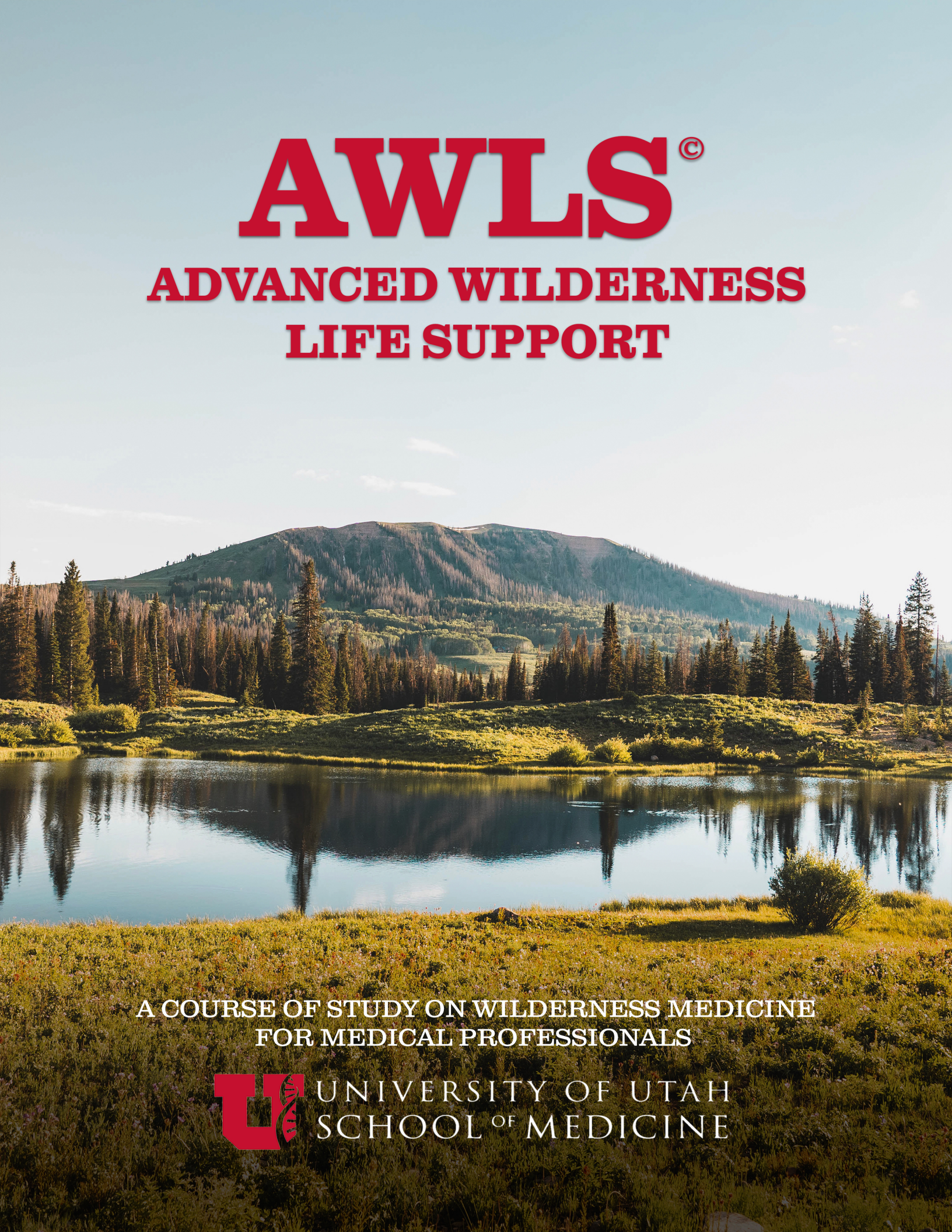
AWLS©

ADVANCED WILDERNESS LIFE SUPPORT



A COURSE OF STUDY ON WILDERNESS MEDICINE
FOR MEDICAL PROFESSIONALS

UNIVERSITY OF UTAH
SCHOOL OF MEDICINE

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Introduction

THE HISTORY OF ADVANCED WILDERNESS LIFE SUPPORT

As more people venture into the backcountry, injuries are increasing. There has been no branch of medicine devoted to teaching medical professionals how to treat or prevent such injuries. Wilderness medicine encompasses the prevention, diagnosis, and treatment of injuries and medical conditions that may occur during activities in remote territories away from cities, ambulances, and hospitals. It covers how to practice medicine where there is no medical support and where a person might have to improvise care.

In 1993, while biking in the mountains near Salt Lake City, Utah, USA, I witnessed a serious mountain bicycle accident in the hills behind the University of Utah School of Medicine. The un-helmeted young rider hit his head on the ground and was knocked unconscious. Then, a week later, while rafting with Boy Scouts on the Colorado River, in the Western United States, one of the participants lacerated his leg. I realized both times that I felt unsure of how I could help someone injured in the backcountry and away from modern medical equipment. I knew that wilderness medicine instruction was not offered at any medical school, and the majority of physicians did not receive this type of training. As a doctor, and an active hiker, biker, and river runner, I knew that people would turn to me for guidance if they were injured in a remote area, and I felt that doctors needed to be prepared.

There was no course of study on wilderness medicine for physicians or medical professions in general. I began to study wilderness medicine while in residency, and in 1998 as a faculty member of the University of Utah's School of Medicine, I approached the curriculum committee about teaching a course to the medical students. They approved the course. While this was great news, I realized that this had not been done before, so now, I had to decide what was going to be taught. I approached a number of doctors and sources to get their ideas. After all, there are literally dozens of topics that might be incorporated. Which of these would be the most important or even essential to include? The University of Utah already had several exceptional physicians on its faculty who had done work in wilderness medicine areas such as high-altitude medicine. Their ideas formed the basis of this first medical school wilderness medicine course. It was taught in the spring of 1998. The course was an instant success, and the students loved it, primarily because so many of the principles that we taught were so very practical and useful.

But the course still lacked structure, a formal teaching and testing process, and furthermore, I felt that we had not really developed protocols for treating people in the backcountry. At this point, a number of wilderness medicine experts from across the country and military joined the program. We worked on setting up a testing process where students could learn standards and protocols. A committee was formed, and we established the Advanced Wilderness Life Support (AWLS) certification program at the University of Utah School of Medicine.

The first step was to list all of the possible subjects that a wilderness medicine certification process could teach. Then we ranked these subjects, listing at the top the most important subjects and at the bottom, the least important. For example, how important is it to teach about spelunking versus water treatment. Is it absolutely necessary to teach high altitude disease? What about children in the wilderness? It was clear to our committee at the outset which of the subjects was the most important, and the core curriculum was established.

Now we turned our attention to treatment protocols. On the surface, this seemed like a simple task as so many of protocols have been established for hospital medicine. But we quickly realized that the situation was so different in the backcountry that it would be a much larger task. For example, how are burns treated when you are days away from help? Should you close a wound using sutures or just keep it covered? Should you evacuate all patients with abdominal pain or let some remain in the backcountry? These questions and protocols are essential and took a significant amount of time and research to develop. Working as a team with medical students and rescue personal with broad knowledge treating people away from a hospital setting, we formulated backcountry medical treatment protocols.

But it did not end there. One of the earliest discoveries was that there were many misconceptions among the general public and medical professionals as to how backcountry injuries should be treated. We needed to dispel these erroneous notions. For example, many people thought that making an incision in a snakebite with a knife and trying to extract the venom from the wound was standard protocol. Actually, there are no effective methods for treating snakebites in the wilderness and it is crucial to evacuate the patient to a hospital as soon as possible. Incredibly, we found that everyone had a different method for removing a tick – almost all of which are ineffective. The most effective method was to simply pull the tick straight off from the victim.

Appropriate evacuation was another issue that we needed to work on. Evacuation is often dangerous, costly, and difficult, and if someone does not need to be taken for definitive care, then it should not be risked. However, there were no guidelines to follow. So, in 2001 several enterprising medical students began a literature search, spoke with numerous specialists, and developed the first guidelines to help backcountry medical providers decide if a patient needed to be evacuated.

Another early concern was what to include in a first aid kit. We developed an algorithm to help people determine what first aid kits would be best depending upon the number of people, the length of the trip, as well as the location of the adventure. It is now the industry standard.

With all of this done, it became necessary to formalize all of this in a textbook format. This was no easy task. Dozens of experts from multiple fields and expertise were employed to write, edit, and

review chapters in this new text. Then these needed to be reviewed again for consistency and accuracy. Illustrations needed to be created. After many months of lengthy work, the AWLS textbook was created and published. Today AWLS has achieved international certification status for medical professionals studying wilderness medicine. The protocols and guidelines that have been developed are considered the standard of care in backcountry medicine. Since its inception, thousands of medical students and medical professionals in all parts of the world have certified with the AWLS program.

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Chapter 1: The Assessment of a Patient in the Wilderness

The management of someone injured or sick in the wilderness is probably the most important topic in all of wilderness medicine. Imagine that you are enjoying a back-country jog and you see another runner fall hard. When you get to her, she is clearly confused and incoherent. You note a bruise on her forehead and her lower leg is bleeding profusely from a deep gash. There is already quite a bit of blood. In this situation, what should you do first? What medical issues are the most important? There are **four effective survey techniques** that are strongly recommended to use in your initial assessment of a sick or injured person in the wilderness. These four survey techniques are: scene survey, primary survey, secondary survey, and ongoing survey.

SURVEY TECHNIQUES

Scene Survey

The first survey technique is the scene survey. When you first approach a scene, the tendency is to approach the patient immediately and start rendering aid. Don't. You must first make sure that the scene is safe before you enter to assess the victim. Don't put yourself in harm's way and potentially become a victim yourself. Look around and consider physical dangers such as snow, ice, rocks, fire, and animals. Other potential hazards include bikers on single track, climbers above, or hunters shooting guns. The adage, "Don't just do something, stand there!", is true. Making sure that the scene is safe is critical before entering to assess a victim.

Once you've determined the scene is safe to enter, you need to determine how many people have been injured and how they were injured. This survey should take only a few moments. This can effectively be performed by discovering the mechanism of injury (MOI) and the nature of the illness (NOI). If victims are conscious, ask them if there were others involved, as other victims may have fallen behind a bush or been swept downstream.

Primary Survey

The second survey technique is the primary survey. The purpose of the primary survey is to keep the victim alive. To help prioritize the treatment of injuries during the primary survey, refer to the table below which uses the **MARCH** acronym. It's important to note that preventing major hemorrhage is the top priority, even coming before Airway.

If the patient is awake and alert, you should ask the patient if she/he would like your help. It is good practice that before you start treating a responsive patient you should identify yourself and ask if they want help. This helps protect you legally and gives the patient the opportunity to refuse

care. If the patient is not able to clearly communicate their consent for treatment, then the consent is implied.

Primary Survey prioritization using MARCH

M	Massive hemorrhage
A	Airway (with C-spine precautions)
R	Respiration
C	Circulation
H	Hypothermia/Hyperthermia or Hike vs. Helicopter

In the Intro scenario above, the fallen runner was bleeding profusely. Anytime there is major bleeding you should always take steps to stop the bleeding first. Typically, direct pressure is done to stop heavy bleeding. In the wilderness, however, don't hesitate to use a tourniquet. It is a fast and simple method to stop a major bleed.

If a victim is unresponsive, assume there is a C-spine injury even if there is no clear mechanism. Therefore, for Airway, you should hold the C-spine as a precaution during your primary assessment. If the patient becomes responsive later, you can re-evaluate the need to hold C-spine.

Next, you can quickly check for a victim's Respiration before evaluating their pulse. Checking the pulse falls under Circulation when using MARCH. Hypothermia/Hyperthermia refers to making sure that the patient is warm and dry and whether or not the patient will need to be evacuated or not (thus the alternative of Hike vs. Helicopter). Using the MARCH prioritization as you quickly go through the primary survey ensures your patient is alive and as stable as possible. Learn it well.

Secondary Survey

The third survey technique is the secondary survey. This survey is done after the Primary survey and can be remembered using the **SAMPLE** acronym.

Secondary Survey using SAMPLE

S	Symptoms/Subjective
A	Allergies
M	Medicine
P	Prior medical history
L	Last oral intake
E	Events leading up to illness/injury

Address these items to the victim as questions and pay close attention to what they say. If they cannot answer, ask if family, friends, or people at the scene might be able to help with some or all of the questions. As well, you can look for medical alert tags and bracelets on the victim. Check backpacks, purses and wallets for medical information too.

Ongoing Survey

The fourth survey technique is the ongoing survey. You should repeat this survey as often as needed. If the patient is unstable, go through the survey more frequently. Until the patient is in the hands of medical help you should keep assessing them with the Ongoing survey.

If at any time there is a change in the patient's status you should always go back and repeat the primary assessment. This is essential to determine what caused the change in the patient's medical status.

Ongoing Survey using AVPU

A	Alert
V	Verbal
P	Pain
U	Unresponsive

Summary of Surveys

These are the four effective survey techniques recommended to use in your initial assessment of a sick or injured person in the wilderness. However, there are often other issues that present themselves and may need to be addressed during these four survey techniques. The victim may have an altered mental state, or be in a significant amount of pain. They may be unconsciousness and remain that way. They may have nearly drowned or have fallen from a cliff. Let's explore these types of issues and how you would assess a victim in these situations.

OTHER ISSUES

Altered Mental Status

There are many reasons that can lead to an altered mental status, and often there can be multiple causes for one patient. A well-known pneumonic to use is **AEIOU Tips**. There are some minor, but important additions for its use in wilderness medicine.

Start at the top of this list and work your way down to come up with a differential of potential causes for a victim's mental status. Victims with an altered mental status, or who are unresponsive, can be some of the most challenging patients to care for. Remember, you should check for medical alert tags which may be around the neck, wrist, ankle or even tattooed on the skin. They also might have information in a pocket, in their gear, or wallet/cell phone

Altered Mental Status Checklist using AEIOUTIPS

A	Allergies/Altitude
E	Environment/Epilepsy
I	Infection
O	Overdose
U	Underdose
T	Trauma, toxins
I	Insulin (diabetes)
P	Psychological disorders
S	Stroke

Pain

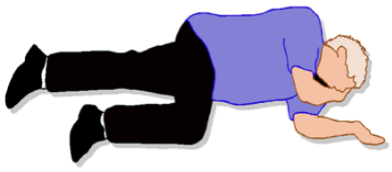
Pain is often a common presenting sign in a victim. Understanding the caliber of someone's pain may well be the key to a diagnosis of what is causing it. The acronym, COLDERR, is used to characterize a victim's pain.

Pain checklist using COLDERR

C	Character
O	Onset
L	Location
D	Duration
E	Exacerbation
R	Relief
R	Radiation

Recovery Position

Another situation you may encounter is that of an injured and unconscious victim. If you are alone, you may realize that your only option is to leave the victim and go get help. Before you go, put the victim on their side in the recovery position. This helps keep the airway open and prevents them from aspirating if they vomit.



Airway is assessed with C-spine in the MARCH acronym. The victim is on their side with the top arm forward and the top leg forward. This position will help keep the patient from rolling onto their back. You don't want the patient on their back as they are at risk of aspirating if they vomit and their airway may not stay open.

Drowning

After performing a scene survey, if you pull someone from the water and suspect drowning, what should you do? Your thought might be to conduct the Primary survey, using the acronym MARCH. However, in the case of a potential drowning victim, they need air in their lungs quickly. Therefore, you should perform rescue breaths if the patient has a pulse. Since there is no massive hemorrhage, airway and respirations are the next steps for the primary assessment.

A submersion injury is a special case where oxygen becomes an important part of giving CPR, as drowning victims will often have a depletion of oxygen. Therefore, start with two-rescue breaths. Once the patient is breathing on their own, you would finish the primary assessment. If they don't have a pulse, then you should start chest compressions. Chest compressions only, or "hands-only CPR," is an option for lay rescuers in urban settings. However, in a submersion injury, patients usually need oxygen, and CPR with breaths becomes very important. Maneuvers to remove water from the airway is unnecessary and is potentially dangerous.

Scene Safety

In a case where the scene is not safe for the victim, you may need to move them to a safe location. For example, consider a situation where a person falls a short distance off of a rock-climbing cliff. This fallen person is now below the cliff, and other people are still climbing with the potential to dislodge loose rocks. These falling rocks could be a danger to the victim lying below. Should you move the patient to a safer location and risk causing a potential spinal injury? Clearly, the scene is not safe. You need to move the injured person away from the base of the cliff. If you started treating the victim here, you would be subjecting the victim, yourself and other rescuers to additional injury.

When considering scene safety, it is important to keep in mind the risk-to-benefit ratio. Moving the victim(s) may result in spinal injury but keeping them at the base of the cliff could result in more injury or even death if there is more rockfall. In this case, the risk of rockfall outweighs the risk of spinal injury in moving the patient. Be careful of the spine!

Blood Sweep

In the example above where someone has fallen from a cliff, they could easily have cuts on their skin. A quick look will determine if they are bleeding. This is known as the blood sweep and allows you to identify any major bleeding. It's important to look under layers of clothing when doing your sweep, as blood can collect between these layers, especially if the clothing is waterproof. It's recommended to perform the sweep in small segments to determine where the blood is coming from.

The blood sweep also allows you to find deformities in the musculoskeletal system. An injured patient might not have cuts on their skin, but may have internal injuries. The body can bleed out in several internal cavities within the human body. The chest, abdomen, the space behind the kidney,

and the thigh are all big enough areas where a person can bleed to death. To help you remember these internal areas, use the **CARTS** pneumonic.

Blood sweep checklist using CARTS

C	Chest
A	Abdomen
R	Renal
T	Thigh
S	Skin/street

There is often little you can do if someone is bleeding to death inside their body, other than evacuate them very quickly. At least you will know to do this. Remember also, that people will often bleed on the 'street' or they will bleed in one place and then stumble to another place. Be sure to look on the ground or the street for blood.

Wound Irrigation

If the patient's wound need to be treated, irrigation can be very messy, even when done correctly. Even if you are irrigating away from yourself, the liquid can still splash backward. Protect yourself with proper Body Substance Isolation (BSI) any time you are treating a patient. You might need to improvise BSI in the wilderness. You should cover yourself with waterproof clothing, even if you borrow the patient's gear. Using the waterproof clothing ensures that your gear does not become contaminated. If you are in a situation where the patient will be at risk of hypothermia without their waterproof layer, you can use your own jacket. It is better to use the patient's gear, so your own clothing does not become contaminated with blood. You can also use a different piece of the patient's gear (such as their backpack) to create a shield.

Exposure

You should always look under the patient's clothes for additional injuries. However, proper exposure is a double-edged sword in the wilderness. It's important to check the whole body for any hidden injuries, but it's also important to ensure that the patient stays protected from the environment. Avoid damaging the patient's clothes, which are a valuable resource when it's cold outside. In fact, cutting off the patient's clothes for better exposure could be a waste of resources. If the patient recovers after rewarming, they would be unable to walk out because they would have no clothes. While it's important to start the rewarming process, it is vital to first examine the patient for any injuries.

Medical Documentation

Medical documentation is an essential part in caring for a patient. The most common method for creating a document is to use the acronym SOAP. A SOAP note is considered a standard in medical documentation.

Medical documentation using SOAP

S	Subjective
O	Objective
A	Assessment
P	Plan

Be prepared to give a verbal presentation when the patient is handed off to medical personnel. The verbal presentation should be structured the same way as a SOAP note. The SOAP note and verbal presentation should start with demographic information on the patient. This would be followed with the patient's chief complaint or chief injury (subjective). You would then briefly state what you found on your exam (objective) including patient vitals, followed by a list of injuries or medical problems you found, and the treatments performed (assessment and plan).

Chapter 2: The Management of Wounds in the Wilderness

Wound management in the wilderness backcountry is different than wound management in an urban setting. One significant difference is that backcountry wounds are often dirty or may become dirty. There's often a lack of first aid material too. A single abrasion wound may use up all the gauze pads in your entire kit, leaving nothing for other injuries. You may not have the appropriate first aid material for closing a wound, such as sutures or steri-strips. And, if the injury happens at night, seeing the wound could be difficult without proper lighting. The following addresses these types of issues in managing wounds in the wilderness.

TYPES OF ISSUES IN WILDERNESS WOUND MANAGEMENT

Exposure

The first step to any wound management after the primary survey is to have exposure to the injured area. Direct visualization is needed to create a treatment plan. You may have to first remove equipment from the patient, such as a backpack, helmet, or gloves. You may need to cut or tear open the patient's clothing near the affected area(s). Be mindful of exposing only what is necessary, as hypothermia can occur even in mild climates.

Hemostasis

The next step is to stop the bleeding. This is called hemostasis. If the wound is such that a person is going to bleed out, this becomes emergent and is first in the primary survey using the MARCH protocol, where 'M' stands for massive hemorrhage. Direct pressure is the first step in stopping any blood loss. The application of direct pressure controls bleeding from most wounds. Use the cleanest materials available and apply direct pressure to the source of bleeding. This may take several minutes. Larger wounds may require direct pressure for a longer period. Scalp wounds may require continuous, direct pressure for 30 to 60 minutes in order to achieve hemostasis.

If direct pressure does not stop the bleeding, use a tourniquet. Rapid arterial bleed can cause a patient to go into shock very quickly. It is vital to recognize a severe arterial bleed that requires a tourniquet which will quickly and efficiently control the bleeding. If a tourniquet is used for more than several hours, it places the patient at risk for limb loss. Elevation of the limb above the heart alone is rarely sufficient enough to stop bleeding. You should always check for distal neurological function to ensure adequate blood flow to the extremity.

How to Place a Tourniquet

- Place the tourniquet over clothing if possible, about two to four inches above the wound.
- Do not place the tourniquet on a joint or directly over a wound or a fracture.
- Once the tourniquet is in place, it should be tightened so that all bleeding stops. Secure the windlass so that it does not unwind.

- Mark the time that you placed the tourniquet on the patient's forehead, so it is rapidly visible to other personnel when the care for the victim.
- There is no need to intermittently loosen a tourniquet for "perfusion" of an extremity.

Cleaning/Debridement

All wounds need to be cleaned. "High-pressure" irrigation is the most important intervention to prevent infection and decrease bacteria content for most wounds. A wound should not be closed by any means prior to proper irrigation and decontamination. Leaving the wound to dry and scab over has the potential to form a larger scar and become infected over time.

