.

* **Feral pigs:** In the southeast, feral pigs are known to grow as large as 300 pounds, and sometimes will attack humans.

* **Deer:** in some national parks where deer are protected from hunting, they are so tame they come up to people begging for handouts. Unlike the well-known (and overrated) danger of bears, few know that deer have razor-sharp hooves that can disembowel a person in a fraction of a second.

* **Others:** Skunks with their spray, and porcupines with their spines, are hazards too well-known to be discussed further. Any American encyclopedia will provide a good general reference for those unfamiliar with them.

Reptiles: Snakebite represents the greatest concern in many parts of the country, and is discussed in the chapter on *Bites and Stings.*

Insects and Arachnids: Hymenoptera (bees and wasps) cause more deaths (from anaphylaxis, discussed in the chapter on *Wilderness Medical Problems*) than all other animal hazards combined. Spider and insect bites are covered in the chapter on *Bites and Stings.*

Preventing Insect Bites and Tick Attachment

Insect bites may create a simple, itchy annoyance, or may cause serious infections and some envenomations may, at times, cause tissue loss. The best treatment is therefore prevention.

You may protect yourself from insect bites with garments which pose a physical barrier to insects. For example, tucking your pants into your socks will help prevent ticks and insects from crawling up your legs.

The most widely used insect repellent preparations currently contain DEET. These provide convenient protection for areas of the body not conveniently covered by clothing, such as the face, neck, and hands. DEET is available in many concentrations, some as high as 90%. However, DEET is absorbed through the skin, and has some toxic effects, particularly on the central nervous system; there are even reports of seizures caused by DEET.[18] Therefore, recent efforts have led to repellents with lower percentages of DEET in a special vehicle that extends the time the DEET stays on the skin, and repellents that have a lower percentage of DEET with a synergist chemical to maintain effectiveness. R-326 is one of the most common synergists.

DEET is effective against mosquitoes and ticks, but not against the biting black flies so common in many northern areas in the late summer. "Old Woodsman's Fly Dope" is a tarry, smelly, staining preparation of natural resins that is widely available in biting fly areas. It is effective against black flies, but is also known to repel humans as well. A chemical known as R-11 is effective against black flies, but recently has been replaced a new chemical known as R-326.* Little is publicly available about the effectiveness or safety of this compound, but the Environmental Protection Agency has tested it and found it to be both safe and effective. Commercial products combining low to intermediate DEET, in a long-lasting formula or with a synergist such as with R-326 to prevent black fly bites, seem to be appropriate all-around repellents. An example is Sawyer DEET-PLUS™.*[19]

A new tick and mosquito repellent called permethrin is generally applied to clothing; combined with long-acting DEET or DEET with synergists, this provides a very high level of protection against bites.[20]**

A commercial concentrated bath oil, Avon *Skin-So-Soft*, is widely touted as the best repellent for black flies and mosquitoes. We are aware of no good controlled studies of its efficacy compared with other alternatives. Its safety for continued widespread use on the skin is undetermined. It also is reputed to wear off quickly, requiring you to frequently reapply it.[20]

Removing ticks

Ticks have recently become a popular topic of conversation among those traveling out of doors. This is due to their link in transmitting Lyme disease, as well as Rocky Mountain Spotted Fever. If you find yourself or a teammate outsmarted by a tick which managed to breach protective clothing, chemical protection, and skin, you will need to remove the offending tick immediately.

Removing ticks has become a bigger topic of conversation than the ticks themselves. You can best remove a tick by grasping the head as close to the mouth parts as possible with forceps (tweezers) and pulling the tick out of the skin with gentle traction. Apparently, the tick's jaws fatigue and loosen their grasp.

Jerking suddenly may decapitate the tick, leaving its head embedded in the skin and likely to cause an infection. If this happens, carefully remove the retained mouth parts with a needle or the tip of a #11 scalpel blade. (You can use the same technique as described for splinters in the chapter on *Wilderness Medical Problems.*) Using a hot object, crushing the tick, or covering the tick with petrolatum may cause the tick to vomit into the skin and blood vessels, making disease transmission more likely, and should be avoided.

Regardless of the method chosen, clean the remaining bite wound thoroughly and dress with an appropriate antibiotic ointment.[21,22,23]

Manmade hazards

Manmade hazards in wild areas include the following.

- Search teams often run across, and must search, unsafe structures (buildings, mines).
- Electrical lines may be a danger in aircraft crashes and catastrophic disasters, or even in some areas where they may droop low enough to encounter the WEMT's handheld radio antenna or backpack frame. Electric fences are a common hazard for rural search team members.

*** R-326 stands for "Repellent #326." Chemically Di-N-propyl isocinchromeronate, this repellent is also known as MGK-326, for McLaughlin-Gromley-King, the Minneapolis firm that makes almost all insect repellent ingredients.

* Available from Sawyer Products, Box 188, Safety Harbor, FL 34695; (813) 725-1177. DEET-Plus lotion or spray is $3.49 for 2 oz.