Irrigate the wound with a solid stream of the cleanest water available. Tap water has been shown to be as effective as sterile saline. You can use a syringe with a catheter tip to create a high-pressure stream of water, or you can fill a plastic bag filled with water. Poke a small hole in the corner of the bag, and then close the top of the bag to create a seal in order to force a stream of high-pressure water from the bag. An alternative would be to use your plastic water bottle that has an adjustable top. Rinse the wound forcefully with the water, protecting your skin and eyes from fluid splashes. If a splash shield is not available, a 4x4 gauze pad can be taped at the opening of the irrigation system.

It is important to remove visible foreign matter from the wound to minimize infection, inflammation, discomfort, and skin tattooing. If possible, remove any clearly devitalized tissue, which may serve as a culture medium for any remaining bacteria. Debridement should be followed with another round of high-pressure irrigation and reexamination.

Dressing a Wound

Dressing a wound is difficult in the wilderness but very important. It protects wounds from the dirty wilderness environment, helps with the prevention of infection, and can be accomplished in a number of ways. If a commercial pad or dressing is not available, improvise using a 4 x 4 pad covered in an antibiotic ointment. Cover this dressing with an absorbent gauze dressing, then secure with tape. If the injury is on a flexible part of the body you might want to immobilize the joint using a splint to prevent the wound from reopening.

Topical antibiotics are appropriate for all skin wounds in the wilderness. Bacitracin is a good choice. Neomycin is less ideal because it is associated with allergic reactions. A great topical ointment is honey. The osmolarity and bacteriostatic compounds in unprocessed honey make it an extremely effective, inexpensive and readily available alternative for topical application. Oral antibiotics is still a debated subject. Adequate cleansing and protection from the environment are

much more important factors in prevention of infection. If it is a complex or mutilating wound or grossly contaminated with a lot of debris, oral antibiotics would be given. Some animal bites require antibiotics as well. Any wounds with signs of infection should receive antibiotics. These signs include pain, redness, swelling, or purulent discharge. If you suspect a wound is infected, you should always apply a new dressing and consider evacuation.

When to Evacuate a Wound

The injuries that requires considerations for evacuations are:

- Complex or mutilating wounds
- Grossly contaminated with penetrating debris
- Laceration of eye lid, ear or cartilage
- Penetration of bone, joint or tendon
- Bites of hands, legs or feet
- Amputations

Scabs

Contrary to popular belief on letting a wound scab over, recent studies have shown that keeping the wound environment moist promotes wound healing and reduces scar formation. This can be done with daily application of Vaseline, honey, or a clean moist dressing. When wounds are kept exposed to the air, they will dry and form a scab.

Scabs slow the wound healing process. The purpose of the scab is to protect the wound from environmental contamination. A scab forms a barrier to the generation of new tissue. Studies have shown that, under the influence of scabbing, the regenerative wound healing processes take more time and thus increases the risk of scarring and infection.

Wounds should be kept moist for the entire duration of healing. Grass doesn't grow well under a rock, and skin cells do not grow well under a scab. Keeping the wound open and dry slows wound healing and promotes scar formation. The wound should be rinsed daily to keep scab formation to a minimum. Dressing inspection and dressing changes should happen daily, if possible.

Closing a Laceration

Closing a laceration in the wilderness is difficult. The decision to close a wound is broken down to two courses of action:

1. Primary closure: You can close it with sutures, staples, tape, or skin glue.

2. Delayed primary closure: You can pack it with gauze, wrap it and clean it often until you can get to definitive care.

Closing the wound with sutures, staples, tape, or tissue adhesive has the advantage of immediate treatment with better mobility and less pain. However, the risk of infection is higher. If you decide to pack the wound, the infection rate will be less, but it is more painful, and the patient will have less function of the area. There's also the consideration that only one of the two action plans may be suitable or even available given the situation. Interestingly, there is no improved outcome of primary closure versus delayed primary closure.

Steri-strips or tape: Closure may be simply achieved by placing steri-strips or tape of some kind over the wound and pulling the wound together. If necessary, trim the hair around the edges of the wound so the tape will adhere better. Duct tape with perforations made with a safety pin may suffice. The holes should be made from the sticky side pushed out towards the non-sticky side so that it will allow better drainage of fluid from the wound.

Sutures and staples: These can both be used effectively if continued cleanliness of the wound can be assured and are more appropriate for large wounds and those in high-tension areas. Staples can be used anywhere except the face.

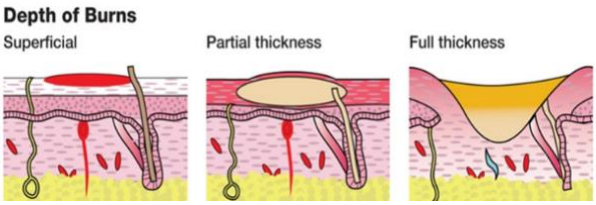
Tissue adhesives: Skin glue can be used for closing small and uncomplicated lacerations. The glue is applied on top of the wound and serves as a bandage to close the wound. They are used in low tension areas. They are good because they produce an impenetrable barrier that requires a thoroughly cleansed wound.

If an injury is on a flexible part of the body, such as an elbow or a finger, immobilize the joint with a splint to prevent reopening of the wound. Do not take aspirin. Taking aspirin with an open wound may worsen bleeding. One should not close a wound in the wilderness to aid in hemorrhage control. It can lead to an increased infection rate. The one exception is scalp injury. The increased vascularity of the scalp can make bleeding control more difficult. At the same time, the increased vascularity makes the scalp and face one of the body areas least prone to infection. Animal bites to hands, leg, and feet require medical attention in a clinic or hospital. There is an elevated risk of infection, and antibiotic prescription is often needed. The patient might also need a tetanus booster and a rabies vaccination.

Burns

Burn injuries are common in the wilderness, where many sources of heat are used. Before initiating treatment, a burn must first be classified, as its classification determines how it is treated. Burns are classified three ways:

- by depth
- by area
- location on the body



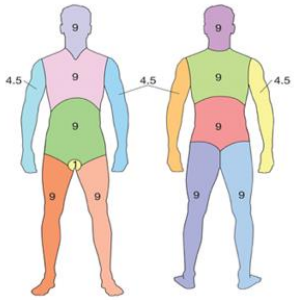
In superficial burns, the skin can become red and painful. Mild sunburns are a type of superficial burn. Partial-thickness burns are generally very painful as the burn depth is at the level of the nerve endings. They blister and can have skin discoloration. Full-thickness burns are deep and are classically painless. They burn through the dermis.

Treatment of Superficial Burns

Treat superficial burns with aloe-vera gel and for comfort, cool the area with damp, wet cloths. Aloe vera has no antimicrobial properties, however. Leaving the wound to dry increases scar formation and slows wound healing, so keep the burn moist. It is essential to avoid further exposure to heat and sunlight. Patients with these types of burns might be able to stay in the backcountry if the pain is controlled.

Treatment of Partial and Full Thickness Burns
Partial and full-thickness burns are more serious and will be painful. Gently clean the burn with cool water to remove loose skin and debris and trim away all loose skin. Apply a thin layer of antibacterial Ointment (i.e. Silvadene) to the burn and cover it with a non-adhesive, sterile dressing. Inspect the wound and change the dressing at least once a day. These might be too painful to keep in the backcountry. Do not apply ice directly to burns for more than 15 minutes, as this may cause more tissue damage due to a decreased blood supply to the area.

Know the **TBSA** (Total Body Surface Area) for burns to aid in decision making for evacuation.



The Rule of Nines	
Each arm	9%
Each leg	18%
Front of trunk	18%
Back of Trunk	18%
Head and Neck	9%
Groin	1%

When to Evacuate a Burn
Burn injuries that require evacuation consideration are:

- Partial thickness burns greater than 10% body surface area
- Full thickness burns greater than 1% body surface area
- Partial- or full-thickness burns involving the face, hands, feet or genitals
- Electrical burns
- If the burn victim is medically ill
- Uncontrolled pain
- Burns complicated by smoke or heat inhalation (evidence of smoke inhalation include difficulty breathing, hoarse voice, singed nasal hairs, or carbon in patient's sputum)

Blisters
A blister is a pocket of fluid between the upper layers of skin and are common to develop in the wilderness. The most common causes of blisters are friction (i.e. from poor fitting shoes), freezing of the skin (frostbite), and burns.

The blister bubble is formed from the epidermis, the uppermost layer of skin. Its purpose is to protect and cushion the layers underneath. Blisters can be filled with serum, plasma, blood, or pus, depending on how and where they are formed. Friction blisters usually form a 'hot spot' (sore spot) first.

If a small blister or hot spot forms, place a dual-layer pad over that area. Blist-o-ban is one such material. These pads address the two causes of friction blisters, the friction and shear forces on the skin. The dual-layer will allow the bandage to glide smoothly in all directions, deflecting friction and shear forces away from the skin. The key to preventing blisters is to reduce 'hot spots' by properly breaking in boots and reducing moisture by wearing wool socks.

You can treat a blister that has already formed, by cutting a hole in the moleskin and placing the ring of moleskin around the blister. This reduces the pressure placed on the blister. This should help reduce the pain. It is not recommended to pop or drain blisters that are small (<2cm or <0.75 in).

When should a blister be opened? The answer is not clear. In general, if the blister is 2 cm in diameter or larger, then it is likely to rupture spontaneously and may be amenable to initial treatment by intentionally rupturing it. However, there is no best answer to this issue. In those cases where it is large enough or it has already ruptured, wash the area and puncture the base of the blister with a sterile needle or sterilized safety pin. Debride the external flap of skin from the blister, apply an antibiotic ointment, and cover the blister with a sterile dressing. This can be protected with moleskin or mole foam. Hydrocolloid dressings have increased in popularity, also providing protection and comfort.

Amputated Digits

An amputated digit should be transported promptly. It should never be placed directly on ice, nor should an attempt be made to reattach the finger in the wilderness. Placing an amputated finger in milk has no benefit. (Placing tooth in milk is good to preserve it.)

Penetrating Objects

Never try to pull a penetrating object out of the patient in the field. Use gauze or similar material, alone or with a bulky dressing, to stabilize the object as best you can and evacuate as soon as possible. Removal of the object in the field may cause additional damage and/or cause bleeding and result in serious harm to the patient. Although the surface of a puncture wound should be cleaned to facilitate examination, puncture wounds themselves should generally not be irrigated, as this may further push in contamination. The wound should be dressed without closure. Puncture wounds should be evaluated more frequently than simple lacerations, as they are associated with a high risk of infection.

What Ointment should be used on a Wound?

Honey has been used in wound care for thousands of years to prevent infection and speed the healing process. **Medihoney** works by keeping the wound bed moist and slow-releasing an antibacterial agent into the wound site. Most normal honey has varying levels of hydrogen peroxide, but Medihoney specifically uses **Manuka honey**, which also contains methylglyoxal. This helps it to fight a broader range of bacteria strains.

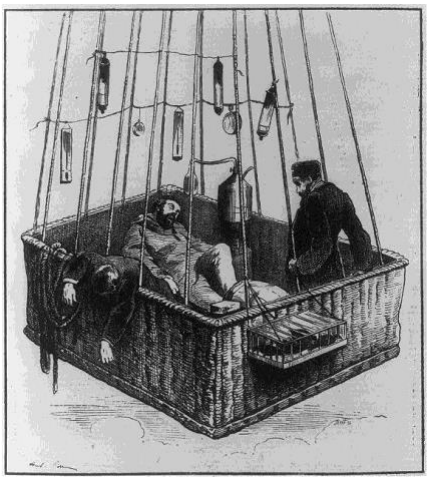
Lodosorb is an advanced wound care gel used to treat open wounds, stalled wounds, and infected wounds. The gel design provides an excellent wound healing environment while slowly releasing antibacterial iodine into the wound bed. Iodine concentrations at the wound site suppress bacterial

populations, including antibiotic-resistant strains like MRSA, while leaving the body's cells unaffected.

Topical First Aid Antibiotics are available over the counter. These include **bacitracin**, **neomycin**, and **polymyxin B sulfate**. Some also contain the anesthetic lidocaine for pain relief. These products are well tested. There is a large allergic reaction rate to neomycin, so clinics are moving away from this. Make sure someone is not allergic to sulfa, as bacitracin is sulfa based.

Silvadene Cream 1% (silver sulfadiazine) is a topical antimicrobial drug indicated as an adjunct for the prevention and treatment of wounds and in patients with second- and third-degree burns. It contains both silver as antimicrobials, but it also contains emollients that help ease the pain.

Chapter 3: Altitude Illness



What would happen to you if you were taken immediately to the summit of Mt. Everest? The answer is you would pass out, and likely die within minutes. A similar scenario occurred in the balloon flight of the 'Zenith' in 1875. At that time, ballooning had progressed to where high altitudes were obtained, and scientists were going to dizzying heights to discover the effects of 'thin' air. Three French scientists wanted to go higher than anyone had before. When they reached the 'death zone' of about 27,000 feet (8,200 meters), they passed out. One of the scientists awoke to find the other two were dead. The Zenith crashed to the earth outside of Ciron, France. The two men had died of altitude illness.

WHAT IS ALTITUDE ILLNESS?

Most people are unaware that ascending to altitude includes an inherent risk of becoming ill and even dying. There are many tragic stories of people dying on the mountain just because they were high in elevation. About 100 years after the flight of the Zenith, in 1978, Messner and Habler ascended Mt Everest without oxygen. They went as high as the Zenith, yet, they survived. The difference is that they allowed time for their bodies to acclimate.

The problem is not a lack of oxygen at altitude, as the oxygen content of the atmosphere is stable up to 10,000m+ (32,800 ft). The issue is that the partial pressure of oxygen decreases logarithmically as altitude increases, which causes hypobaric hypoxia. This is the reverse effect of diving, where the partial pressure of oxygen increases dramatically. Altitude illness is extremely rare at elevations below 2,000m (6,500 ft).

Alveolar Gas Equation

The first thing that happens to a person when exposed to hypobaric hypoxia is an increase in their respiratory rate. The body does this to improve oxygenation. This is explained by the effects of the alveolar gas equation:

$$PaO_2 = PiO_2 - PaCO_2/RER$$

In the formula above, PaO_2 is the arterial oxygen pressure, PiO_2 is the partial pressure inspired oxygen, and RER (Respiratory Exchange Ratio) is a constant and is approximately 0.8 to 1. In the example below, we'll use RER constant = 1.

To show an example at higher altitudes, and using the RER constant equal to 1, the general principle is that for every 1 mm of CO_2 we exhale and removed from our blood, another 1 mm of O_2 can be held in our blood.

Normally, at sea level, $PaCO_2$ is around 40 torr. This is acceptable because PiO_2 is roughly 150 torr, which gives us a PaO_2 of about 75 (RER here is 0.8). However, the measured PiO_2 on the summit of Mt. Everest is only 43, so we need to drastically lower the $PaCO_2$ by hyperventilating. Otherwise, we'd never get any oxygen into our blood. We hyperventilate to reduce our $PaCO_2$ down to around 10. This allows our PaO_2 (retention of oxygen in our blood) to stay up around 30, which is survivable (43-10=33). The respiratory rate at the top of Mt Everest is 50 to 60 times per minute.

In simple terms, we need the pressure to push oxygen into our bloodstream. If there is not enough pressure when a person is at altitude, then the body will reduce the pressure inside the vessels by lowering the levels of carbon dioxide, by hyperventilating. Unfortunately, hyperventilating removes the CO_2 that drives us to breath and eventually makes us alkalotic enough that we decrease our breathing. To allow us to continue hyperventilating our kidneys secrete bicarbonate, causing people to urinate more at altitude.

Swelling

The most severe symptoms of altitude sickness arise from edema, or fluid accumulation, in the body. This can occur anywhere, including the tissues under the skin. The most severe consequences of this swelling happen in the brain and the lungs.

At very high altitude, swelling in the brain is called acute mountain illness (**AMS**), which progresses as the edema increases to be called high altitude cerebral edema (**HACE**). As edema forms in the lungs, it is called high altitude pulmonary edema (**HAPE**).

The physiological cause of altitude-induced edema is not conclusively established. It is currently believed, however, that **HACE** is caused by local vasodilation of cerebral blood vessels in response to hypoxia, resulting in higher blood flow and, consequently, more significant capillary pressures. On the other hand, **HAPE** may be due to general vasoconstriction in the pulmonary circulation (usually a response to regional ventilation-perfusion mismatches), which, with constant or increased cardiac output, also leads to increases in capillary pressures.

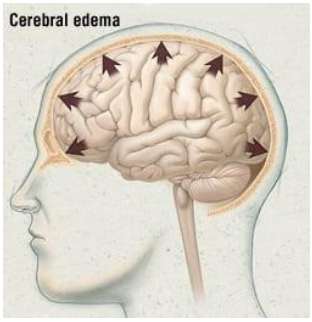
Acute Mountain Sickness

Medical history is the key to diagnosing Acute Mountain Sickness (**AMS**) because there are no specific physical exam findings. It is vital to assess the rate of ascent and the total elevation gain. AMS is a common illness that may occur in 10% – 70% of individuals, depending primarily on the rate of ascent. The Lake Louis Consensus criteria is a standardized international symptom set that determines the diagnosis of AMS. It is diagnosed in the setting of a recent gain in altitude with the presence of a headache, and at least one of the following symptoms:

- Dizziness or lightheadedness
- Fatigue or weakness
- Nausea/vomiting/anorexia
- Insomnia

The most significant risk factors for AMS are a prior history of AMS, fast or high ascents, and obesity. Men and women and children are equally susceptible.

High Altitude Cerebral Edema (HACE)

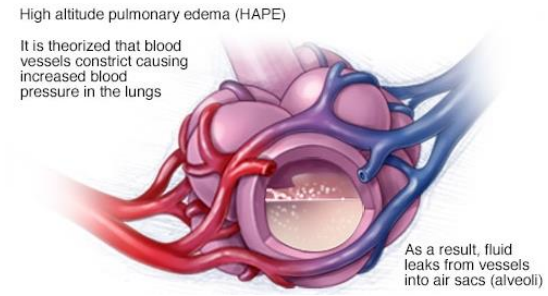


As edema in the brain increases, symptoms become more profound, and AMS progresses to HACE, a life-threatening disease. HACE is defined as severe AMS symptoms with additional apparent neurologic dysfunction:

- Ataxia: this is the most common presenting sign of HACE
- Altered level of consciousness
- Severe lassitude

While the boundary between AMS and HACE can be blurry, HACE almost never occurs without AMS symptoms first. The progression of AMS to coma typically occurs over 1 – 3 days. HACE and HAPE are often present simultaneously.

High Altitude Pulmonary Edema



HAPE usually evolves over two to four days after ascent to altitude. The Lake Louis consensus criteria for HAPE diagnosis are symptoms of at least two of the following.

- Dyspnea at rest
- Cough
- Weakness or decreased exercise performance
- Chest tightness or congestion

The Lake Louis consensus criteria for HAPE diagnosis are signs of at least two of the following.

- Crackles or wheezing in at least one lung field
- Central cyanosis
- Tachypnea
- Tachycardia

The primary symptoms are dyspnea at rest, cough, and exercise intolerance. The initial sign will often be a marked decrease in exercise tolerance in an individual as compared to previous days. Occasionally, frothy pink sputum is produced, but this is usually later in the illness. Neurological symptoms may be seen with concomitant HACE. Hypoxemia and respiratory alkalosis are universally present. Mild cases may resolve within hours after a descent. In contrast, severe cases may progress to death within 24 hours, particularly if descent is delayed.

Prevention

Graded ascent is the safest method to facilitate acclimatization and to prevent any altitude illness. Current recommendations for climbers without experience at high altitude are to spend two to three nights at 2500 – 3000 meters before a further ascent. Increases of greater than 600 meters in sleeping altitude should be avoided. One should consider an extra night of acclimatization for every 300 – 900 meters of altitude gain. Medicines can help but are no substitute for a gradual ascent.

AMS/HACE

Taking acetazolamide, 125 mg twice daily, starting 1 – 2 days before ascending, is effective for AMS prophylaxis. It works by increasing the respiratory rate. Since, during a hike, people are already breathing fast, its effects are felt mostly at night during sleep. There is mixed evidence to suggest that gingko biloba, 120 mg twice daily, starting five days prior to ascent, may be helpful in preventing acute mountain sickness. However, it cannot reliably be counted on to be of benefit and thus is no longer recommended. Ibuprofen has been shown to treat and prevent high altitude headache effectively. It remains unclear if it actually has an effect on preventing AMS.

HAPE

Prophylaxis against HAPE should be reserved only for those with previous episodes of HAPE. Nifedipine slow release, 20 mg every 8 hours, has been shown to be effective for prophylaxis in these individuals. Salmeterol has also shown to be effective in reducing the risk of HAPE in those known to be susceptible to recurrent episodes. Phosphodiesterase inhibitors, tadalafil, and sildenafil have also been shown to be effective in decreasing the risk of HAPE in those at risk, though Nifedipine remains the gold standard. HAPE susceptible individuals should limit the ascent rate to no more than 350 meters (1155 ft) a day.

Treatment

AMS

The treatment for acute mountain sickness (AMS) is to discontinue ascent and rest. Take acetazolamide, 250 mg twice daily, until symptom-free. Acetazolamide is the treatment of choice for the prevention and treatment of AMS. as it facilitates acclimatization. It is a carbonic anhydrase inhibitor. This causes the kidneys to secrete bicarbonate, resulting in diuresis and metabolic acidosis with compensatory hyperventilation. It is a sulfa-based medicine, so it should not be given to those with a history of anaphylaxis to sulfa. The descent is the definitive treatment.

HACE

The treatment for HACE is IMMEDIATE descent (almost always with assistance). This is imperative and should not be delayed. Even modest elevation losses can be helpful. In addition to descent, administering dexamethasone should be given immediately. Acetazolamide should be given if the victim is able to tolerate oral medications. If descent is not possible, place the victim in a portable hyperbaric chamber if there is one. Recovery with prolonged problems, especially ataxia, can last for weeks. Most who survive eventually fully recover neurologically.

HAPE

The treatment for HAPE is IMMEDIATE descent. All that may be required is 500 to 1000 meters of descent before improvement is observed. The patient should rest after a descent. No intervention should delay an opportunity to descend.

Evacuation Guidelines

With all altitude-related illnesses, the definitive treatment is always descent. However, the descent is not the same as evacuation. In select circumstances, victims with altitude-related illnesses can descend for some time while their bodies acclimatize before re-ascending.

Victims with AMS do not necessarily need to be evacuated. Rest at the current altitude, and medical interventions, such as acetazolamide and dexamethasone, may be sufficient for complete recovery within 24 to 48 hours. Extreme caution should be used if the victim is to continue to ascend because symptoms can progress to HACE. Victims should be symptom-free for at least 24 hours after steroid use before proceeding to ascend again.

Victims with HACE should be evacuated after a descent. While full neurologic recovery is likely if they survive, sequelae such as ataxia can persist for weeks. For this reason, victims with HACE are not safe to attempt to re-ascent on the current expedition.

Victims with HAPE should be evacuated. Death from HAPE can proceed rapidly, so descent followed by evacuation should not be delayed. Some climbers with mild HAPE (characterized by dry cough, and mild tachypnea at rest) may be reluctant to abort an expedition, as these trips usually represent thousands of dollars of investment. However, the need to descend is imperative.

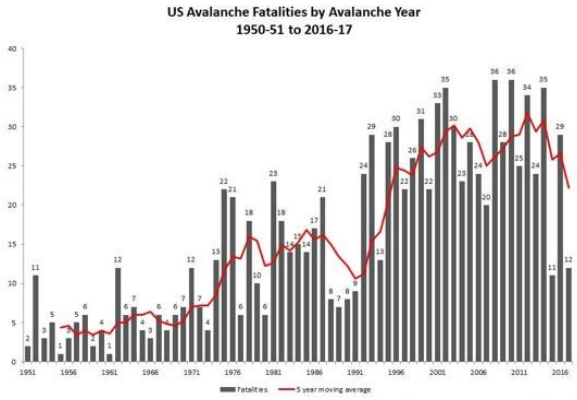
Chapter 4: Avalanche

This chapter outlines important medical concepts related to avalanches but does not cover all aspects of avalanche safety. To be truly safe from an avalanche, a person needs to take an avalanche safety course. To understand avalanches is one of the more critical topics in wilderness medicine, if not for any other reason in that injury and death rates are rising.

AVALANCHE FACTS

Most avalanches occur spontaneously during storms under an increased load due to the additional snowfall. The second-largest cause of natural avalanches is metamorphic changes in the snowpack, such as melting due to solar radiation. Other natural causes include rain, earthquakes, rockfall, and icefall. Artificial triggers of avalanches include skiers, snowmobiles, and controlled explosive work. Contrary to popular belief, avalanches are not triggered by loud sounds. The pressure from the sound in orders of magnitude is too small to trigger an avalanche

Injury and death due to avalanches have dramatically increased over the past two decades. Sadly, human factors contribute to nearly all avalanche accidents. In the vast majority of avalanche burials, the victim, or someone in the victim's party triggered the avalanche. Snowmobiler's account for the largest group of backcountry users who are killed in avalanches.

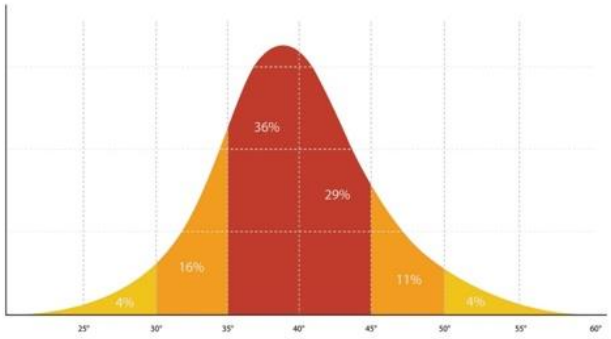


The most crucial factor in avalanche survival is the amount of time someone is buried in the snow. Asphyxiation is the predominant mechanism of death among avalanche victims. Hypothermia is a rare cause of death among avalanche victims. Avalanches can reach speeds of up to 100 mph in less than 10 seconds, so trauma is also a cause of death and injury. As many as one-third of avalanche victims sustain significant blunt trauma.

Slope Angle

Slope angle should be one of the first things that come to mind when traveling in the backcountry. It is a primary factor in every avalanche. Avalanches happen when four elements of snow are present:

1. A slab of snow
2. A weak layer of snow
3. A trigger (like new snow)



4. A slope angle steep enough for snow to slide, generally between 25-55 degrees

Not all slopes are steep enough to slide, and some are too steep to form slabs regularly. Recognizing what slopes are safe to ride and what slopes are prone to avalanching is an integral part of making safe backcountry decisions.

The best way to answer the poignant question of "can this slope slide" is to know the angles of the slopes you are riding. The most common slope angles on which avalanches typically happen is between 36-38 degrees, though it is important to note that not all avalanches start on slopes with these precise angles. If a gentle slope of 25 degrees or less is connected to a larger, steeper slope it is still possible to trigger a slide from below without ever getting on the steepest part of the slope. This is known as remote triggering and is a common way that riders get drawn into an avalanche in the backcountry, especially in avalanche run-out zones. When traveling in terrain that requires the crossing of avalanche run-out zones, it is imperative to cross one at a time and always keep a watchful eye on one another.

Avalanche Types

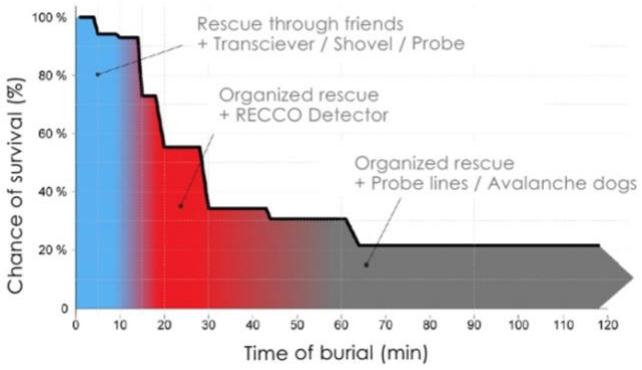
Slab avalanches are commonly triggered during, or just after, a snowstorm and cause the most injury. These are also referred to as wind, wet, or storm slab avalanches. Slab avalanches occur when two layers of snow, such as granular snow on smooth snow, do not adhere to one another. It starts as a cohesive unit (slab) of snow, which fractures from surrounding snow. Slab avalanches are comprised of a relatively stable layer of snow over a relatively weaker layer. Because these two layers are well beneath the snow surface, the danger is often invisible. Clues such as sinking, cracking, or collapsing snow should alarm you of snow layer instability.

Loose wet snow / dry snow avalanches occur anytime there are prolonged periods of elevated temperatures that warm up the snow surface. This typically happens more often in the spring. Avalanches primarily occur in the afternoon, after the sun has had time to melt several centimeters of the snow surface. These types of avalanches are slower moving but are more difficult to escape. Dry snow (powder) avalanches start as a single point and grow into a fan shape as they progress down the mountain. These are typically smaller and less destructive when compared to a slab avalanche. Dry snow slides are common to skier and snowboarders after fresh snow has fallen.

Pathophysiology

The pathophysiology of death by avalanche follows the sequence of trauma, acute airway obstruction, early asphyxia, late asphyxia, and hypothermia. Only about one-fourth of avalanche victims have massive trauma as the primary cause of death. Multiple injuries, such as spinal and long bone fractures, blunt abdominal trauma, and closed head injuries are sustained as the avalanche victim is dragged over rocks and through trees.

Air pressures under an avalanche are much higher than atmospheric pressure. This is due to the heavy nature of the snow and the snow's power. Victims find that snow is 'forced' into their airway. Whether it's inhaled or forced in, the snow will cause rapid asphyxiation if the victim is unable to clear his or her airway.



Acute airway obstruction, or acute asphyxiation, is responsible for the immediate drop in survival observed after 19 to 35 minutes of burial. If a victim can be rescued within 18 minutes, the survival rate is higher than 91%. The survival rate drops to 34% in burials between 19 and 35 minutes.

If chest movement is not restricted to the point of compromising breathing mechanics, then survival depends on the size of the air space created near the victim's face as the snow flows downhill to a stop. All air pockets will ultimately fail for two reasons: 1) Heat from the expired air causes an ice lens to form on the air-snow interface, preventing continuous gas exchange. 2) Re-breathing expired air with increased carbon dioxide (3% to 5%) and decreased oxygen (16%) content will result in hypercapnia, hypoxemia, and eventually death from asphyxiation. Avalanche victims die from trauma or asphyxiation far sooner than they die from hypothermia. And while hypothermia can significantly increase the morbidity of the victim, it is rarely the primary cause of death.

Avalanche Safety and Survival

Most injuries can be avoided by good decision making, minimizing risk by traveling wisely with good techniques, and avoiding high-risk terrain. When it comes to risk management, people behave and think differently. This is particularly true in young people, where the risk of injury from avalanche is highest.

Here are some critical rules that you are strongly urged to follow:

- When traveling on snow terrain, never go directly above any member of your party.
- Avoid terrain traps like cliffs, bodies of water, crevasses, roads where debris piles up, or valley bases within a known avalanche slide path.
- Avoid gullies and narrow valleys, as these serve as run-out zones where avalanches that start further up the mountain can funnel through, and usually burying everything at the bottom of the gully.

- Travel on ridgelines above avalanche start zones, or in dense forest, or well away from damaged vegetation.
- Travel from one safe zone to another, one person at a time. If an exposed area needs to be crossed, never expose more than one person at a time. Keep the rest of the party in a safe area so they can perform a rescue if an avalanche does occur.
- When traveling through avalanche-prone terrain, always send one person at a time and follow the same tracks.
- Be on the lookout for "red flags," such as collapsing, cracking snow, or sinking into wet snow.
- Start on low angle slopes, which are less than 25°, before venturing to steeper slopes. This gives you the opportunity to better assess snow stability before traveling on more risky slopes.
- Always call the Forest Service or Avalanche Forecast Center for a report of the current snow conditions.
- Always carry avalanche rescue equipment including at a minimum, an electronic avalanche rescue transceiver (beacon), and a shovel and probe. Practice using them.

Avalanche Victim Rescue

If an avalanche is witnessed, the survivors should make every effort to maintain sight of the victim as he/she is pushed down the slope. Once the survivors lose sight of the victim, a mental note should be made of the area where the victim was last seen using fixed landmarks such as rocks and trees.

Since more than one avalanche is possible in the same area, extreme caution should be used by the rescuers to avoid getting caught in a second avalanche. One member of the rescue party should be designated as the team leader and should stand at a safe distance away from the debris and other rescuers, and be on the lookout for potential danger.

Transceivers (beacons), shovels, and probes constitute the basis of avalanche survival and rescue equipment. Transceivers work on the assumption that an avalanche victim can be found within the "golden eighteen minutes" after burial. After 18 minutes, the chance of survival dramatically decreases. If a member of a party is buried in an avalanche, rescuers should switch their transceivers from the "send" to the "receive" mode. This will allow rescuers to pick up the signal transmitted by the victim's beacon. Using a systematic pattern, rescuers can home in on the victim's signal with their receiving transceivers. A rule of thumb is to start at the place where the victim was last seen and work "downstream," making wider and wider switchbacks as you travel down the avalanche path.

Treatment

Hypoxia and hypercarbia are significant threats to life in avalanche victims. As with any victim, primary attention should first be given to the MARCH protocol. Because major trauma is frequently

associated with avalanche burial, cervical spine precautions should be used when extricating the victim. Resuscitative efforts should continue on an asystolic victim buried more than 45 minutes if an obvious air space is identified at extrication. Continue with the secondary assessment, as previously discussed. Keep in mind the patient's exposure to the environment. Snow can be insulating, but once the victim is extracted from the snow and exposed to wind, core body cooling can accelerate if the body is not properly insulated against the environment. Any avalanche burial victim should be evacuated immediately.

Other Methods

The best way to avoid being caught in an avalanche is to not be near the trigger points for one. However, there are several devices that might increase your chance of survival if you are caught in one. Make no mistake, though, a person's primary goal is to never be in an avalanche.

Avalanche Airbags

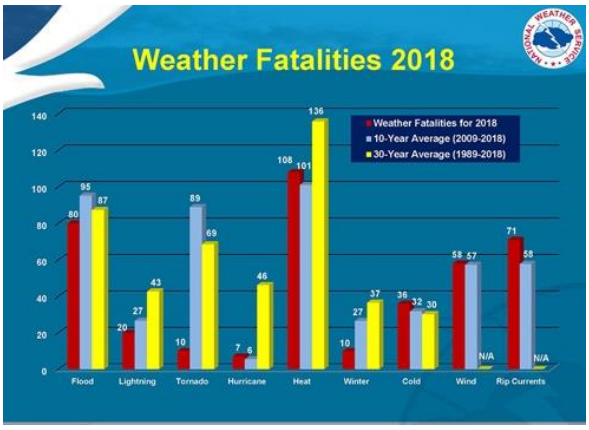
Avalanche airbags help a person avoid being buried by making the user an even larger object, relative to the moving snow, which forces the person toward the surface. Avalanche airbags work on the principle of inverse granular convection.

Avalanches, like mixed nuts and breakfast cereal, are considered granular materials and behave in a fluid-like way, where smaller particles settle to the bottom of the flow and larger particles rise to the top. Provided the airbag is deployed correctly, the chances of a complete burial are significantly reduced.

Avalung

A device called the Avalung has been introduced for use in avalanche terrain. During an avalanche burial, victims not killed by trauma usually suffer from asphyxiation, as the snow around them melts from the heat of the victim's breath and then refreezes, disallowing oxygen flow to the victim and allowing toxic levels of CO_2 to accumulate. The Avalung ameliorates this situation by drawing breath over a large surface area in front and pushing the warm exhaled carbon dioxide behind. This buys additional time for rescuers to dig the victim out.

Chapter 5: Heat Related Illnesses



Heat-Related illnesses are the most common cause of weather-related deaths in outdoor medicine. The 30-year average is well above all other outdoor-related weather deaths. To understand heat illnesses, it is essential to understand what heat is and how the body handles heat. The normal human body temperature is averaged around 98.6oF (37oC). This fact is critical in understanding heat-related illnesses.

Another important fact to know is that the body is only approximately 10-25% efficient in processing the food that we eat into energy. All of the unused energy is given off as heat. If the body can't divest that excess heat, the human core temperature could rise above the average temperature of 98.6oF (37oC). That rise is known as hyperthermia.

THE SCIENCE BEHIND BODY HEAT LOSS

Body heat is given off three ways:

1. Radiation occurs whenever the air temperature surrounding the body is less than 20°C (68°F). Heat loss by radiation is constantly occurring during the winter months when temperatures fall significantly below this threshold.
2. Conduction occurs when the body is in contact with any object that is cooler than the body. Heat loss by conduction can be a significant issue when in contact with snow, ice, or cold water.
3. Convection occurs when the heat is transferred away from the body through circulating air currents. This is like sitting in front of a fan, and it's why we feel cooler when the wind is blowing. Heat loss by convection can be significant during winter storms with exposure to the wind.

Evaporation is the process that occurs when you sweat. It utilizes all three methods of heat transfer and is not a separate method. This same process can occur when wearing wet clothes.
It is crucial to keep in mind the different ways that heat is lost from the body in order to prevent heat-related illness. Heat moves from hot temperatures to cool temperatures. No heat can be transferred when two objects are at the same temperature. When air temperatures rise, radiation no longer works, and the body relies on convection and conduction. Water (sweat) is poured onto the skin to facilitate heat loss by wind and conduction. When the air temperature is the same as the body temperature, then no heat can be lost from the body and the body temperature will start to

rise dramatically. **Hyperthermia** is the name of the illness that happens when the body cannot transfer heat, or at least not transfer heat fast enough.

Medical Conditions

Anything that prevents heat from being transferred from the body will increase the risk of developing hyperthermia. Some medical conditions than can exacerbate this include heart disease, skin diseases such scleroderma, and burns that prevent heat from leaving the body. Diseases that cause water loss, such as dehydration, vomiting, and diarrhea, will promote heat retention. Endocrine and neurological exercises, as well as someone with a fever, will develop hyperthermia more readily.

Obesity is an excellent insulator and will cause the body to hold onto heat.

There are drugs and toxins that will prevent the body from losing heat. These include beta-blockers, anticholinergics, diuretics, alcohol, antihistamines, and cyclic anti-depressants.

Environmental Factors

There are environmental factors that will increase the risk of developing hyperthermia. Anything that will raise the body temperature or raise the temperature of the environment around the body will to this. These would include exercising in a hot climate, lack of air conditioning or proper ventilation, inappropriate clothing, a decreased fluid intake, being inside a hot tent, or being inside an auto in the sun or sitting in a hot tub.

Physiological Response to Heat Stress

The first, and most apparent, response to heat is a person's skin will turn red. This is because of vasodilation. Blood flow will increase to lose heat faster. Blood flow will increase from **0.2 L/min to 8 L/min**. Simultaneously, the core vessels will vasoconstrict to shunt heat away from the core to the skin. The heart responds to massive vasodilation and decreased peripheral vascular resistance by increasing heart rate and cardiac output. The net effect is increased blood flow to the skin, which facilitates heat transfer to the environment. Sweat glands are activated to increase the amount of evaporative heat loss.

There is inhibition of metabolic heat production. This is controlled by the hypothalamus. Less metabolic heat production decreases the amount of heat that the body has to regulate.

The body's physiological responses eventually deteriorate as cardiac output reaches its limits. In conjunction with the limits of the cardiovascular response, progressive electrolyte and water depletion further contribute to heat injury.

Clinical Manifestation

There are important clinical manifestations of heat injury that occur on a spectrum of severity, ranging from minor to life-threatening:

Heat Cramps

Heat cramps are caused by a loss of salt in the body. This happens when the lost fluid is replaced by a fluid solution without enough salt. Cramps typically involve only one muscle group (usually the calves) but can occur in any muscle. Cramps are often brief, intermittent, and involuntary contractions of the muscle. The victim will often provide a history of prolonged activity in a hot environment, attempted hydration with a non-electrolyte solution, and reduced salt/electrolyte intake. The key to treatment is to replace the lost salt. This is achieved through salty snacks and electrolyte drinks, which can be mixed by placing ¼ to ½ teaspoon of salt in a quart of water. If the patient does not respond to this treatment through symptom res olution, evacuation should be considered for IV rehydration. Drinking plain water will worsen the situation, and stretching the muscles will not address the underlying cause of cramps due to low salt. The individuals that are most likely to develop heat cramps are those who have exerted themselves in a hot environment and replaced fluid losses with water only.

Sweating depletes the body of salt and water simultaneously, and both must be restored to maintain a proper balance in the body. Replacing fluid losses with solutions that do not contain enough salt can worsen the salt deficit in the body and lead to involuntary contraction of skeletal muscles, causing cramps. They are painful and debilitating. It is essential, therefore, to obtain salt (sodium) in addition to drinking water. There is a misconception that a lack of potassium causes heat cramps. This is not the case. It is sodium (salt is sodium chloride) that is involved in skeletal muscle contraction.

Heat Edema

Heat Edema is an extremity swelling that is due to fluid pooling. The liquid pooling can be a result of hydrostatic pressure, vascular leaking, or vasodilatation. Oftentimes, high temperatures lead to vasodilatation, which results in dependent edema.

This is a benign, self-limiting condition. To mitigate, provide elevation to the extremity and/or frequent voluntary contraction of the muscles to redistribute the fluid. People may want to wear compression stockings for ongoing edema.

Heat Syncope

Heat syncope results from dehydration, dilation of blood vessels in a hot environment, and pooling of blood in the legs while standing. Patients are typically not profoundly dehydrated or hyperthermic. Heat syncope usually affects two populations: the **non-acclimatized** and the **geriatric** demographic.

Heat syncope usually afflicts standing, stationary individuals. Peripheral blood vessels are dilated to facilitate heat transfer to the environment. The combined effect of these factors leads to decreased cardiac output and poor cerebral perfusion. The flow of oxygen to the brain may descend below the threshold where unconsciousness occurs.

People will usually have lightheadedness, vertigo, restlessness, nausea, and will experience yawning. If the blood supply to the brain decreases, a loss of consciousness or syncope will occur. Syncope typically resolves once the patient is horizontal, as this facilitates the redistribution of blood from the lower extremities back into the central and cerebral circulations. There may be tonic jerking associated with syncope.

Treatment for heat syncope is straightforward. The actual loss of consciousness of heat syncope should be brief and resolves once venous return to the brain improves. For initial treatment, lie the patient flat and elevate their feet. Symptoms generally resolve quickly once the individual is horizontal, as this allows blood to reach the brain more easily. Those who maintain proper hydration, or who is lying down, are less likely to experience heat syncope. Remove them from direct sunlight to increase radiative heat loss from the body, and also move them to a cool area if possible.

Heat Exhaustion

Heat Exhaustion is a form of heat illness that represents significant heat stress, leading to intravascular volume and sodium depletion. Symptoms of heat exhaustion include weakness**,** fatigue, nausea with or without vomiting, headache, and thirst.

Headache is a common symptom of heat exhaustion and is often accompanied by dehydration. Headache is the first sign of dehydration. Although heat exhaustion isn't as severe as heatstroke, it isn't something to be taken lightly. Without proper intervention, heat exhaustion can progress to heat stroke, which can damage the brain and other vital organs and even cause death. Other signs of heat exhaustion include fast heart and fast breathing rate, profuse sweating, orthostatic hypotension, elevated body temperature. and an altered mental status. Heat exhaustion is part of the continuum of heat illness that progresses to heatstroke.

Treatment for heat exhaustion is to treat with liberal fluid volume and electrolyte replacement, including:

- Stop all immediate activities.
- Move the patient from direct sunlight to a cool, shaded area.
- Loosen restrictive clothing.
- Fluid replacement is essential. Give them water as quickly as possible without causing them to vomit. The treatment goal for mild heat exhaustion should be one-two liters over two-four hours.

- Increase heat loss by using the three methods of heat transfer: convection, conduction, and radiation.
- Make the patient "sopping wet" with tepid (comfortable room temperature) water and fan the patient with anything that increases air movement and thus the evaporation of the water.
- Ambient temperature water lessens the shivering reaction and helps to keep the skin vessels dilated, which increases heat transfer. Shivering will increase core body temperature and should be avoided. Get them out of the sun and 'fan' them to increase convective heat loss.

Heat Stroke

Heatstroke is a true medical emergency and is classically defined as severe hyperthermia (core temperature > 40° C [104° F]), central nervous system (CNS) disturbances, and anhidrosis (absence of sweating) *although this may be absent*. However, experience has shown that following these three symptoms as strict criteria for the diagnosis of heatstroke is too conservative and may delay critical treatment.

Neurological abnormalities are the hallmark of heatstroke and are the most sensitive indicators of significant heat injury. These include:

- Ataxia (stumbling gait)
- Irritability, confusion, combativeness, bizarre behavior, seizures, hallucinations, and fainting
- The victim may lapse into a coma. One of the earlier neurological manifestations of heat stroke is ataxia because the cerebellum is very sensitive to heat stress

A mild elevation in temperature does not preclude the diagnosis of heatstroke. A rectal or other core thermometer should always be utilized in the evaluation of a heat-related injury patient, as non-core temperature determinations may be misleading and delay treatment.