** available from Travel Medicine, Inc., 351 Pleasant St., Suite 312, Northampton, MA 01060, (800) 872-8633

- Chemical hazards include forest spraying with insecticides; field fertilizers; toxic waste dumps; and mine tailings.
- Military aircraft crash sites are replete with weapons, armed ejection seats, and possibly radioactive materials.
- Crime may be a problem even in the wilderness. Booby traps around stills or marijuana fields, or assault by those protecting them, are significant hazards in certain parts of the country.

Subjective hazards

Subjective hazards include lack of knowledge regarding the wilderness environment, or regarding the nature and scope of the tasks at hand.

Overconfidence is the bane of many a climber, backpacker, or hunter who is otherwise an excellent outdoorsperson. For the EMT, application of "street" EMS concepts in the wilderness is a common overconfidence error. A particularly common example is underestimating time and difficulty of a wilderness evacuation by a factor of 5 to 10.

Poor judgment may be exhibited by allowing mission goals (e.g., reaching the patient, finishing the evac) to cause personal danger, injury or death.

Fear is healthy and may prevent one from taking unreasonable risks. Panic, however, may lead to rash and unreasonable behaviors resulting in serious injury and possibly death.

The lack of the will to survive may ultimately lead to death.[24]

Caves[25]

- Caves are dark. **Completely** dark. Everyone carries three sources of light.
- Caves are vertical. Some caves may have vertical shafts, at entrance or anywhere in cave. Pits up to 200' deep are found in most cave-bearing areas.
- Caves are tight. Sometimes you have to take off your helmet or coveralls to get through. Sometimes, you may not even be able to get through no matter what you do (even though patient managed somehow).
- Caves are wet. Water formed most caves, and is often still present; often, it's in the form of sticky/slippery mud, or perhaps as a stream, a water-filled crawlway, or a waterfall. Sometimes the waterfall is the main passage, and WEMT's and the patient must go up or down the waterfall.
- Caves are cold. The average temperature for mid-Appalachian caves is 50-54°F (10-12°C). Cold surface runoff may make cave water colder. This may not seem cold, but wet clothes and lots of direct contact with cold rock combine to make hypothermia a common cave problem.
- Caves are confusing. Many cave passages look alike, and many caves are 3-D mazes.
- Caves are long. Most caves are short (e.g., Pennsylvania caves are mostly less than a mile long), but in Kentucky, Virginia, and West Virginia, and some other areas, caves may be 10-30 miles long or more.
- Caves have bats. Bats may be rabid, or infected with other diseases. Keep physical contact with bats to a minimum, for the bat's sake as well as yours. Avoid bat and bird droppings, if you can; they may be a source of infection with many contagious diseases.
- Quoting from a direct contribution from the Eastern Region, National Cave Rescue Commission: "Caves are not the place for the uninitiated. If you think that you might have to respond to a cave rescue as a WEMT, get the

proper training: a Cave Rescue Orientation class from the National Cave Rescue Commission. Emergency phone number for Eastern Region, National Cave Rescue Commission: 1-804-674-2400 (Virginia Emergency Operations Center). NCRC national number: 1-800-851-3051."

The Wilderness "Ambulance"

The litter team members' booted feet are its "tires." Blistered feet or slippery shoes on a rescue team may be just as hazardous as bald tires on an ambulance. Training in good foot care, and proper personal equipment are essential parts of the wilderness "ambulance." One might argue that the rescue team's equipment can be all team equipment, with no need for personal equipment, but a quick thought about boots will belie this. A five-mile hike in standard, not-broken-in "team" boots would make any rescuer into a casualty.

The rescuers' headlamps are the wilderness ambulance's headlights. Night-time wilderness rescuers trying to carry (and care for) a patient using hand-held flashlights are probably worse off than EMT's in an ambulance with no headlights and no interior lighting.

These analogies can, of course, be carried to extremes, but are a useful starting place for examining the equipment needs of a wilderness rescue team.

Glossary

Alum: A chemical sometimes used as an aid in wilderness water disinfection.

Cataracts: Opacities in the lens of the eye.

CO_2: Carbon dioxide.

CO: Carbon monoxide.

Flux: The "amount" of light or other electromagnetic radiation.

O_2: Oxygen.

PABA: Para-AminoBenzoic Acid; a sunscreen.

Photodermatitis: A rash, similar to sunburn, caused by exposure to the sun's ultraviolet "A" light after taking certain medications.

Wilderness: A tract or region uncultivated and uninhabited by human beings; an uninhabited region left in its natural condition; something likened to a wild region in its bewildering vastness, perilousness, or unchecked profusion.

Wilderness EMS: A system capable of providing medical care and rescue beyond the means of routine or conventional EMS systems. This may require transport of equipment, personnel, and medications on team member's backs over rugged terrain to the patient, and during evacuation from the site to an entry point into the "normal" EMS system.

Wilderness EMT: A specially trained member of a well-organized, wilderness-oriented, physician-controlled system that provides medical care to patients in backcountry or wilderness situations.

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