Anhidrosis is classically associated with heatstroke. However, it is usually a very late finding and cannot be relied upon to make an accurate diagnosis. Typically, heatstroke patients are profusely diaphoretic until the very late stages of the illness. The key to prevention and treatment is to understand that heat exhaustion and heat stroke are not separate entities but are a continuum of

the same illness. The onset of central nervous system abnormalities should alert providers that a patient is suffering from significant heat illness.

Treatment includes active cooling. Remove all restrictive clothing and utilize cold-water immersion. This has been shown to reduce core temperature twice as fast as evaporative cooling and has been shown to be safe in young, healthy heatstroke victims. This cooling could include a lake, pool, river, or stream. If you can't immerse them, pour cool/cold water on them. The victim's skin should be kept "sopping wet" and continuously fanned to promote evaporation. If available, ice packs and cold compresses may be placed in an area where large arteries run, such as the groin, axilla, and neck. The initial treatment goal is to drop the body core temperature to below 40°C (104° F) as rapidly as possible. The secondary treatment goal is 39°C (102°F). At this temperature, all active cooling should be discontinued to avoid an overshoot to hypothermia. Acetaminophen, aspirin, and NSAIDs are not effective and should not be used.

Evacuation Guidelines

Any patient with a prolonged loss of consciousness, persistent pre-syncope signs and symptoms, more than one episode of syncope, or signs of heatstroke, should be evacuated. As well, a patient with severe heat cramps that do not respond to oral salt solutions, or someone who has multiple cramps, should also be considered for evacuation depending on the situation. Patients showing signs of heatstroke should be evacuated, as the development of these symptoms indicates the involvement of the central nervous system, and is a medical emergency requiring immediate evacuation. Patients with heat exhaustion do not need to be evacuated as long as they can be treated in the field, they respond well to treatment, and they do not develop signs of heatstroke.

Prevention

Heart disease, dehydration, vomiting, diarrhea, and fever all increase the risk of developing a heat-related illness. The most significant risk of developing heat-related injuries is dehydration. Most of the risk factors involve dehydration. Previous episodes of heat exhaustion or heat stroke are also risk factors for developing a heat-related illness. High humidity inhibits the body's ability to lose heat through sweating and evaporation, thereby increasing the risk of elevated body temperature and leading to heat illness. Increased physical exertion, wearing heavy clothing that does not 'breathe,' lack of acclimatization, and decreasing fluid intake will all increase the risk of heat illness.

Fluid intake is essential in preventing the onset of heat illness, and sometimes water is not the only reasonable option. For example, plain water can lead to toxicity and death if ingested excessively in situations where body salt is low from profuse sweating. Therefore, electrolyte drinks can be essential at times. Highly caffeinated beverages should be avoided as they can lead to dehydration through the diuretic effects of caffeine. Obesity, alcohol use, Benadryl and other antihistamines, certain motion sickness medications, stimulants like cocaine and amphetamines, as well as salt and water depletion, can all increase the risk of developing a heat-related illness.

Rehydration should include a combination of water and electrolytes to maintain proper balance in the body. Too much water in the absence of electrolytes can lead to dangerously low levels of sodium, causing neurological damage and dysfunction. Rehydration should also occur slowly over several hours to allow the body time to maintain a balance between fluids and electrolytes. High carbohydrate content in drinks should be avoided, as this can inhibit fluid absorption. If needed, sports drinks can be diluted to a more appropriate concentration of carbohydrates for rehydration. A proper rule of thumb is to replace each pound of sweat lost with 500ml, or 2 cups, of fluid.

Consistently clear urine is a reliable way to gauge hydration status. Hydration is an essential factor in the prevention of heat illness. Due to variations in temperature, humidity, activity level, and body size and conditioning, it is difficult to recommend a certain amount of liquid consumption that will be adequate in all situations. It is, therefore, best to assess one's hydration status based on the color of the urine. Good sweat output continues until the late stages of heatstroke and is therefore not a reliable indicator of hydration or development of heat illness. The onset of a headache is often the beginning of heat illness, and the goal of hydration is to avoid heat illness altogether. It is best to catch signs of dehydration well before the onset of a headache and heat illness.

Preventative measures for heat-related illness include wearing loose-fitting clothing, which helps to dissipate heat by promoting airflow over the body and facilitates evaporative cooling. This is the most efficient way to cool the body. Dark-colored clothing absorbs light and increases body temperature and should be avoided. Tight-fitting clothing is restrictive and prevents efficient airflow that is needed to create evaporation. Dousing often in cooling fluids or misting sprays can be another effective method of cooling.

Acclimatization also decreases the incidence of heat injuries and improves performance in hot environments. Heat acclimation or acclimatization plays a large part in the body's physical responses and overall ability to cope with heat exposure. It is a complex series of changes or adaptations that occur in response to heat stress. These adaptations are beneficial to exercise in the heat and allow the body to better cope with heat stress. Adults should gradually increase the time and intensity of activity in a hot environment over 7-10 days. Children and the elderly require 10-14 days to maximize acclimatization. Acclimatization can be done using saunas and steam rooms 7-10 days in advance of a trip. De-acclimatization generally occurs within 1-2 weeks after being removed from the hot environment and will need to be repeated before returning to a hot climate.

Chapter 6: Cold-Related Injuries

Hypothermia is most often associated with prolonged exposure to cold winter activities such as skiing, snowshoeing, and mountaineering. It can also result from immersion accidents. Hypothermia occurs more frequently in the urban homeless, intoxicated, or patients with co-morbidities. The lowest known core temperature from which a patient with accidental hypothermia has been successfully resuscitated is 13.7°C (57°F).

Hypothermia can also be a danger during the hot summer months. Both the elderly and young babies have a challenging time with thermoregulation and are susceptible to becoming hypothermic due to elevated levels of air conditioning indoors. As well, windy days and wet, cold weather in the summer are risk factors for hypothermia, as is cold water even on a hot day. It is crucial to be mindful of this and to be aware of the signs and symptoms of hypothermia year-round.

It is important first to understand how the body loses heat. Heat is lost from the body through radiation, conduction and convection, and evaporation. It is important to remember there is no such thing as "cold." If something feels cold, it just has less heat. Heat moves or is transferred, from a warmer object to a colder object. The human body is continuously transferring a significant amount of heat to the cooler environment around it. Our body temperature is about 37° C (99° F), and we are rarely in temperatures that are hotter than we are.

HYPOTHERMIA AND HEAT LOSS

Three Methods for Heat Loss

1. Radiation occurs whenever the air temperature surrounding the body is less than 20°C (68°F). Heat loss by radiation is constantly occurring during the winter months when temperatures fall significantly below this threshold.
2. Conduction occurs when the body is in contact with any object that is cooler than we are. Heat loss by conduction can be a major issue when in contact with snow and ice.
3. Convection occurs when heat is transferred away from the body through circulating air currents. This is like sitting in front of a fan. This is why we feel cooler when the wind is blowing. Heat loss by convection can be significant during winter storms when exposed to the wind.
4. Evaporation is the process that occurs when you sweat. It utilizes all three methods of heat transfer and is not a separate method. This same process can occur when wearing wet clothes.

It is crucial to keep in mind the different ways that heat is lost from the body in order to prevent cold-related injuries, especially when out in the field. When searching for possible places for

shelter, look for areas that are dry (conduction), insulated (radiation), out of the wind (convection), and no direct contact with ice and snow (conduction). This will limit the effects of evaporation, radiation, conduction, and convection.

When you are planning anything from a day trip to an overnight trip in the winter, the potential for hypothermia and other cold-related injuries, such as frostbite and frostnip, should always be of concern. Even when air temperatures are hot, frigid river water splashing on a body combined with the wind blowing upstream can drop a body core temperature rapidly. And while atypical, even in warm or hot weather, people can become hypothermic.

The single most important aspect of hypothermia and other cold-related injuries prevention is adequate preparation. By being aware of changing weather conditions, bringing the proper gear, having a backup plan in case of an emergency, and being aware that cold-related injuries can occur in above-sub-zero temperatures, you are significantly lowering your chances of developing hypothermia or other cold related injuries in the wilderness. Remember, cold-related injuries are much easier to ***prevent*** in the wilderness than they are to ***treat*** in the wilderness. Therefore, preparation and prevention are crucial.

It is also important to note that stroke can present in a similar manner to hypothermia, but the symptoms of a stroke are more focal and more rapid onset. Reaction to antihistamines can also cause similar symptoms, but they usually do not give poor coordination to arm and hand muscles as hypothermia does. Fatigue can promote confusion, but it is not usually associated with focal coordination problems.

Physiology of Hypothermia

The healthy body maintains a core temperature of 37°C +/- 0.5°C. Humans have a limited physiologic means to avoid the development of hypothermia. The body conserves heat through vasoconstriction of the skin and extremities.

When the body begins to lose heat, shivering utilizes muscle activity to produce heat. Additionally, because most of the heat loss from the body occurs at the skin, the narrowing of blood vessels, also called vasoconstriction, prevents blood from reaching the skin. Therefore, the blood is not cooled as fast. As the body continues to lose heat, some organs, including the heart and lungs, begin to shut down. This is the body's last attempt to conserve heat and protect the brain.

A core body temperature of 35°C (95°F) or less defines hypothermia. The perception of temperature is closely linked to skin temperature rather than core temperature. For example, shivering may begin when the core temperature is 37 degrees Celsius (98.6°F). Hypothermia compromises heart function, leading to decreased output and fatal arrhythmias. The body must expend energy in order to shiver and to vasoconstrict peripherally. Ultimately, the depletion of energy stores leads to a loss of temperature homeostasis and vasodilatation. When this occurs, blood rushes back to the skin, and the individual feels warm. This may lead to the phenomenon

known as “paradoxical undressing,” whereby hypothermic individuals take off their clothes despite being cold. The paradoxical undressing precipitates a further drop in core temperature as blood returns to cold extremities and is subsequently circulated back to the core.

After-drop refers to a decrease in the core temperature as the extremities are rewarmed. As the periphery vasodilates during rewarming, blood volume increases to these areas. Cooled blood returns to the core, decreasing overall body temperature. In cases of severe hypothermia, cardiac arrest may result from even a small (5 degree Celsius) subsequent drop in core temperature.

A core thermometer (rectal or esophageal) is ideal for diagnosing hypothermia as temperature measurement may be grossly inaccurate using peripheral methods. It is important to note that most commercial thermometers can only register temperatures down to 34.5°C (94.1°F). Since most people faced with hypothermia in the wilderness do not have thermometers, this becomes an impractical means of diagnosing hypothermia. Individuals must, therefore, rely on clinical symptoms to make the diagnosis.

Classifications of Hypothermia

There are a number of guidelines to grade the severity of hypothermia. Most of these use temperatures as a means of classification. However, as stated, an accurate core temperature measurement in a wilderness environment is often impractical.

Mild hypothermia is defined by a core temperature ranging from 32° to 35° C (89.6-95°F). The cold temperature defense mechanisms are still working and will cause the patient to start to turn blue and create a sensation of cold. The victim may start to shiver uncontrollably. Their mental status may become impaired with varying degrees of confusion and disorientation. Urinary frequency is common due to increased renal perfusion caused by elevated cardiac output and peripheral vasoconstriction, increasing blood flow to the kidneys. The victim may have an elevation in their vital signs, including tachycardia, tachypnea, and hypertension.

Moderate hypothermia is defined by a core temperature ranging from 28° to 32°C (82.4-89°F). The victim’s blood pressure, heart rate, and respiratory rate will decrease. As well, victims are more confused, their pupils will dilate, and their muscles will tighten. Thermoregulation is less effective (shivering), and rewarming is required. Shivering ceases at and below a core temperature of 30°C (86°F). Cardiac arrhythmias are common and, unless rewarming is possible, the victim will eventually cool to ambient temperature and die.

Severe hypothermia is defined as a core temperature between 24°C and 28°C (75.2-82.4°F). At this temperature, the victim will go into a deep coma with dilated pupils and muscular rigidity. Their blood pressure will be barely detectable, and their pulse may be as low as 10 to 20 beats per minute. Life-threatening arrhythmias, such as ventricular fibrillation, are easily induced in these victims with even with the slightest of movements. The correction of such arrhythmias is nearly impossible without core rewarming.

Profound hypothermia is when the core temperature falls below 24°C (75.2°F). There is little chance of survival at this point.

Modified Swiss Staging System

Stage	Clinical Symptoms	Typical Core Temperature
Mild	Conscious, shivering	32 to 35°C (92 to 95˚F)
Moderate	Impaired consciousness, not shivering	28 to 32°C (82 to 90˚F)
Severe	Unconscious, not shivering, vital signs present	240C to 28°C (77 to 82˚F)
Profound	No vital signs	< 24°C (75˚F)

Treatment of Hypothermia

The most important consideration in treating hypothermia in the field is preventing further heat loss. To accomplish this, remove the victim from the situation that caused him or her to become hypothermic. Transport them to a shelter, removing wet clothing, and providing an insulating barrier around the patient. Keep them out of the wind.

Remember that the three methods of heat loss are from **radiation**, **conduction**, and **convection**. Prevent conductive heat loss with the use of insulating materials, including clothes, blankets, sleeping bags, and sleeping pads. Evaporative heat loss is addressed through the application of a vapor barrier, such as bubble wrap or a tarp. Anything that can be done to help rewarm the victim will be helpful, such as sitting by a fire, and carbohydrate-rich food or beverages. Importantly, avoid alcoholic beverages, which may actually exacerbate hypothermia by causing peripheral vasodilatation. Handle the patient gently, as excessive physical stimulation may precipitate fatal arrhythmias. In a rescue situation, it is important to remember the premise that "no one is dead until they are warm and dead." The caveat to the above "rule" is that an individual in the wilderness may have died from a non-hypothermia related condition such as trauma or a medical illness.

As mentioned above, vital signs may be markedly abnormal in hypothermic patients and should be checked over a 60-second span to assure accuracy. People suffering from severe hypothermia may be severely comatose, though alive and savable with proper medical care. Hypothermia decreases basal metabolic rate and lowers oxygen requirements, which may, in turn, allow victims to survive for a prolonged period without a detectable perfusing rhythm.

For the treatment of mild hypothermia, you need to remove the victim from the elements and shelter them to avoid further heat loss. The individual should completely undress, then dress in dry

clothes and be wrapped in blankets, taking special care to cover the head and neck to avoid heat loss from radiation. Carbohydrate-rich beverages, and foods may be helpful in both rewarming and meeting the increased caloric requirement for shivering, taking care to avoid alcohol. Limited exercise may generate some heat. However, this is not advised in moderate and severe hypothermia. Do not use baths or water immersion to treat even mild hypothermia. This intervention may increase the likelihood of after-drop, exacerbate hypotension, and cause cardiovascular collapse. Body-to-body rewarming may improve the comfort of the mildly hypothermic patient as a result of decreased shivering but should not be done at the expense of delayed evacuation. Generally speaking, those suffering from mild hypothermia will have a favorable outcome as long as the cooling process is halted.

For the treatment of moderate hypothermia, the individual has exhausted their capacity to achieve rewarming by shivering, and active rewarming must be performed in order to get their body temperature to a near-normal level. You should attempt rewarming in the field with items such as large electric heat pads or blankets, and warm water bottles. The areas of the human body with the highest potential for conductive heat loss include the axillae, chest, and back.

For severe hypothermia**,** treatment is a true medical emergency that requires aggressive treatment and prompt medical management with evacuation for initiation of active core rewarming. These victims have no ability to reheat themselves at this stage. It is important to consider that victims suffering from this condition may exhibit altered mental status if they are still conscious. Care must be taken in handling victims suffering from this condition as extremely cold core temperatures can cause cardiac irritability. Even the slightest jolt may cause these individuals to degenerate into life-threatening dysrhythmia, such as ventricular fibrillation. This becomes extremely important in determining when CPR needs to be initiated. Victims with severe hypothermia may have faint pulses, severe bradycardia, and appear to be dead. So, it is important to assess vital signs over a minimum of 60 seconds.

If the patient has vital signs, even if very slow, CPR should NOT be performed. After determining that the patient has no vital signs, CPR (including breathing) should be initiated.

Evacuation Guidelines

Evacuation guidelines indicate that all victims with moderate to severe hypothermia must be evacuated from the wilderness. They have lost the capacity to rewarm themselves and it is extremely difficult to actively rewarm these victims in the wilderness setting. Victims with mild hypothermia may not require evacuation as long as they are able to warm themselves, and they do not develop any sequelae from the episode. When transporting hypothermic patients, handle the individual very gently to prevent degeneration into a fatal rhythm, and keep him or her horizontal to prevent exacerbating potential hypotension.

The single, most important aspect of hypothermia treatment is adequate **prevention** through preparation. Hypothermia is the “killer of the unprepared,” but even experienced and prepared

outdoors, people have succumbed to this ailment. You should be aware of weather conditions and bring appropriate gear. Have a contingency plan in case a bad situation happens.

OTHER COLD-RELATED INJURIES

Frostbite

Frostbite occurs when the skin is exposed to temperatures that are below freezing. While the incidence of frostbite is unknown, it occurs most often in the extremities, with a slightly higher incidence in feet than in hands. Frostbite can actually occur in any area of the body. It more commonly affects exposed areas, but in severe conditions, frostbite can arise on parts of the body that are covered. It is a hazard for anyone who ventures outdoors in wintry weather. Frozen tissue is damaged during freezing and rewarming (mostly during rewarming). Rewarming can be very painful. Blisters and edema develop after rewarming, and a hard eschar may form with healthy tissue deep to the eschar.

Degrees of Frostbite

Degrees of Frostbite are not determined at initial exposure, but later, after the physical signs have developed.

- 1st Degree. In first-degree frostbite, only the superficial layers of the skin are involved. Generally, blisters do not form from 1st degree frostbite.
- 2nd Degree. In second-degree frostbite, the deeper layers of the skin become frozen. Blisters form, containing a clear fluid.
- 3rd Degree. With third-degree frostbite, there is complete freezing of the skin and the tissue layers under the skin. Blood blisters will develop, as well.
- 4th Degree. Fourth-degree frostbite is associated with full-thickness skin involvement, muscle and tendon involvement, and blisters containing red fluid. This is also known as deep frostbite and can freeze bone.

One common risk factor for frostbite is diabetes. A diabetic person typically will have poor circulation and nerve damage in the extremities. This predisposes them to cold injury and can make it more difficult to sense when hands and feet are too cold. There is no additional risk involved with rewarming a patient with diabetes.

Treatment of Frostbite

Overall, prevention is better than treatment. Frostbite is difficult to treat in the field due to the importance of sustained rewarming without the possibility of refreezing, but there are some guidelines for treating frostbite.

- **Rapidly rewarm the frozen extremity**
  Place the affected body-part into warm water (approximately the temperature of a hot tub). The optimal temperature for rewarming is between 40-42°C (104-108°F). If the water is too hot, it will burn the skin, which will worsen the injury. If it is too cool, it will delay thawing, which will also worsen the injury. It is important that the temperature of the water be closely monitored. The body-part should be thawed for approximately 15-30 minutes.
- **Do not allow extremities that have been thawed to refreeze**
  Refreezing of a previously thawed frostbitten body part will result in a significant increase in the damage that will occur. It has been shown that refreezing is more detrimental to the affected body part than a delayed thawing. Therefore, in the wilderness setting, it is better to have a person walk out on a frozen foot than to risk a refreezing injury. If you are unsure that you can keep an extremity warm enough to thaw it out, wait until the patient is in a protected environment to begin the thawing process.

- **Do not place the frostbitten body-part next to a dry heat source such as fire**
  The fact that the temperature is not controlled may lead to delay in thawing but may also burn the areas as the area is numb.
- **Do not rub the frostbitten area with anything**
  The friction can cause further damage to the skin. Do not rub the area with snow; this was an old recommendation that was proven to be harmful in the 1950s.

It is important to note that the pain felt while thawing indicates that warm blood is returning to the affected appendage, and the thawing process should be continued. There will be an extensive amount of pain during the rewarming process, and this pain, while it can be excruciating, is a sign that the affected area is thawing, and warm blood is returning. It does not indicate that the rewarming is occurring too fast. Rapid rewarming is recommended to prevent further tissue damage. Therefore, do not slow down or stop the thawing process.

Aspirin or Ibuprofen can be given in the backcountry to prevent clotting and inflammation, and Ibuprofen, in particular, may also be given to a victim of frostbite before they undergo rapid rewarming of the frostbitten body part. Ibuprofen is preferred to aspirin because aspirin may block a subset of prostaglandins that are important in injury repair.

All victims with frostbite must be evacuated from the field. This is necessary for definitive rewarming and management of their frostbite. If you know a patient is promptly evacuated, it is important to begin thawing because prolonged frostbite can lead to tissue damage. Even with first-degree frostbite, the skin will be swollen and continue to be red for several hours after rewarming. It can be difficult to determine the degree of frostbite until the area has thawed. Therefore,

evacuation is always the top priority, after scene safety, when treating a patient with any degree of frostbite.

Frostnip

Frostnip is a condition that is commonly confused with frostbite. The difference between frostnip and frostbite is that there are no ice crystal formations in frostnip. When frostnip is present, the skin is still soft and pliable. This indicates that there is no ice crystal formation. However, if left untreated, ice crystals can form from the fluids in skin cells, resulting in frostbite. There is no permanent damage that occurs in frostnip. However, frostnip should be taken seriously because it can lead to frostbite if left untreated. Evacuation is not usually necessary unless you are having trouble rewarming the body part.

Chilblains

Chilblains are an unusual reaction to the cold over time. Chilblains are a non-freezing injury where the skin reacts and will develop sores and blisters but does not die due to non-freezing temperature exposure. It is important to warm the victim and have them eat warm food and drink warm liquids. People who have diabetes are generally at greater risk.

Rapid rewarming could result in a worsened condition because large temperature changes tend to increase possibilities of infection in people with chilblains. Chilblains will generally heal themselves in about one week. The victim does not require immediate evacuation. This usually can be treated in the back country.

Trench foot (Immersion foot)

Trench foot is a condition where the feet are in cold water for too long. The important step is to first dry them off and warm them. This will help with the pain. The victim should wear dry shoes that are loose-fitting. Putting a victim's feet in very warm water is incorrect, as the feet need to be dried. You should not massage the feet as this can cause more damage. Trench foot is serious. If left untreated too long, the skin will molt off the foot, and infection will become likely. Use towels and dry clothes to dry and insulate the affected areas without applying pressure on the feet.

Conclusion

As mentioned throughout this chapter, prevention is the best treatment for all cold-related injuries. The severity of cold-related injuries and the unforgiving environment that creates cold injuries can make treatment in the field extremely difficult. Remember that these injuries can occur year-round and that the single most important aspect of hypothermia and other cold-related injury prevention is adequate preparation.

Chapter 7: Lightning

Background

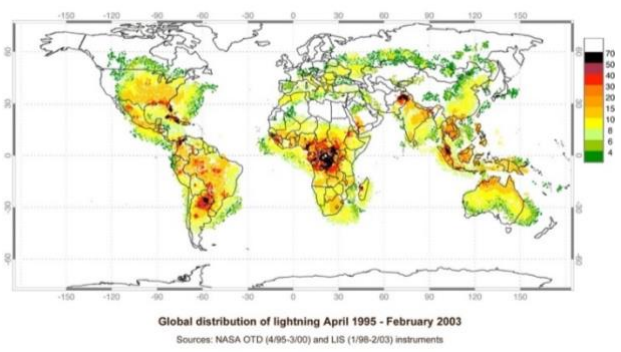
The power of lightning is immense. For every ten feet of ascension through the air, there is a 300-volt potential difference in electricity. This amounts to approximately 380,000 volts at the top of the atmosphere. This powerful "battery" tries to discharge through lightning strikes, striking the earth more than 100 times each second and 8 million times per day.

Worldwide, approximately 50,000 thunderstorms occur per day that may result in forest fires, injury to animals and people, damage to electrical and communication lines, and electronics, leading to millions of dollars in downtime for businesses. There are approximately 240,000 lightning incidents worldwide each year. The annual fatality count is not known, and estimates vary. One view lists the annual global death toll at 6,000. However, the National Geographic estimates that about 2,000 people are killed worldwide by lightning. In using this lower number, this means that a person roughly has a 1 in 100,000 chance of falling victim to lightning in their lifetime.

According to the National Oceanic and Atmospheric Administration (NOAA), over the last 20 years, the United States has averaged 51 annual lightning strike fatalities. This places the number of lightning fatalities as the second highest in the United States, behind deadly flooding. About 90 percent of people struck by lightning are estimated to survive, but they often suffer from long-lasting neurological damage.

TYPES OF ISSUES ENCOUNTERED WITH LIGHTNING

Lightning Hotspots Worldwide



Global distribution of lightning April 1995 - February 2003

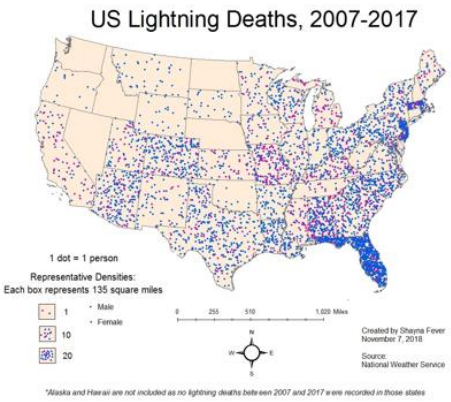
Sources: NASA OTD (4/95-3/00) and LIS (1/98-2/03) instruments

As people travel into the wilderness, it's essential to know the risks of lightning. Thunderbolts often rain down with great fervor in tropical central Africa. The weather patterns in Africa bring in warm air from the Atlantic Ocean that collides with mountains, producing many thunderstorms and lightning year-round. Another lightning hotspot is the Himalaya, where the mountainous topography forces the

convergence of air masses to rise from the Indian Ocean. The North and South Poles, however, rarely experience thunderstorms and, therefore, have almost no lightning. In the United States, lightning researchers estimate that 22 million lightning flashes strike the ground each year. The most lightning prone region is Florida, on the Gulf Coast, which has, on average, 12 flashes of lightning per square kilometer per year.

Know When You are at Risk

The ***highest*** risk is for people in an open field, a sports park, or in/near water during thunderstorms. This group accounts for just over half of all deaths from lightning strikes. Swimming is particularly dangerous during thunderstorms with lightning. Not only do swimmers protrude from the water, which presents a potential channel for electrical discharge, but also because water is a good conductor of electricity.



Lightning is attracted to tall objects such as trees. Trees are frequently struck, making this the ***second*** highest unsafe location for someone to stand beneath.

Playing on a beach in the open is the ***third*** most common place where people are struck and killed by lightning. Many farmers and ranchers are struck and killed by lightning while working on or near farm equipment, making this the ***fourth*** highest group at risk. Lightning can, and often does, strike in the same place twice.

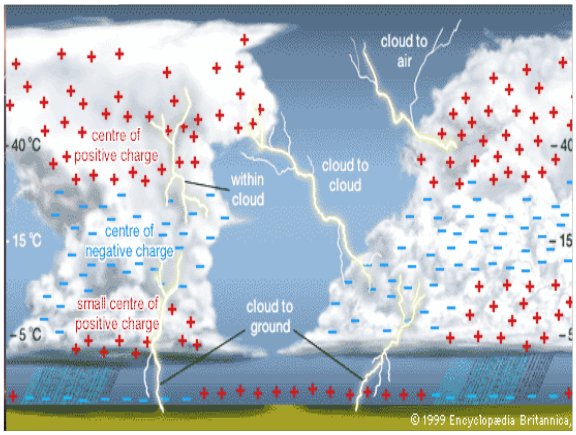
Location of Lightning Deaths	**Percentage**
Open fields, sport parks, in/on water	54%
Under trees	23%
On beaches	12%
Working on farm equipment	7%
Other	
Standing near open windows, riding a bike	4%

Far more injuries and deaths occur in tropical and developing countries. Complicating the increased risk people suffer in these countries because of higher lightning density, poor housing, and greater everyday exposure are the superstitions that may cause inadequate prevention and mitigation. Many people in these countries believe in two kinds of lightning: "natural lightning" and "man-made lightning" that can be called down by witches or prevented with charms, herbs, and burying something under a structure as it is being built. Some believe that anyone injured by lightning must be cursed, and they will shun the entire family afterward. Families have been forced to uproot and move to villages where their history is not known

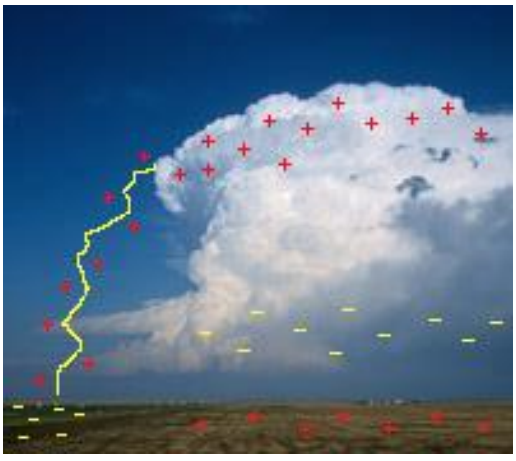
The Physics of Lightning

As lightning connects from the clouds to the ground, the second stroke of lightning will return from the ground to the clouds (upward streamer) following the same channel as the first strike. The heat from the electricity of this return stroke raises the temperature of the surrounding air to around 27,000 C° (48,632 F°). The heated air is compressed, raising the air from 10 to 100 times the normal atmospheric pressure. The compressed air explodes outward, forming a shock wave of compressed particles in every direction. Like an explosion, the rapidly expanding waves of compressed air create a loud, booming burst of noise that we call thunder. If a person is near this wave, significant trauma is likely.

Most experts define ***four*** primary types of lightning:



1. The first is ***intra-cloud***, which occurs within a single thunder- cloud and is the most common form of lightning.
2. The second is ***cloud to cloud***, which starts and ends between two different thunderclouds. This is the second most common form of lightning. These two types of lightning account for up to 70%-90% of all lightning.
3. The third most common type of lightning is ***cloud to air*** lightning that occurs when the air around a positively charged cloud top reaches out to the negatively charged atmosphere around it.
4. The fourth most common type of lightning is the most well-known, ***cloud to ground***, and primarily originates in the thundercloud and terminates on an earth surface. Anywhere from 10-30% of lightning can be cloud to ground, depending on the storm. Of the four primary types of lightning, it poses the greatest threat to life and property since it terminates at, or strikes, the earth.



Not all lightning forms in the negatively charged (the lower area) of the thunderstorm cloud. Some lightning originates at the top of the thunderstorm, the area carrying a large positive charge. Lightning from this area is called positive lightning. Positive lightning is particularly dangerous because it frequently strikes away from the rain core, usually ahead of the thunderstorm. It can strike as far as 5 or 10 miles (8 or 16 kilometers) from the storm in areas that most people do not consider to be a lightning-risk area. This is why most lightning strikes happen prior to a storm.

Types of Injuries from Lightning

Injury from lightning can occur by several mechanisms:

***Ground current**:* When a lightning strike hits the ground, the electricity does not disappear into the earth. It spreads out in the ground as a potentially deadly current with voltages decreasing from the point of the strike. These currents are lightning's biggest danger because they affect large areas in circles, extending out from where lightning reached the ground, such as at the bottom of a tree. If a person happens to be standing in a place affected by a ground current, it can travel up one leg, through the body (and potentially stopping the heart and breathing), and then down the other leg.

***Side splash**:* This refers to lightning that jumps from an object to a person, or even from one person to another. Side splash occurs because lightning follows the path with the least electrical current resistance to the ground.

***Upward streamer**:* The third most common cause of lightning deaths and injuries are the upward leaders, also called "streamers," that rise from high objects and the ground just prior to lightning strikes.

***Direct strike**:* Lightning that hits someone directly from the sky is called a direct strike. This rarely happens.

***Contact**:* It is well known that lightning when it strikes a building can get into the wiring or the water pipes and kill someone talking on a phone with a cord or someone taking a shower. This does happen, but such "contact strikes" are as rare as direct strikes.

Deaths Due to Lightning by Type	
Ground current	50-55%
Side splash	30-35%
Upward streamer	10-15%
Contact	3-5%
Direct strike	3-5%

***Blunt Trauma**:* This occurs from the impact of the concussive force of the strike itself or from being thrown due to the extreme nature of the muscular contraction from the electrical charge. Blunt Trauma is responsible for most of the lightning injuries.

Treatment for Lightning Strikes

The most common cause of death in lightning strikes is a cardiopulmonary arrest. This condition results from both the direct current to the heart and paralysis of the respiratory center in the brain. Persons who have been hit by lightning and are in respiratory arrest may need only artificial respiration to prevent the secondary hypoxic arrest. Almost all persons hit by lightning who do not have cardiac and/or respiratory arrest at the scene survive, even though they may be seriously injured. If multiple persons are struck by lightning, triage priorities must be reversed. This is called

reverse-triage. Those in cardiac and/or respiratory arrest appear dead but must be treated first. Persons struck by lightning have a better chance of survival than persons who experience cardiopulmonary arrest from other causes. Resuscitation for persons struck by lightning must be initiated immediately.

Immediate cardiac arrest from a lightning strike results from direct current depolarization of the myocardium of the heart. Immediate respiratory arrest after a lightning strike is a result of paralysis of the medullary respiratory center. Although cardiac rhythm may spontaneously return, concomitant respiratory arrest may persist and lead to a secondary hypoxic cardiac stoppage. The duration of apnea, rather than the duration of cardiac arrest, appears to be the critical prognostic factor. Some other important lightning information is that victims of lightning do not retain the charge and are not "electrified." It is safe to help them.

Pathophysiology Effects from a Lightning Strike

In addition to flowing on the outside of the body (flashover), the electrical current may also enter the body through the cranial orifices (eyes, ears, nose, and mouth) and flow through the body. This may explain why some patients have certain injuries such as ocular and/or ear, and others do not. Although the current flow occurs over a very short period of time, the amount of current is huge with an amazing amount of energy.

Damage to the ***central nervous system*** is the second most debilitating group of lightning injuries. Neurologic complications include immediate loss of consciousness, amnesia and confusion, retrograde amnesia, hemiplegia, aphasia, coma, and seizures.

Eye complications are also common and include cataracts, macular holes, corneal lesions, hyphema, iritis, retinal detachment, and injury to the optic nerve.

Hearing complications are frequent. People struck by lightning often have a ruptured tympanic membrane, temporary hearing loss, dizziness from eighth nerve damage, and injury to the hearing bones.

Other common complications of being struck by lightning include chronic pain syndrome and neuromuscular pain. Many people develop neurocognitive deficits, including short-term memory loss, difficulty accessing or processing new information, attention deficit, personality change, distractibility, or loss of ability to multitask. Many develop depression and the feeling of isolation. Sympathetic nervous system dysfunction is seen including positive tilt tests and hypertension. People frequently report dizziness and sleep disorders. Symptoms similar to post-concussion syndrome (e.g., headaches, nausea, and confusion) are seen. People develop an atypical seizure disorder. Endocrine problems can develop, including pituitary or hypothalamic damage with secondary endocrine effects. These symptoms can start right after the strike or often appear weeks to months later and can persist for years.

Few individuals experience the full energy of a lightning strike because only about 3-5% of injuries are from a direct strike. Most of the energy is transmitted by other objects that are hit, such as the ground or a tree. Fewer than half of affected persons have signs of burns or any other marks. There are only about 20 cases reported of lightning strikes to pregnant women. The maternal outcome is generally good.

The identification of a victim of a lightning strike is easy if the strike was witnessed. However, there may be situations where it is unclear. Lightning injuries must be suspected when in the outdoors and in weather conditions conducive to lightning. Always follow the MARCH protocol. Call for evacuation to the closest medical facility. Any patient who is a victim of a lightning strike should be evacuated as soon as possible.

Reduce Risk

"When thunder roars go indoors." If you hear thunder, then you should seek shelter. This is based on the fact that the distances that sound travels are well within the distance of a lightning strike. Furthermore, you may miss lightning because the clouds or other terrain hide it. There is no safe place outdoors.

There is little you can do to substantially reduce your risk if you are outside in a thunderstorm. The only completely safe action is to get inside a safe building or vehicle. However, some people in the wilderness sometimes find themselves exposed, far from shelter. If you absolutely cannot get to safety, you can *slightly* lessen the threat of being struck with the following tips. But, don't be deceived--you are **NOT** safe outside. Know the weather patterns of the area you plan to visit. For example, in mountainous areas, thunderstorms typically develop in the early afternoon, so plan to hike early in the day and be down the mountain by noon. Find the weather forecast for the outdoor area you plan to visit. The forecast may be very different from the one near your home.

If you are in the wilderness, and thunderstorm develops, these tips can ***slightly*** lessen the threat of being struck by lightning:

- Avoid open fields, the top of a hill, or a ridge top.
- Crouched positions offer little protection.
- Stay away from tall, isolated trees or other tall objects.
- If you are in a forest, stay near a lower stand of trees.
- If you are in a group, spread out to avoid the current traveling between group members.
- If you are camping in an open area, set up camp in a valley, ravine, or other low areas.
- Remember, a tent offers NO protection from lightning.
- Stay away from water, wet items such as ropes, and metal objects such as fences and poles. Water and metal do not attract lightning, but they are excellent conductors of electricity. The current from a lightning flash will easily travel for long distances.

Unless specifically designed to be lightning safe, small structures do little, if anything, to protect occupants from lightning. Many small open shelters on athletic fields, golf courses, in parks, at roadside picnic areas, in schoolyards, and elsewhere are designed to protect people from rain and sun, but not lightning. A house or other substantial building offers the best protection from lightning. However, people should stay away from windows and doors, and avoid contact with anything that conducts electricity, such as landline telephones.

Cars provide good protection. Lightning flows around the outside of a car, and the majority of the current flows from the car's metal cage into the ground below. It is not the rubber tires that protect you. In essence, a car acts like a mobile Faraday cage. (A Faraday cage is an enclosure formed by conductive material used to block electric fields.) Convertibles do not have metal roofs, which compromises the Faraday cage effect

The best rule is that if you see lightning or hear thunder go indoors. The threat of lightning continues for a much longer period than most people realize. Wait at least 30 minutes after the last clap of thunder before leaving shelter. And remember, don't be fooled by sunshine or blue sky.

Chapter 8: Water Safety and Drowning

One only needs to look at drowning statistics to rethink safety when in, or around, water. Drowning is the ***third*** leading cause of unintentional deaths worldwide. Even with swim and safety classes available in many countries, large numbers of people drown every year.

There were an estimated 360,000 drowning deaths worldwide in 2019 This means that at least one person died from drowning approximately every 1.5 minutes. Sadly, these estimates may be significantly underestimated, as some data sources suggest that as many as one million people die annually from drowning. That is more than two victims per minute.

DROWNING OCCURRENCES IN THE YOUNG

Drowning is a calamity of the young. It is one of the top five causes of death for people aged 1-14 in 48 out of 85 countries. Natural water is where 38% of drowning deaths happen. Swimming pools account for 20% of drowning deaths, and about 11% occur in bathtubs. Alcohol plays a major risk factor in drowning deaths, with males at twice the mortality rate of females due to riskier behavior, and drinking alcohol before swimming and boating.

There is a correlation between the victim's age as to where the drowning occurred. For children ages four (4) and under, home swimming pools, bathtubs, and buckets pose the highest risk. Over half of the fatal and non-fatal drownings in adolescents occur in natural water settings, such as lakes, rivers, and oceans. Nearly 80% of people who die from drowning are male. Drug and alcohol are involved in half of adolescent and adult deaths associated with water recreation. Trauma from water recreation is secondary to dives, falls, and horseplay. And, failure to wear a personal floatation device (PFD), while boating, results in a staggering 88% of drowning deaths.

Definitions

Over the years, different terms have been used to describe and define the types of accidental drownings, but there has been confusion associated with these definitions. To eliminate this confusion, in 2015, the International Liaison Committee on Resuscitation (ILCOR) recommended new definitions. Some terms, such as *near-drowning*, *wet drowning*, and *dry drowning,* have been eliminated. It is critical to have a solid understanding of these new terms because they have ramifications on the treatment for victims.

New Terms:

- **Drowning** is defined as a process that results in respiratory impairment from submersion or immersion in a liquid medium, thus causing death, morbidity, or no-morbidity at all.

- **Immersion** means to be covered in water, and **partial immersion** means to be partially covered in water.
- The **drowning process** can be thought of as a continuum from the onset of the airway being immersed to when the patient dies. The drowning process can be disrupted at any point by rescue and resuscitation. The length of time within the drowning process correlates to the amount of organ damage and morbidities seen.
- **Shallow water blackout** is a special cause of drowning that occurs in people who hyperventilate before going underwater to raise their oxygen level in an effort to stay under longer. But in reality, rather than raising their oxygen level (which is already high), they reduce their $PaCO_2$. It is CO_2 that stimulates the respiratory centers in the brain. Thus, the victim doesn't realize they need to surface to get air. The victim will use up oxygen, which will cause hypoxemia and unconsciousness.

Drowning – The Pulmonary System

The pulmonary system is the organ system that is primarily involved in drowning pathophysiology. During the drowning process, the victims become panicked, which causes an increase in respiratory rate. At some point, victims are thrust underwater and have to hold their breath. This lowers oxygen levels while increasing CO2 levels in the blood. As the victim struggles to stay above water, they use oxygen. With the rise of PaCO2 and the fall of PaO2, the medulla in the brain is stimulated, causing involuntary respiration. Victims inhale water into their lungs, causing pulmonary damage. They become very hypoxemic, which will then cause secondary organ damage. The heart becomes ischemic, and neurological injury can result.

Arrhythmias

Arrhythmias are a common EKG finding after drowning but are not usually caused by electrolyte disturbances such as high calcium, high magnesium, or high sodium, as the volume of aspirated water is rarely enough to disturb plasma electrolytes. The arrhythmias are typically secondary to severe hypoxemia that causes an ischemia in the cardiac conduction system. In addition, hypoxia can cause respiratory acidosis, which contributes to cardiac arrhythmia by increasing the early and delayed depolarization of the nerve fibers.

Interestingly, some studies have shown that arrhythmia (in this case, prolonged QT syndrome) can cause patients to die. This highlights the importance of monitoring patients with medical conditions (mainly seizure disorders and cardiac complications) when swimming. Along with arrhythmias, hypoxia can also cause a decrease in cardiac output.

Hypoxia

Hypoxia causes injury and inflammation in the brain that can lead to cerebral edema and increased intracranial pressure. This process can occur after a relatively short period of hypoxia, which is why oxygenation is so important in the management of submersion injury. After resuscitating patients, it is important to monitor them for further neurologic deterioration, as reperfusion injury can occur.

Drowning itself is quick and silent, although it may be preceded by distress, which is more visible. Generally, in the early stages of drowning, very little water enters the lungs. A small amount of water entering the trachea can cause a muscle spasm that seals the airway and prevents the passage of both air and water until unconsciousness occurs. This means a person drowning is unable to shout or call for help or seek attention, as they cannot get enough air. The instinctive drowning response is the final set of autonomic reactions in the 20 to 60 seconds before sinking underwater. To the untrained eye, it can look similar to calm, safe behavior. Persons trained in rescue learn to recognize drowning people by watching for these movements.

Rescue

Rescue involves bringing the victim's mouth and nose above the water's surface. A drowning person may actually grab the rescuer, submerging the rescuer in the process. Thus it is advised that the rescuer approach with a buoyant object, or from behind, twisting the victim's arm on their back to restrict movement. If the rescuer does get pushed underwater, they should dive downwards to escape the victim.

The priority is then to transport the victim to the water's edge in preparation for removal from the water. The victim is turned onto their back with a secure grip used to tow from behind. If the person is cooperative, they may be towed in a similar fashion held at the armpits. If the person is unconscious, they may be pulled in a similar way held at the chin and cheeks, ensuring that the mouth and nose are well above the water.

Since drowning is mainly an oxygenation problem, rescue breaths should be started immediately. The European Resuscitation Council recommends that five (5) rescue breaths be initiated instead of two (2) breaths when starting CPR. Most patients with respiratory arrest will respond after the first few rescue breaths. Chest compressions are ineffective without a sturdy surface under the patient and should be avoided until the patient is on land. There are no drainage procedures for clearing the airway, and the Heimlich maneuver is no longer recommended in submersion injury.

On physical exam, patients will present with several signs and symptoms that correlate to the underlying pulmonary pathologies. The patient will be short of breath with dyspnea as the lung compliance drops. Patients will complain of air hunger due to the reduction in both ventilation and

perfusion. Irritant receptors in the airways will be stimulated by the aspirated water, causing the patient to cough.

Trauma

In any drowning scenario, the pulmonary system is usually the first system to be treated. However, it is always important to consider the possible mechanism of injury in the primary assessment. Cliff diving has a fairly obvious risk for head and neck injury, while submersion in a river is less so.

The current protocols for wilderness spine immobilization are very similar to the standard criteria. If the patient has an altered mental status (or intoxication), has neurological deficits, or a thoracic/distracting injury, they should be immobilized. If there is spine pain, vertebral tenderness, or if the patient has a reduced spinal range of motion, then they should be immobilized. Patients with penetrating injuries to the spine (including gunshot wounds), should not be immobilized.

Infection

While there is a risk of bacterial, fungal, and amoebic infection of the respiratory system, and given that these infections have a high mortality rate, there is no evidence that antibiotic prophylaxis therapy is useful. Besides, the full range of potential infection makes it difficult to determine the proper antimicrobial drug.

Hypothermia

While drowning in cold water can be protective, it is essential to note that hypothermia has to occur at the time of the submersion. Most patients will be hypothermic from prolonged exposure to the water (conductive heat loss) and are already dead from the drowning process. As opposed to dying from the drowning process, the patient can also die from *immersion syndrome*, suffering cardiac arrest from the shock of cold water. In very cold or freezing water, reflex reactions can be lethal, killing up to 70% of people within 15–30 minutes. Initially, victims first give rise to cold shock, a combination of uncontrolled gasping and massively increased blood pressure with possible cardiac arrest, followed by the rapid loss of control of bodily functions needed for swimming and gripping.

Evacuation

Any degree of resuscitation warrants an evacuation in a submersion injury. In some cases, though, continuation on the route may be the fastest and safest evacuation plan. For example, if there's a drowning victim during a river rafting or white-water rafting trip, it might be quicker to raft the rest of the river, in which case monitoring the patient for any complications is essential.

Having a stethoscope and portable pulse oximeter in your medical kit will significantly enhance your patient assessment in drowning scenarios. Without these tools, it is much harder to decide to evacuate or to stay. This decision has enormous impacts. Either way can put the rest of your group at risk. Patients that are asymptomatic after their submersion episode should be re-evaluated after six hours. If the patient has a regular exam with no symptoms (no cough, normal breath sounds, and vitals), they can stay in the wilderness. If there are any respiratory complaints or findings on the exam, the patient should be evacuated.

Other factors that warrant evacuation include loss of consciousness, dyspnea, persistent cough, air hunger, tachypnea, an abnormal pulmonary exam, or hypoxemia on pulse oximetry.

Factors that indicate a bad prognosis after a drowning incident include:

- Less than three (3) years of age
- Submersion/immersion greater than five (5) minutes
- No resuscitation for more than ten (10) minutes
- Comatose upon emergency room admission, or a pH less than 7.1

Note: Three (3) or more of these factors drops the chance of survival to less than 5%.

Prevention

Prevention is more important than any action one can take after a submersion incident has occurred. Alcohol should be avoided when participating in or supervising water activities. Everyone on a boat should always wear approved personal flotation devices that will support the person's head above water, even if the person becomes unconscious. Camp far enough away from water so that people, especially children, do not accidentally wander into the water. Young children should always be supervised when around water. A one-minute phone call or other distraction is all it takes for a child to become submerged. Toddlers have drowned in toilets and small buckets of water. Toddlers have drowned in bathtubs when left alone with older siblings to watch them without adult supervision. Patients with seizure disorders should always be supervised when swimming, and should probably use a shower stall, not bath in a bathtub.

Chapter 9: Medical Problems in the Wilderness

Think of the differences in having a serious medical problem while you are home, knowing there is medical help nearby, to having a serious medical issue when you are in a remote section of the backcountry, and have no clue how to get help. Some medical problems occur with higher frequency in the backcountry, while others occur about the same rate while at home. By being able to recognize the signs and symptoms of serious medical conditions, you can provide a proper treatment plan for someone in the wilderness and potentially saving their life.

CARDIAC EMERGENCIES

Not long ago in the mountains surrounding Chamonix, France, a 56-year-old man began having chest pain while hiking on the famed Tour du Mt. Blanc. Friends and family were the only people nearby. The man survived and was ultimately brought out by a rescued team, but it was only after many hours. Evaluating and treating cardiac problems can be difficult in a hospital setting where the full spectrum of diagnostic equipment and treatments are available. It is even much more difficult in the wilderness. Let's go over the basics of backcountry care of cardiac problems.

Angina

Angina is the term given to chest pain that is associated with diminished blood flow to a portion of the heart that does not cause actual damage. It is cardiac ischemia (low blood flow) but not infarction (death of heart muscle). Angina results from an imbalance between cardiac muscle oxygen demand and oxygen supply. This supply may be restricted due to atherosclerotic disease. But there are many reasons for an imbalance in oxygen supply and demand to occur in the wilderness. For example, there is an increased exertion that causes increased cardiac work. People are in cold temperatures, which creates peripheral vasoconstriction and increases cardiac work. Fear, mental stress, and/or pain, all of which increase the release of catecholamines, which in turn increase both heart rate and blood pressure. There can be decreased pressure of oxygen as a person gains altitude, which results in less oxygen being delivered to the heart.

There are two types of angina:

1. Stable angina is chest pain due to cardiac ischemia that is well known to the patient for a period of several weeks, months, or even years. It is commonly due to stable atherosclerosis in the coronary arteries. The patient knows the symptoms and usually knows what level of activity causes these symptoms.

2. Unstable angina is new chest pain that is concerning for cardiac ischemia or a changing pattern in formerly stable angina. This is commonly attributed to a worsening of atherosclerosis in the

coronary arteries or a sudden rupture of an atherosclerotic plaque with the formation of a partial clot in a coronary artery.

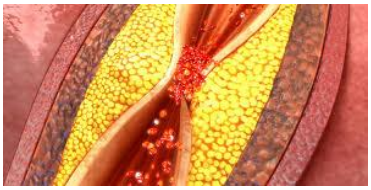
Symptoms of both stable and unstable are chest pain and/or pressure. This is often described as a squeezing or tightness. The pain is usually in the center of the chest, but it may occur unilaterally or even across the entire chest. The pain may radiate to the arms, jaw, neck, or back, typically more towards the left. Victims may have shortness of breath, nausea or vomiting, lightheadedness, or actual fainting. They can sweat.

Treatment for angina includes any steps to reduce the oxygen demand of the heart muscle. Also, rest is the key to the recovery of anginal pain. You should minimize exposure to the cold and decrease the elevation when possible, if possible, provide oxygen to the patient.

Medications can be used, as well. The patient might have been prescribed a drug called Nitroglycerin (NTG). It is given as 0.4 mg sublingual. This may be repeated every 5 to 10 minutes until the pain is relieved or until three tablets have been given. After three tablets have been given, you may continue to give the NTG if it is working, and it is all that you have, which is usually the situation. However, when going beyond the initial 3 NTG tablets, it should be given with a greater time interval between the tablets. If symptoms do not resolve after 3 NTG tablets, you should assume the patient is having a myocardial infarction and begin immediate evacuation plans. The biggest side effect of NTG is a drop in the blood pressure. If the patient has a strong radial pulse, then it is probably safe to give them at least one tablet. You should have the patient lying supine when you give them the NTG. If there is any concern of dropping the blood pressure too much or if the patient is ill-appearing, then it may be prudent to not treat with NTG. This is because the NTG can help the pain, but it will not stop or treat a myocardial infarction.

Aspirin 325 mg chewed is also possible. It is chewed to ensure that it is rapidly absorbed. Aspirin is an anti-platelet agent that may decrease the formation of thrombus in the coronary arteries. It is proven to decrease mortality in myocardial infarction (heart attack). It does not help with angina, but in the backcountry, it is never clear if the patient is having angina or a heart attack. All patients with unstable angina must be evacuated from the wilderness as soon as possible.

Acute Myocardial Infarction (MI)



Acute Myocardial Infarction (MI) is the term given to chest pain that is associated with absent or diminished blood flow to a portion of the heart that causes myocardial tissue death (infarction).

The most common etiology for an MI is an atherosclerotic plaque in one of the coronary arteries that rupture, causing the formation of a clot within the artery. This clot obstructs the flow of blood distal to that obstruction. If that clot is not relieved as soon as possible, myocardial cell death will occur within 15 to 60 minutes with larger areas of infarction as time progresses.

Symptoms of MI are similar to angina. However, the symptoms are usually more severe in nature and last much longer than angina. Typical angina should be relieved within 15 minutes. If symptoms last longer than 15 minutes, the patient should be considered to be having an MI. Patients without a prior history of angina should be assumed to be having an MI and treated as such.

Chest pain or pressure is one defining difference between MI and angina. This is often described as a squeezing or tightness. The pain may be in the center of the chest, unilateral, or even cover the entire chest. The pain may radiate to the arms, jaw, neck, or back, frequently towards the left side.

Other symptoms are shortness of breath, nausea or vomiting, lightheadedness or actual syncope, diaphoresis, and a feeling of impending doom.

Treatment of an MI is immediate evacuation. This is the most critical priority for the patient with a suspected MI. The fastest way to the hospital is the best way to the hospital. This means that you may be required to put a patient through some exertion-such as walking out-in order to get him/her evacuated instead of waiting for evacuation. All of the following treatments are temporizing measures only until the patient can get definitive treatment. Steps to reduce oxygen demand of the heart muscle are important and similar to angina treatment. They should rest, reduce exposure to the cold, minimize anxiety, and go to a lower elevation.

Medications such as Nitroglycerin 0.4 mg are given under the tongue. This may be repeated every 5 to 10 minutes until the pain is relieved or until three tablets have been given. After three tablets have been given, one may continue to give the NTG. However, it should be given over a longer period of time, checking the patient's radial pulse each time prior to giving an additional dose. The biggest side effect of NTG is a drop in blood pressure. If the patient has a steady radial pulse, then it is safe to give them at least one tablet. There is one type of MI, right ventricular infarction, which is very sensitive to preload (venous return) reduction. This means the patient may have a significant drop in blood pressure with even one NTG tablet. Understand that this is a potential complication and ensure that you evaluate the patient's vital signs before each NTG tablet by checking for a steady radial pulse each time.

Aspirin 325 mg chewed is chewed to ensure that it is rapidly absorbed. Aspirin is an anti-platelet agent that may decrease the formation of thrombus in the coronary arteries if that is the primary problem. It is proven to reduce mortality in myocardial infarction.

Clopidogrel (Plavix) 300-600 mg orally. This is an anti-platelet agent that works through a different mechanism than aspirin. You should give this if it's available in addition to the aspirin. Most people will not have this on them.

All patients with acute MI must be evacuated from the wilderness as soon as possible.

RESPIRATORY EMERGENCIES

The inability to breathe normally is a scary feeling and causes anxiety for many. Respiratory issues are common in the wilderness for a variety of reasons, including increased allergens, smoke from campfires, lower oxygen and drier air associated with higher altitudes, increased exertion, and increased physical and emotional stress.

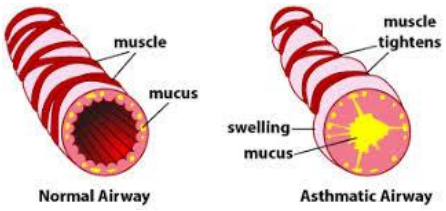
COPD

COPD exacerbation is not frequent in the wilderness as patients with COPD generally do not venture very far into the wilderness. Patients with COPD usually know that they have it and are on medication to treat it. Patients complain of shortness of breath, similar to episodes that they have had in the past. Some patients will complain of tightness in their chest in addition to difficulty breathing. This is difficult to differentiate from angina or MI, especially in the wilderness.

The treatment is to minimize the patient's activities and exertion. Review the patient's medicines and administer them if available and needed. Increase oxygen for the patient by descent, supplemental oxygen, or both, if the opportunity is available. Short-acting inhaled medicines are most helpful in relieving acute symptoms. Beta-agonists such as albuterol (Proventil) usually are with the patient, and you should administer these. Keep in mind an infection such as pneumonia as a potential etiology for their symptoms.

Consider antibiotics presumptively to treat for respiratory pathogens. Patients with an exacerbation of COPD should be evacuated from the wilderness.

Asthma



Asthma is a chronic, non-progressive lung disorder characterized by increased airway reactivity to irritants, airway inflammation, and reversible airway obstruction. In the wilderness, asthma can be triggered by a multitude of potential etiologies such as increased strenuous activity, exposure to cold, changes in humidity, exposure to environmental allergens, exposure to camp smoke, and medication noncompliance due to running out of medications.

Patients who have asthma usually know that they have it and are taking medication. They will have shortness of breath on exertion, wheezing, or a dry cough. Most patients will know when they are having an asthma exacerbation based on their previous episodes. They should also be able to tell you whether their current symptoms are mild, moderate, or severe in comparison to previous episodes. This is useful in terms of judging their response to treatment and the need for evacuation.

If the patient can speak in full sentences, then this is a mild exacerbation. The treatment of mild to moderate exacerbations is administering a short-acting inhaled beta-agonist such as albuterol. They will usually have one, but if not, maybe someone else might. Oral steroids can be taken to improve symptoms and to prevent a recurrence. You might need to evacuate a patient depending on the severity and the response to treatment.

If the patient can only speak a few words at a time, they are having a severe exacerbation. A short-acting inhaled beta-agonist in repeated inhalations should be given as much as needed. An epi-pen is a significant consideration if the patient is not responding to the inhaled medications or if inhaled medications are unavailable. Steroids such as prednisone or dexamethasone must be given. Patients with severe exacerbations of asthma must be evacuated from the wilderness. Those patients with mild to moderate exacerbations must be monitored closely and should have their activities limited. They do not require evacuation unless their symptoms do not resolve with field treatment.

Pneumonia

Pneumonia in the wilderness is a clinical diagnosis based on the patient's history and exam findings. The patient will have chest pain that may be dull or sharp, may have a pleuritic component, and a cough that may be dry or productive of sputum. They will have shortness of breath, and also on exertion. They will have a fever and chills and an increased respiratory rate.

If you suspect that someone has pneumonia, you should start antibiotics, even if unsure. Azithromycin or doxycycline are good choices. Remember to keep the patient well hydrated. If you suspect pneumonia, then the patient should be started on antibiotics and evacuated.

Pulmonary Embolism (PE) & Deep Venous Thrombosis (DVT)

Pulmonary Embolism (PE), or a blood clot to the lung, can be seen in wilderness activities. Traveling a long distance with relative immobilization places someone at risk of developing a deep venous thrombosis (DVT) and/or a PE. This is an essential consideration for those who traveled great distances to begin their wilderness adventure. High-altitude climbers are more susceptible to PE, particularly if they are dehydrated. Risk factors for DVT/PE include a previous history of a blood clot/DVT/PE, a long travel time to get to the destination, leg trauma while hiking or doing other outdoor activities, being tent bound or sitting on a raft for a long period of time, oral contraceptives, especially in women over age 35 who smoke, a family history of blood clot/DVT, and a history of cancer or recent surgery.

Symptoms may look similar to pneumonia. They may have a sudden onset of chest pain that may be dull or sharp and may have a cough that may be dry or productive of bloody sputum. There could be shortness of breath and/or dyspnea on exertion, an increased respiratory rate, and unilateral leg swelling.

There is no specific treatment that can be given in the wilderness that will help these patients. Recognition of this potential diagnosis is the most important part of the management of these patients. Aspirin could theoretically help. Descent, if at altitude, may help those with more significant symptoms. All patients with suspected PE or DVT should be evacuated as soon as possible.

NEUROLOGIC EMERGENCIES

Cerebral Vascular Accident (Stroke)

Cerebral Vascular Accident (CVA), or stroke, can occur anywhere but are seen in the wilderness for a variety of reasons. There are two types of stroke: Ischemic and Hemorrhagic.

Ischemic

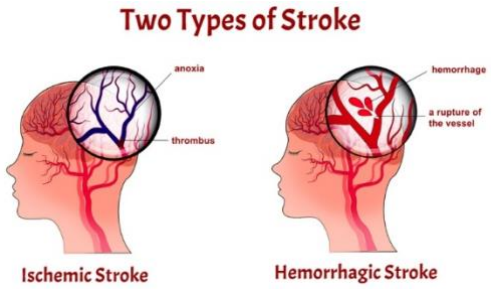
This is the most common type of stroke. Obstruction of blood flow to a portion of the brain leads to one-sided weakness, paralysis, trouble talking, or facial droop. This obstruction is most commonly due to a small intra-arterial blood clot.

Hemorrhagic

This stroke is due to intra-cerebral bleeding, most often from high blood pressure or a ruptured brain aneurysm. Patients usually have a significant headache and a denser neurologic deficit, or complete loss of consciousness.

The signs and symptoms of each are not consistent enough to allow one to discern an ischemic stroke from a hemorrhagic stroke in the wilderness. The only accurate way to tell the difference between ischemic and hemorrhagic strokes is by brain imaging (CT or MRI). Always consider hypoglycemia of a migraine headache, as they have stroke-like symptoms.

The signs and symptoms of a CVA vary depending on which part of the brain is affected. It can be a single sign or a combination of any of the following depending on the area and extent of the involvement.



- Alteration of mental status. Common symptoms include confusion, stupor, and unconsciousness.
- Difficulty speaking or an inability to speak and ataxia. Symptoms include weakness to complete paralysis with the involvement of a single leg, arm, hand, or a facial droop.
- Unilateral facial involvement. Symptoms include numbness or a total loss of sensation. If symptoms resolve quickly, then it is more likely a transient ischemic attack (TIA), sometimes called a “mini-stroke.” However, a TIA is a harbinger of a stroke, so even if the symptoms resolve, the patient must be evacuated as soon as possible.

Treatment for presumed ischemic CVA or TIA is the same; evacuate the patient as soon as possible. Aspirin is to be given in an ischemic CVA, but not a hemorrhagic CVA. Since an Ischemic CVA is more likely than a hemorrhagic CVA, a single aspirin is unlikely to affect a hemorrhagic stroke adversely (if you're not sure of the difference). However, it is not recommended to give aspirin to a patient with a known hemorrhagic stroke. All patients with CVA or TIA should be evacuated from the wilderness as soon as possible.

Seizures

Seizures are an uncommon medical problem in the wilderness because most people with this disorder tend to avoid wilderness activities. Either that or they are well controlled. In general, patients should be seizure-free for approximately six months before attempting to trek into the wilderness for any significant amount of time. There are numerous reasons for a patient with a known seizure disorder to seize in the wilderness, including:

- Fatigue and lack of adequate sleep.
- The risk of diminished absorption of their medications due to dietary changes.
- A higher risk of missed medication doses due to the rigors of the trek and a different schedule than at home.
- Increased stress, which could exacerbate someone's condition.

Note, Hypoglycemia is an alternative cause of seizures and should be considered as a diagnosis.

There are many forms of seizures, including **generalized** and **partial**. *Generalized* seizures involve a loss of consciousness and may include tonic and clonic phases lasting from one to five minutes, with loss of bowel or bladder function, followed by a postictal period of confusion and fatigue. Seizures lasting longer than 5 minutes, or repeat seizure activity for longer than 30 minutes or without regaining normal consciousness in between, indicates status epilepticus. Mortality rate is as high as 30 percent, and permanent neuronal damage may result within one hour in patients with uncontrolled seizures. People who have *partial seizures* do not lose consciousness during the seizure. Although fully aware of what's going on, find they can't speak or move until the seizure is over.

Treating a seizure in the backcountry can be a real problem if everyone in the group is in a remote setting. The seizure may occur in someone while the group is doing a more technical activity, such as climbing or rafting. When treating a seizure, look for trauma, and consider hypoglycemia as an etiology. Allow the seizure to run its course. Most seizures will resolve spontaneously within 1 – 5 minutes. While the patient is seizing, you can do things to protect them from harm, such as:

- Remove the patient from any hazards, such as pulling them out of water or away from a cliff edge.
- Lay the patient on the ground so that they do not fall and hurt themselves further. Do not restrain them or hold them down. If possible, positioning them on their side may help avoid aspiration. Once they have stopped seizing, consider the recovery position.
- Move objects that are a potential danger away from the patient.

- Do NOT try to prevent them from biting their tongue by placing objects in their mouth. They will NOT swallow their tongue. You will do more harm by placing objects in their mouth.

The group trip must be halted until the patient is out of the postictal phase. This timeframe may last hours, up to a day, and can be characterized by drowsiness, confusion, nausea, and headache.

Evacuate anyone who has had a new seizure. If the patient has a known seizure disorder, it might be possible to increase the patient's anti-seizure medicine in order to keep them in the wilderness (as long as there are no other risks such as falling from a significant height or drowning). This should only be done in conjunction after a thorough discussion with the patient, and the group, regarding the risks.

DIABETIC EMERGENCIES

Diabetic patients who travel in the wilderness have very few limitations. Most diabetics know their diabetes well and are usually able to manage it appropriately on their own. Diabetics should carry a method to measure their serum glucose level on their trips. The diabetic should educate other people on how to use their glucose monitoring equipment in case they are unable to measure it themselves. This is especially important for you to know if you are going to be the medical provider on a wilderness trek.

If you are leading a group, or providing medical care, on a wilderness trek here are some proactive precautions you should take if you know you will have a diabetic patient in your group:

- Check that their diabetes has been stable for one year before going to altitude.
- They need to stay well hydrated.
- Their insulin needs to be kept at an appropriate temperature; otherwise, it may become ineffective.
- There should be enough medicine to last for a period of time past the scheduled end of the trip in case the trip is extended due to unforeseen circumstances.
- Diabetics must monitor their serum glucose more closely in the backcountry as food and activities will be different.
- Always keep a sugar source nearby to treat low blood glucose if necessary.

Hypoglycemia is common in the backcountry. It occurs when a person's blood sugar becomes too low. It could be the result if the patient:

- Took too much insulin or too much of an oral agent;
- Ate too little in comparison to the diet they are on at home;
- Exertion level is much higher than usual, resulting in higher glucose metabolism than expected.

Symptoms may look precisely like a stroke, so hypoglycemia should be considered as a diagnosis. Rapid onset of confusion, irritability, combativeness or agitation, or the loss of coordination, or

inability to walk. They can have a headache, slurred speech, weakness or numbness, tremors, and sweating.

Treatment for hypoglycemia is sugar (glucose). Administer it immediately as hypoglycemia is a true emergency where minutes do count. There are several methods to give glucose. The most common is oral glucose paste; however, carrying a small tube of cake frosting will work. If the patient is unable to eat, you may rub the glucose solution on the gums of the patient. Once you have gotten them out of the initial stage and the patient's mentation has cleared, feed them. Give them a meal that has complex carbohydrates and protein that will last for a longer period of time. These patients must be monitored closely for the next 6 hours to ensure that their hypoglycemia does not recur.

Patients with hypoglycemia do not require immediate evacuation. Evacuate those if their hypoglycemia returns despite treatment with glucose and a meal. Evacuate those who do not have a rapid clearing of their neurological deficits.

High altitude is associated with severe diabetic ketoacidosis, though the reason is unclear. Above 2,500 meters, freezing temperatures, hypoxia-induced lack of appetite, medication side effects, and the higher incidence of mountain sickness can make diabetes difficult to control. Diabetics CAN travel safely to high altitudes, but they should be warned of these potential issues.

ALLERGIC REACTIONS AND ANAPHYLAXIS

Allergic reactions are common in the backcountry. On a spectrum, there are three types of allergic reactions that exist: **local**, **generalized**, and **anaphylaxis**. Any of these reactions can occur within seconds of exposure to an allergen.

Local reactions are very common in the wilderness setting. They are characterized by red and swollen areas of the skin that are usually pruritic. Topical corticosteroids provide relief and should be carried in a first aid kit. Benadryl (Diphenhydramine) may be useful for the itching. Cold packs may alleviate some of the pain or discomfort.

A **generalized** reaction can come from any source. Symptoms include itching, hives, redness, and possibly difficulty breathing. Any of these may begin immediately or hours after the exposure occurs. Treatment is to remove the patient from the allergen and to treat them with antihistamines and possibly prednisone.

Anaphylaxis is a real life-threatening emergency. It begins as a generalized reaction but rapidly results in respiratory and/or circulatory collapse. These reactions are not subtle and include

pruritus, hives, flushing, and swelling of the tongue and lips. The patient will have shortness of breath, wheezing, and tightness in their chest. Nausea, vomiting, diarrhea, and abdominal cramping sometimes occur. A drop in blood pressure may also occur.

Treatment for anaphylaxis must be immediate, as shock and respiratory arrest can occur in a matter of minutes. A delay of even several minutes can be life-threatening. An EpiPen® (epinephrine auto-injector) is the primary treatment. The dose is 1:1000 epinephrine 0.3 mg for adults and 0.15 mg for children. There are many types of epinephrine auto-injectors available, and all are reasonable to use as long as they have the appropriate dosing. This auto-injector also comes in both adult and junior forms. Every wilderness medicine kit should carry one of these.

Give the IM injection directly into the thigh muscle, through pants if necessary. There is better absorption when the IM is given in the thigh in comparison to the deltoid muscle. Be careful to hold the pen the correct way, without your thumb on the tip, to avoid injecting yourself. Familiarize yourself with the pen prior to your trip to avoid confusion in an emergency. A second dose of epinephrine may be required within 5 - 20 minutes after the first dose, depending on the severity of symptoms and the initial response to the epinephrine.

Antihistamines need to be given. There is no best antihistamine, although non-specific antihistamines such as diphenhydramine (Benadryl) or chlorpheniramine (Chlor-Trimeton) are most commonly used.

An H_2 blocker such as cimetidine (Tagamet), ranitidine (Zantac), or famotidine (Pepcid) should be administered in addition to the other antihistamines. Steroids should also be given, such as prednisone. And inhaled albuterol can be used for wheezing.

All patients with anaphylaxis require immediate evacuation from the wilderness. Although the patient may rapidly improve with epinephrine, and all of the other medications, they are at risk of rebound anaphylaxis that could be worse than the initial reaction. Those with local and generalized reactions do not usually require evacuation unless their symptoms do not resolve with treatment, or they have worsening symptoms.

ABDOMINAL EMERGENCIES

Any cause of abdominal pain in a city can also be a cause of pain in the backcountry. However, there are some causes that are more common in the backcountry. It can be a challenge to know what is causing the pain, and if a person should be evacuated out of the backcountry.

Severe Constipation / Fecal Impaction

This is more common in the wilderness than most people realize. A person can become dehydrated easily, which leads to hard stools. They may feel awkward defecating outdoors, the delay of which can lead to impaction.

Symptoms are no stooling for several days, gradually increasing the pain. The treatment is high levels of hydration plus increased fiber. Bowel stimulants are indicated. Caffeinated drinks can stimulate bowel motility. Fecal impaction is not an indication for immediate evacuation, but it can lead to severe problems if not resolved.

Gastritis / Gastroenteritis

This is a very common cause of backcountry abdominal pain. It is often caused by a virus or a bacterium that is ingested with food.

Symptoms include nausea, vomiting, and abdominal pain or discomfort. The patient often has, or will have, diarrhea that may be watery and contain mucus and blood. They may have a fever. Patients may have significant malaise and fever. Dehydration may occur from an inability to take liquids and considerable fluid loss from diarrhea. While in an urban setting, Diarrhea is uncomfortable, in the wilderness setting, it can pose a serious problem.

Treatment is large amounts of fluids that contain sugar and electrolytes. This should be given frequently in smaller than usual amounts due to nausea/vomiting. Imodium may be used in those with frequent stooling. However, this is an area of controversy due to the concern of worsening illness in those with symptoms due to a bacterial infection. Patients may respond to Cipro, particularly those with bloody stools and fever.

Most patients with gastroenteritis will resolve their symptoms in 24 to 48 hours with symptomatic treatment. Those with intractable nausea, vomiting, and diarrhea who have significant dehydration, abdominal pain, or fever should be evacuated.

Ectopic pregnancy

Ectopic pregnancy is probably the most urgent cause of abdominal pain due to its potential to take a life. The symptoms are not subtle. There is lower abdominal pain or abnormal vaginal bleeding in a sexually active fertile female. The pain may be in the midline or unilateral in location, depending on where the ectopic pregnancy is located. Initially, the pain may be mild in nature. Not all patients will have vaginal bleeding or specific vaginal symptoms. An over-the-counter urine pregnancy test is very reliable and accurate in determining pregnancy. The best urine sample is the first-morning void as it is the most concentrated. Always consider bringing several pregnancy tests along if you are the responsible health care provider on a wilderness adventure. An important differential diagnosis is a ruptured ovarian cyst, which presents similarly with unilateral pain but with a negative pregnancy test. A cyst that ruptures adjacent to a vessel may continue to hemorrhage and requires emergent surgical intervention.

Treatment is immediate evacuation for any patient you think might have an ectopic pregnancy. This is a true medical emergency, and immediate evacuation is required.

Appendicitis

Appendicitis does occur in the backcountry, and it is difficult to diagnose. It's difficult to diagnose appendicitis in the hospital setting, even with diagnostic testing, so you can imagine the difficulty with making a diagnosis in a wilderness setting.

Symptoms often start as epigastric discomfort that may be associated with anorexia, nausea, and possibly vomiting. The abdominal pain progressively worsens over the next 6 to 24 hours as it localizes to the right lower quadrant. The patient will develop initial tenderness in the right lower quadrant, which then progresses to peritoneal signs. Patients may develop a fever much later in the disease process.

Ensure that the patient has not already had their appendix removed. Appendicitis is a disease that requires surgical removal. All patients whom you suspect of having appendicitis should be evacuated. Consider administering antibiotics such as Cipro if the patient is not going to be evacuated within four hours. This *may* help delay perforation or help treat the patient if their appendix has already perforated. Evacuate all cases of suspected appendicitis.

Gallstones

Gallstones have occurred in people on a wilderness trip, but no more frequently than if one is at home. Most people know if they have gallstones, or have had gallstones, and will recognize the pain. This will help in making decisions. Gallstones present with abdominal pain that is typically located in the middle of the abdomen. The pain may radiate to the back or into the right shoulder. Nausea and vomiting are common and may be the initial symptoms before the pain.

Treatment is to first ask the patient if they have gallstones or if they have had their gallbladder removed. Pain relief can be provided with ibuprofen or possibly opiate analgesics depending on the amount of pain. A "gallbladder attack" alone is not necessarily an indication for evacuation unless the symptoms do not resolve over 6 to 12 hours. Evacuate those patients who have continuous or worsening pain, or intractable nausea and vomiting.

Kidney Stones

Kidney stones can occur in the backcountry, and possibly with more frequency in people who are prone to them. The reason is dehydration. People will who have had kidney stones should make sure they stay hydrated. Symptoms are the sudden onset of severe pain in the flank or back or unilateral abdominal pain. The pain is colicky and may radiate to the groin. The patient has difficulty finding a comfortable position and will be writhing in pain. Treat them with pain relief. Ibuprofen may help, but a narcotic might be needed. The primary reason to evacuate someone is

due to the amount of pain they are in. Most patients will require evacuation, but those achieving adequate pain control with NSAIDs may be able to stay out in the wilderness.

General evacuation guidelines for abdominal pain are to evacuate a patient if abdominal pain has any of the following:

- The pain is associated with any signs or symptoms of shock.
- The pain persists for longer than 24 hours or gets progressively worse over a period of time.
- The pain localizes, and there are signs of guarding, rigidity, and tenderness.
- Blood appears in the vomit, feces, or urine.
- The pain is associated with a fever higher than 102 degrees F.
- The patient has a positive pregnancy test.
- The patient is unable to drink or eat.

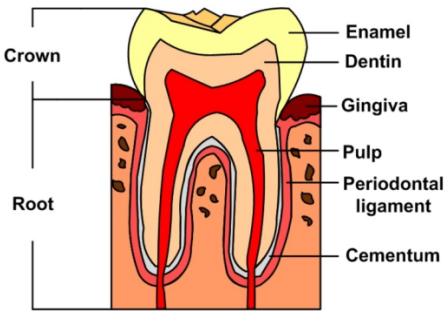
Chapter 10: Wilderness Dentistry

Dental problems are common on backcountry trips and provoke considerable anxiety. Most people don't even think to learn about dental problems and procedures beforehand. Backcountry trips increase the incidence of dental issues, as participants often have dry mouths from increased respiratory rate and inadequate fluid intake. Also, brushing and flossing teeth often becomes a secondary consideration when people are tired. Teeth are exposed to extreme cold (or heat) so tooth sensitivity can become an issue. Teeth may be subject to trauma as well. This chapter is to teach dental first aid, to help get a person back home where a dentist can take care of the dental problem.

BASIC DENTAL ANATOMY

Let's start with basic anatomy. This will help you as you learn how to treat dental problems. Each tooth is made up of the same four components: **enamel**, **dentin**, **cementum,** and **pulp**.

Enamel is the substance that covers the anatomic crown of the tooth. It is the hardest substance in the body. The enamel is the first line of protection for the tooth. It can withstand biting pressure but does not have the ability to regrow once fully formed. It chips easily. In fact, the entire enamel can be chipped off in a fall.



The **dentin** is the substance that lies beneath the enamel and the cementum. It is not as hard as enamel, and it makes up a significant portion of the tooth. The dentin is comprised of microscopic tubes known as dentinal tubules. Because dentin is softer than enamel, if decay passes through the enamel and invades the dentin, it can spread very rapidly. If the tubules become exposed, teeth become very sensitive to cold and air.

The **cementum** is the substance that covers the root of the tooth. It is also very thin and not as hard as the enamel but has a similar hardness to bone.

The **pulp** is the final component, and it is where all the nerves and blood vessels that supply the tooth are housed. If the pulp is exposed, you get a toothache. If a filling encroaches on the pulp, that can hurt also.

The supporting tissue consists of the **gingiva** (gum), **periodontal ligament**s (PDL), and **bone**.

Oral Infections

Occasionally, people will have a mouth infection while on an outdoor trip. These can be viral, fungal, or bacterial. The first two are less frequent and generally not a significant health threat in the wilderness. However, bacterial infections are more common and can become a severe problem if not treated, in part because they have the potential to spread.

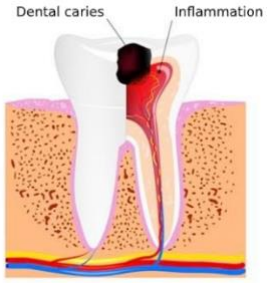
Bacterial infection

A bacterial infection in the mouth or near the mouth can become a serious health threat. Such an infection should be treated aggressively. Oral infections generally spread slowly, but a rapid spread to deep, fascial spaces may occur. Where definitive treatment is delayed, antibiotics should be started. If the swelling is soft and fluctuant (i.e., an abscess is present), drainage will relieve pressure and prevent further spread. This might be challenging for people in the wilderness.

Pulpitis

Inflammation of pulp is the primary cause of most toothaches and is often the precursor for more serious dental and facial infections. The pain can range from mild to debilitating and can be steady or intermittent. Inflammation can arise from bacterial entry into the pulp from tooth decay, also called a cavity. Sometimes a restoration has been placed in close proximity to the pulp chamber, and this can cause pain.

Trauma can cause inflammation of the pulp, which causes necrosis of pulp tissue. Pulpitis in early stages can be reversed. Early on, the tooth will be sensitive to a stimulus such as heat or cold, or sweet or sugary food placed on the tooth. Once the noxious stimulus is removed, the tooth returns to its normal status. The other type of pulpitis is called irreversible pulpitis. Here the tooth will frequently remain achy or painful after the stimulus has been removed.

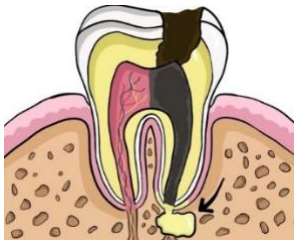


Signs and symptoms of pulpitis may range from mild, intermittent pain to severe, constant pain. It will usually have sensitivity or pain to stimuli such as cold, hot, sweets, or tapping. In the early stages, it may be difficult to identify the offending tooth. In these cases, the tooth may look normal, or have a small cavitary lesion. In later stages, tooth decay may be quite obvious.

The treatment of pulpitis is first to remove any irritants or debris. You can then fill any defect in the tooth. Use NSAIDs and topical anesthetics as the first line for pain management and opiate analgesics for breakthrough pain. A 2008 Cochrane review stated that antibiotics do not improve pain for patients with irreversible pulpitis. All patients with pulpitis should see a dentist upon returning home. Patients with severe, unrelenting dental pain should be evacuated.

Dental Abscesses

These infections can be caused by dental caries (cavity), deep restorations that approximate the pulp chamber, pulpitis, and periodontitis (gum disease). An abscess from a tooth will follow the path of least resistance. Generally, it will stay localized and drain into the oral cavity. However, in some cases, it may spread along fascial planes and into deep tissue spaces. All abscesses should be monitored and treated. Any increased swelling or spread of infection is a reason to evacuate the patient to obtain proper treatment.



Periapical Abscess

This abscess is confined to the apex of the tooth. Swelling may occur on the facial aspect of the jaw and the buccal vestibule adjacent to the offending tooth. Signs and symptoms include pain, swelling (localized), a tooth sensitive to tapping, and the patient may have a prior history of a toothache.

The treatment initially is pain management. Antibiotics are usually unnecessary unless cellulitis is present. Periapical abscesses are typically managed by a dentist who will extract the tooth, perform a root canal, or conduct an incision and drainage. These measures are usually impractical, if not impossible, in the backcountry setting, but there are a lot of stories where these were done. If a fluctuant area is appreciated, a stab incision to the area of maximal fluctuance may temporarily relieve the pain and serve as a temporizing measure.

Periodontal (gingival) Abscess

This is an infection caused by bacteria between the tooth and gingiva (gums). You will see swelling near the gingiva where it meets the tooth. The tooth may be sensitive to percussion and heat or cold. No incision is necessary. Drain through the gingival sulcus (between the tooth and gums) by pulling the gingiva away from the tooth with a blunt instrument. This will hurt at first, but then the pain will go away. You should follow up with warm to hot saline rinses.

Facial Space Abscess

While most dental abscesses localize around a tooth, there is potential for the infection to spread into areas of the head and neck in such a manner that they may become life-threatening. Due to the proximity of the central nervous system and airway to the oropharynx, timely efforts are required to treat this condition. In the wilderness, immediate evacuation is indicated. The patient will have severe swelling and difficulty opening the mouth. Pressing under the tongue will be very sore. The patient should be given antibiotics (see below) and then evacuated.

When a Filling Falls out

When fillings or crowns fall out, the tooth can hurt. Also, food can become stuck in between teeth, making teeth and gums sore. To correct the situation until you can get to a dentist, you should first

remove any debris in or around the tooth. You can rinse the mouth or try to pick debris out if necessary. Once this is done, you need to fill the hole in the tooth with some temporary filling material.

There really are two products that you can choose to put in your first aid kit.

- **Cavit** comes pre-mixed and will harden once placed in the mouth. Cavit can be thinned, if necessary, by mixing it with petrolatum jelly (Vaseline).
- IRM comes in a powder/liquid form that requires mixing. The advantage of IRM is that it can be mixed to any consistency.

Lost Crown or Bridge

If a crown or bridge falls out, the area might hurt. Food can become impacted in the area. It will need to be cleaned out, and the crown replaced. First, clean out the old cement from inside of the crown. Place a thin film of soft, temporary filling material in the crown and place the crown back on the tooth. Have the patient bite down to squeeze out excess cement. Have the patient bite down to ensure that the replaced crown doesn't interfere with his or her bite. Remove excess filling material.

Dental Trauma

Injuries to teeth are common during high-adventure activity, such as mountain biking, skiing, climbing, or rafting. Trauma can be isolated to the tooth, but it often involves the soft tissue and supporting tissue as well. Clean the region well to unmask injuries hidden by blood or debris. Evaluate lacerations for any foreign material, including pieces of broken teeth. You should examine teeth for fractures and pulp exposures. You should evaluate the mandible and facial bones for any fractures.

Uncomplicated Crown Fracture or chipped tooth

These are common in backcountry sports where almost anything can strike the mouth. When you look at it, you will see an obvious chip in the tooth. The pulp is usually not exposed, but it might still be sensitive to stimulus (hot, cold, sweets). The treatment is pain management. You can smooth sharp edges by placing temporary filling (IRM, Cavit, soft wax, or tape) over the tooth. Avoid any stimulus that may aggravate the tooth

Uncomplicated Crown-Root Fracture

This fracture usually occurs with pre-molar and molar teeth, when part of the cusp has broken away but remains in the mouth because it is still attached to the gingiva. There is no involvement of the pulp by definition. When you examine the area, there will be a loose piece of tooth, and there

will be pain or irritation on biting. The treatment is to remove any loose fragment(s), and then cover the tooth with a temporary filling. This will help with pain, but you might need to give Ibuprofen.

Complicated Crown Fracture

This is where there is a fracture involving exposure of pulp. It will be very sensitive to air, cold, and other stimuli because of the exposed nerve. The treatment is to stop the bleeding by biting on some gauze. However, because the nerve has been exposed, the tooth is very sensitive, so the sooner the victim is taken to a dentist, the better. You can try to cover the tooth with a temporary filling and then give pain medicines.

When a tooth is Knocked Loose

Trauma to the mouth may not fracture a tooth. Instead, damage may occur to the supporting structures around the tooth, in which case the tooth will be displaced from its normal position. The following are possible scenarios that can affect teeth and supporting tissues.

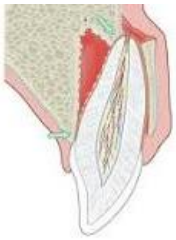
Subluxation

Subluxation is where the tooth has increased mobility but has not been displaced from its original location. Symptoms may vary depending on the severity of injury to the supporting structures. Treatment consists of a soft diet, rest, and NSAIDs for pain management, if necessary. When injured teeth are painful, temporary splinting may ease pain and enhance the ability to eat.

Intrusive Luxation

Intrusive Luxation is where the tooth has been pushed into the socket. The tooth is not mobile. Any wilderness treatment will be temporary, as the tooth will be out of alignment. A dentist will need to realign the tooth.

Extrusion Luxation



Extrusion Luxation is where the tooth is extruded partially from its socket and extremely mobile. Use gentle, steady pressure to reposition the tooth, allowing time to displace any blood that has collected in the socket area. This will hurt to do. After reduction, the tooth should be splinted.

Lateral Luxation

Lateral Luxation is where the tooth is displaced laterally because of bone fracture and can get locked into a new position. If this happens, the tooth will not be mobile. To treat this, grab the tooth at the apex and push toward the crown while the other finger places a small amount of pressure outwards to help position the tooth back into its socket. The tooth may snap back into position and be quite stable. You might need to try this several times. Splint the tooth afterward.

When a Tooth is Knocked Out

Having a tooth knocked out on a wilderness trip is not uncommon. Kayaks are prone to the paddles hitting people in the face, and bikers can fall on their faces. Quick action is needed to increase the survival of the tooth. The longer the tooth is out of the mouth, the less the chance for survival of the tooth. The prognosis also depends on the health of the periodontal ligament (PDL) cells, some of which are on the root of the tooth, while others are in the socket.

The best thing to do is to try to put the tooth back in its socket, so be careful of the tooth. Do not scrub, curette, disinfect, or let the root surface dry out. Rinse the tooth with saline to remove debris. Remove clotted blood from the socket, using gentle irrigation and suction. Avoid scraping the socket walls. Replace the tooth gently with steady pressure to displace any accumulated blood. This will hurt. The tooth will then need to be splinted in place. This may be difficult but necessary.

If immediate replantation is not possible, place the tooth in the best transportation medium available. There are a number of solutions:

- Save-A-Tooth (Hank's balanced salt solution, which is a physiologically pH balanced saline). This you would need in a first aid kit.
- Coconut water: appears to be better than Hanks' solution. A study published in the Journal of Conservative Dentistry in 2008 compared many medium and found this to be superior when transporting an avulsed tooth. But it also showed that milk was very good also.
- Milk is a good solution, if not the best solution, with whole milk being the best. If you don't have milk, have the patient spit into a cup and place the tooth in the saliva. Do not place the tooth in the victim's mouth if there is a possibility that he/she might aspirate it.
- DO NOT USE: Saltwater, Gatorade, sports solutions, and water do not work well as transport solutions because they can damage the PDL cells. They should only be used to clean the tooth for immediate replantation and not for transportation.

Once a tooth has been repositioned back into the socket, it will need to be splinted so that the ligaments can reattach. It may be necessary to improvise with material on hand. Fishing line or even floss could be bonded to splint teeth. Sutures can also be used to support the tooth by running the suture through the gingiva on the facial aspect of the tooth and then through to the lingual gingiva, making a sling that will stabilize the tooth.

Injuries to Primary Teeth

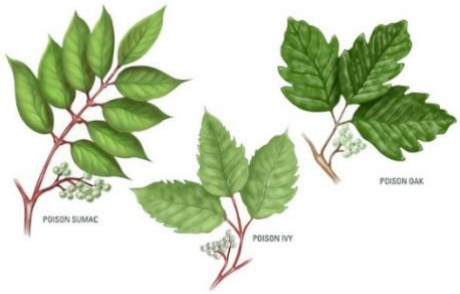
When dealing with first aid for primary teeth, the general rule is to remove the tooth if it is in the way. If a young child has sustained an injury that results in a tooth becoming dislodged or loose, the best treatment is simply to remove it.

Chapter 11: Wilderness Dermatology

Some plants will cause itchy rashes when touched. Some of these are common garden plants and can be skin irritants for people with sensitive skin. It may be parts of the plant that irritate, like the sap of *Euphorbia,* or the roots of hyacinth. For some susceptible people, any part of a plant can cause irritation. However, it is the sap of poison ivy, poison oak, poison sumac, and the spine of stinging nettle that cause the most issues for people when they go outside.

PLANTS THAT IRRITATE THE SKIN

Poison Ivy, Oak, and Sumac



These plants belong to a genus of plants called Toxicodendron. They all contain a toxic resin called urushiol, which is responsible for the characteristic reaction. Urushiol is contained within the leaves, fruit, root, and stem of the plant. The urushiol compound is not a defensive measure. Instead, it helps the plant to retain water. It is frequently eaten by animals such as deer and bears.

Merely touching the plant does not cause a skin reaction. The plant must be broken open to release the resin. It is not difficult to do this, as even raindrops can release the resin. Urushiol is remarkably adhesive and can cling to pets, garden tools, and clothing. It's very heat stable and can attach to smoke particles, making it possible for people who burn these plants to breathe it into their airway and lungs, causing a frightening possibility. The toxin is resistant and lasts on objects for months and even years. It is estimated that about 85% of the population will develop an allergic reaction if exposed to urushiol. A simple rash may be the first reaction with a more pronounced rash and reaction that can occur with subsequent exposures.

These three plants are mostly found throughout the continental United States. In general, poison ivy grows east of the Rocky Mountains, poison oak grows west of the Rocky Mountains, and poison sumac grows in the southeastern United States. The plants may look different depending on the season and the area where they are growing. All of these plants have small white, tan, cream, or yellow berries in the fall. Their berries can help distinguish them from harmless but similar plants. After the leaves have fallen off, these plants can sometimes be identified by the black color on areas where the oil in the plant (urushiol) has been exposed to air.

Poison ivy is found everywhere in the United States except Alaska and Hawaii. It is most common in the eastern and midwestern states. It is less common outside the United States but still found on

every continent. It has three broad, spoon-shaped leaves or leaflets, but it can have more. The phrase, "Leaves of three? Let it be," may help people remember what poison ivy looks like. It grows as a climbing vine or a low, spreading vine that sprawls through the grass (more common in eastern states) or as a shrub (more common in northern states, Canada, and the Great Lakes region). It is a hazard for boaters as it often grows along rivers, lakefronts, and ocean beaches. It has bright red leaves and white or cream berries in the autumn.

Poison oak is most common in the western United States, although it is also found in the eastern states. It rarely is found in midwestern states. It has leaves that look like oak leaves, usually three leaflets but sometimes up to seven on each leaf group. It grows as a vine or a shrub.

Poison sumac is much less common than poison ivy or poison oak. It is found in wooded, swampy areas, such as Florida and parts of other southeastern states. It is also found in wet, wooded areas in the northern United States. It has 7 to 13 leaflets on each leaf stem. The leaves have smooth edges and pointed tips. It grows as a shrub or a small tree.

None of these plants grow well above 4,000 ft (1,219 m), so the higher elevations, in places such as the Rocky Mountains, are relatively free of them. None of these plants grow well in deserts, except along the banks of rivers, streams, and ponds. Heavy rainfall can make a dormant plant grow again, even in a desert.

Hawaii or the south sea islands do not have any of these plants, although other plants that cause a skin rash are found on the islands. For example, mango trees grow in Hawaii, and the skin of mangoes contains the same allergenic oil (urushiol) as Poison Ivy. These plants do not grow in Alaska, and they are rarely found in the rainforests of Washington state and Oregon. Some species of Toxicodendron are found in Taiwan, Japan, Korea, and Sakhalin.

The reaction is called Toxicodendron dermatitis. It is a type IV hypersensitivity reaction. Urushiol contacts the skin after direct encounter or contact through a secondary host such as a pet or a piece of clothing or a tool. Once urushiol contacts the skin it seeps through the protective epidermal level. The toxin is detected by antigen-presenting cells that migrate to the lymph nodes and activate T cells. The cytotoxic T cells mount an attack that leads to the vasodilation and characteristic tissue response at the site of skin contact. Once an exposure has caused the formation of clonal T lymphocytes, a subsequent exposure may cause a more rapid response.

The most common reaction from exposure to one of these plants is an itchy red rash on the skin that came in contact with the plant. The rash often includes fluid-filled vesicles or bullae in a linear arrangement. The vesicles do not contain urushiol, and the rupture of the vesicles does not spread the disease. In a first-time exposure, the appearance of skin lesions is common within 24 to 48

hours but may be delayed up to 21 days. For someone who is allergic, the rash appears between 4 to 96 hours after exposure. The time of onset of the rash can be difficult to describe because urushiol can cause a rash that is due to both contact irritation and allergic response. A small minority of the population is considered "exquisitely sensitive" to urushiol. These patients will develop the rash within 6 hours of exposure. These patients need immediate treatment.

Avoidance of these plants is the surest prevention of poison ivy contact dermatitis. Full-length clothing helps prevent direct contact with the plants, but the urushiol resin can soak through protective clothing, even rubber or leather gloves. Vinyl gloves, however, are an effective barrier.

Once exposed, the area should be washed. A person with an average allergic response can prevent an immune reaction by washing off the resin within 20 minutes. The efficacy of rinsing the affected area seems to diminish as time passes. Rinsing with warm or cold water will help remove the resin without opening pores and enhancing absorption into the skin. Mild hand soaps and non-abrasive rubbing are also recommended. Rubbing alcohol is effective at removing the urushiol resin both from the skin and from tools and clothing. Take care to avoid reusing the cotton to prevent the spread of the resin. When cleansing, take special care to remove resin from the fingernails to prevent further spread of the resin.

A mild rash involves minimal exposure to urushiol, causing only small eruptions on the skin. If available, the use of high-potency topical steroid creams before the formation of vesicles will offer relief and stop the allergic response. However, after vesicles have formed, topical steroids may not change the course of the allergic reaction but can relieve itching. Antihistamines can provide relief. The skin irritation can be soothed with calamine lotion or Aveeno oatmeal bath soaks. Burrow's solution or Domeboro astringent solution may be applied to dry, weeping areas for relief of itching.

These topical products offer relief but do not alter the course of dermatitis. If the rash is larger, the treatment should include oral steroids. Prednisone is the drug of choice in this case. If the reaction causes airway or genital swelling or involves a large amount of body surface, the patient might need hospital care. Therefore, evacuation might be considered. Most cases of poison ivy contact dermatitis are self-limiting and will resolve in 1 to 3 weeks without any treatment. The vesicles will eventually rupture, crust over, and then heal.

Zanfel® Poison Ivy Wash is a product that studies have shown to remove urushiol from the skin any time after the outbreak. It can provide relief of itching and pain. Zanfel works by binding to the urushiol oil, and, when rinsed off, takes the oil with it. Tecnu Extreme® works in a similar fashion. The leaves and the juice from the stem of Jewelweed can also be used as a treatment for poison ivy, poison oak, and other plant induced rashes, as well as many other types of

dermatitis. Jewelweed works by counter-reacting with the chemicals in other plants that cause irritation. The most critical first step in eliminating the rash is to remove urushiol from the skin.

Stinging Nettle

This plant is the best-known member of the nettle family. It grows throughout the United States, Europe, Asia, and the southern islands, including Australia, New Zealand, and North Africa. The plant tends to grow in dense patches near streams, along hiking trails, in ditches, and around farmland, often where the earth has been disturbed. The stems of stinging nettle are singular, with few branches, and can grow 6 to 8 feet tall. The stems may be green or purple and may or may not have stinging hairs. The stem parts of the leaf and undersides of the leaves also have stinging hairs.

Coming into contact with stinging nettle causes a sharp, painful sting, followed by a burning sensation and sometimes itching. The irritation can linger for several hours and cause hives near the site of contact, which can last up to 24 hours. It's important not to touch the rash for the first 10 minutes after receiving the sting. This is because, if the chemicals are allowed to dry on the skin, they're easier to remove. Any touching or rubbing could push the chemicals deeper into the skin and cause the reaction to be more severe and last longer.

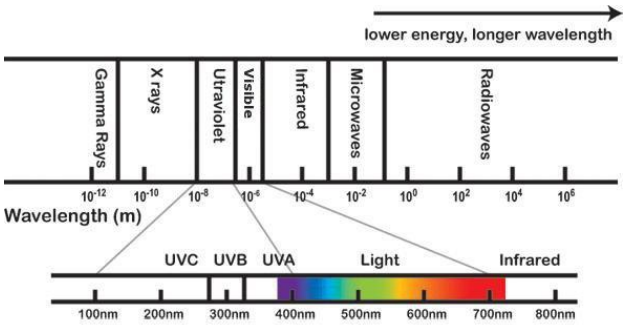
After 10 minutes, use soap and water to wash away the chemicals from the surface of the skin. This can often be enough to significantly reduce or altogether remove any pain, itching, or swelling. A clean cloth can be used if you aren't close to soap and water until the area can be adequately cleaned. After cleaning, use a sturdy tape to remove any remaining fibers from the skin.

These actions will usually bring relief quickly. But sometimes the effects of the sting can last up to 24 hours. Avoid hot temperatures and scratching, as these can further irritate the area. Cool compresses can be applied for relief. You can also try aloe vera and a paste made from baking soda and water. Anything that you put on the skin should be dabbed, not rubbed. Topical creams, lotions, or ointments that contain hydrocortisone can feel soothing and may help to relieve the redness and itching. Oral antihistamines can also be effective as well.

Sunburn

Sunburn is an inflammation of the skin that is caused by overexposure to the sun's ultraviolet (UV) rays. Generally, there are two classes of UV rays that are clinically important in sun exposure: UVA and UVB.

UVA rays penetrate the skin deeply. They damage the DNA of the skin cells, contributing to the development of skin cancers. UVB rays affect the more superficial layers of the skin and are the chief cause of skin reddening and sunburns. They also play a role in the development of skin cancer and wrinkling. The tanning effect of the skin is also a response to UVA and UVB exposure. Ultraviolet light is not safe for the skin. UV rays strike the skin and cause multiple effects. Skin redness appears as the local blood vessels dilate, and inflammatory substances (including histamine) are released. Fair-skinned people are particularly susceptible to sunburn because their skin produces only small amounts of the protective pigment, melanin. Even dark-skinned people, while they have a lower risk, can develop skin cancer.



Most everyone has had a sunburn and can diagnose one. The symptoms can vary from mild redness and warmth of the skin to severe pain and blistering. The classification of sunburn is first-degree and second-degree sunburns. A first-degree sunburn is exhibited with redness and pain that may peel but heal within a few days, while a second-degree sunburn will have redness and pain, but may also have blisters and cause systemic symptoms such as fever, chills, and headache. The best way to treat a sunburn is to avoid one. In the wilderness, sunburn can cause significant problems, including ending someone's trip. People should limit sun exposure to early in the day or late in the evening. Keep contact time to a minimum.

Covering up to prevent sunburn is the best. Wear breathable full-length clothing, use wide-brimmed hats, and seek shade. When the sun cannot be avoided, sunscreen should be applied. Sunscreen works, but not as well as coverage with clothes. Everyone six months of age and older should use sunscreen. Infants younger than six months of age should be kept out of the sun because their skin is thin and susceptible to burning. Sunscreens have not been approved for infants.

Several studies in the early 2000s showed that people wearing sunscreen developed far more skin cancers. That is because sunscreens contain the chemical PABA, which screens UVB rays but not UVA rays. UVA rays are the ones that cause cancer. Sunscreens do not prevent cancer. They only prevent sunburn. They also do not protect against wrinkling. The best way to prevent skin cancers is to cover up. There are newer agents that seek to deal with these issues, but they are not as successful as covering up with clothes or staying out of the sun. Sunscreen should be applied to dry skin 30 minutes before sun exposure. Sunscreen must be reapplied after two hours or sooner if sweating or swimming. Even waterproof sunscreen loses its effectiveness after about 80 minutes.

Sunscreen effectiveness is defined by the SPF. Despite the fact that very few people know what it is, SPF is actually pretty straightforward. SPF stands for "Sun Protection Factor" and is a measure of the sunscreen's ability to protect your skin from UVB rays. The basic calculation works like this. If it takes 1 minute for your unprotected skin to start turning red in the sun, using an SPF 15 sunscreen theoretically prevents reddening 15 times longer. For example, someone purchases an SPF 30 sunscreen. If it typically takes 10 minutes until that person's skin starts to burn, by using the SPF 30, they are theoretically protected from the sun for 300 minutes, or 5 hours. But sunscreens wash off the skin easily. Even sweat will cause them to wear away. There is no such thing as waterproof sunscreens, and they do not last all day.

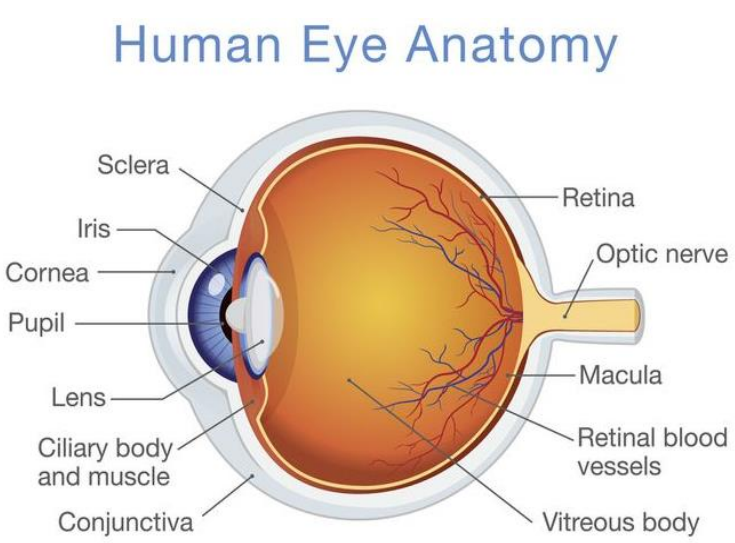
Ultraviolet light, especially UVB, is needed for vitamin D. Human skin makes large amounts of vitamin D when lots of skin is exposed to the sun. The body is designed to get the vitamin D it needs by producing it when your bare skin is exposed to sunlight. So, this remains a challenge. Proper exposure is the key to avoiding sunburns and skin cancer while obtaining appropriate levels of vitamin D.

The mainstays of therapy for sunburns are pain control and skincare. Pain control can be achieved with acetaminophen or Ibuprofen. Benadryl provides a benefit for itching relief. Cool soaks in water or applying moisturizers such as aloe vera are excellent. Topical steroids show little to no benefit at all. First-degree sunburns heal within a few days.

Second-degree sunburns also have redness and pain but are more extensive, have blisters, and may cause larger systemic symptoms such as fever, chills, and headache. In addition to the therapies for first-degree sunburns, these patients may require stronger pain medications. If a large body surface area is involved, if systemic symptoms such as fever, chills, and headache are present, or if pain cannot be controlled, then the patient should be evacuated.

Chapter 12: Eye Problems in the Wilderness

Our eyes are our windows to the world, and although most of us go through life with nothing worse than a speck of dust causing problems, some injuries can occur to the eye in the wilderness that need to be addressed. Some of these injuries are minor but will necessitate treatment in the backcountry. However, others will be so serious that they carry with them the potential for loss of eyesight. The initial step, when confronted with an ocular malady in someone, is to classify it as *traumatic* or *non-traumatic*.

<table>
<tr><th colspan="3">Eye Anatomy</th></tr>
<tr><td>Cornea</td><td>The clear front window of the eye that transmits and focuses light into the eye</td><td rowspan="4"> 
</td></tr>
<tr><td>Iris</td><td>The colored part of the eye that helps regulate the amount of light that enters</td></tr>
<tr><td>Pupil</td><td>The dark aperture in the iris that determines how much light is let into the eye</td></tr>
<tr><td>Lens</td><td>The transparent structure inside the eye that focuses light rays onto the retina</td></tr>
<tr><td>Retina</td><td colspan="2">The nerve layer that lines the back of the eye, senses light, and creates electrical impulses that travel through the optic nerve to the brain</td></tr>
<tr><td>Macula</td><td colspan="2">The small central area in the retina that contains special light-sensitive cells and allows us to see fine details clearly</td></tr>
<tr><td>Optic Nerve</td><td colspan="2">This connects the eye to the brain and carries the electrical impulses formed by the retina to the visual cortex of the brain</td></tr>
<tr><td>Vitreous</td><td colspan="2">Vitreous is a clear, jelly-like substance that fills the middle of the eye</td></tr>
<tr><td>Sclera</td><td colspan="2">It's the white part of the eye. It is the opaque, fibrous, protective, outer layer of the human eye containing mainly collagen and some elastic fiber</td></tr>
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WILDERNESS EYE INJURIES

Traumatic Eye Problems

Open Globe Injury

An open globe injury occurs when there is a full-thickness injury to the cornea or the sclera. This can be the result of a blunt or penetrating injury. Aqueous or vitreous humor leaking from the wound is usually seen, and the globe usually appears sunken due to loss of fluid. Once this is recognized, a protective shield should be placed over the globe. Do not apply a pressure dressing. This condition is very painful. No further exam should be done, and the patient needs to be evacuated immediately. The patient should be given oral antibiotics if available. A fluoroquinolone is the drug of choice. Do not administer topical anesthetics or antibiotics.

Penetrating Foreign Body

If a foreign object has penetrated the eye, do not try to remove it. Stabilize the object by taping a sterile dressing in a donut shape around the eye and then tape a cup or pair of glasses over the eye to prevent any jarring of the embedded object. You may want to patch the other eye shut in order to avoid eye movement if the victim does not have to use his or her sight to navigate out of the wilderness.

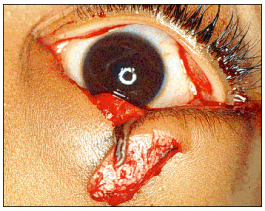
Occult Ruptured Globe

The presence of an open globe injury is not always obvious. Whenever there is trauma to or around the orbit, the eye should be assessed for signs of an open globe. The signs include a large subconjunctival hemorrhage, hyphema (blood pooling in the eye), corneal abrasion, or a peaked pupil. A suspected occult rupture should be treated the same as an obvious globe injury.

Superficial Lid Laceration

A superficial lid laceration does not cut through the full thickness of the eyelid and does not include the lid margins or the eye itself. However, penetration of the eye by a foreign object must be ruled out. Treatment of superficial lid lacerations is the same as that for other minor lacerations. Place some clean gauze to apply pressure to the wound to stop the bleeding. However, it is important not to put much pressure on the eye, but rather on the surrounding bones of the orbit. After the bleeding stops, irrigate the wound with clean water or saline solution to remove dirt or foreign objects. The wound may then be closed with tape. These usually do not need to be sutured. Do not use skin glue to close lid lacerations due to the possibility of getting the material in the eye. You normally don't need to evacuate.

Complex Lid Laceration



A complex lid laceration cuts through the full thickness of the lid, includes the lid margins. When looking at these, make sure there is no damage to the globe. You can use sterile gauze to stop the bleeding. Then, irrigate the laceration with saline solution or clean water. A lot of people are not comfortable closing complex lid lacerations. There is a considerable risk of a poor cosmetic and functional outcome if the laceration is not closed

appropriately. However, due to the need for repair, patients with complex lid lacerations should be evacuated. The wound should be treated with antibiotic ointment and then kept covered.

Blunt Orbital Trauma

Blunt force to the bone around the eye (the orbit) can fracture the thin bones that hold the eye in place. This would likely be obvious, as significant periocular bruising and swelling will occur. More concerning is that there may also be restriction of eye movements, due entrapment of the muscle belly in the fracture. This most commonly affects the inferior rectus muscle as the floor of the orbit is much weaker. Significant swelling, restricted eye movements, clear fluid leaking from of the nose, and decreased vision following blunt trauma to the orbit suggest considerable damage. The victim should be evacuated for evaluation and treatment.

Corneal Abrasion

Abrasions occur when the top surface of the cornea is scraped. A corneal abrasion may result in moderate to severe pain but might also be an irritant. People may tear and experience sensitivity to light. Patients often say that they have a foreign body sensation in their eye. To see the abrasion, you first will apply a topical anesthetic. This usually will get rid of all discomfort and allow for further evaluation of the eye. Next, apply fluorescein dye, and then look at the eye. A corneal abrasion will appear bright green when viewed with the UV light. The sun is an excellent source of UV light. Antibiotic drops and fluorescein strips are good to have in a wilderness first aid kit.

To treat this, you will place some antibiotic eye drops in the eye. This is another useful item for a wilderness first aid kit. Artificial tears can provide substantial relief with no side effects. You might want to patch the eye for comfort. This is done by tightly taping a piece of gauze from the forehead to the cheekbone. Eye patching is not a necessity and does not decrease time to recovery, but some victims report that this provides relief from their symptoms. These usually heal within 24 hours.

Hyphema

A hyphema is a collection of blood in the anterior chamber of the eye and is usually caused when someone is hit in the eye. Hyphemas are best examined when the patient is sitting or standing, as the blood in their eye will settle, resulting in the formation of a meniscus in the anterior chamber. Small hyphemas can be difficult to see when the patient is lying flat. This is a serious condition that mandates evacuation. Avoid using aspirin, ibuprofen, or any other medications that may cause more bleeding. These people may become nauseated due to increased intraocular pressure. Activity should also be restricted as much as possible during the evacuation, though ambulation has not been shown to increase the risk of rebleeding. If able, elevate the head to at least 30 degrees to decrease pressures in the anterior chamber. Do not lower the head below the heart for the same reason.

Non-Traumatic Eye Problems

Acute Vision Loss in a Normal-Appearing Eye

If someone loses their vision in a normal-appearing eye, you have to consider a serious condition that cannot be treated in the backcountry. Conditions such as a retinal detachment, or a stroke, are near the top of the list. There is no definitive treatment available in the wilderness for any of these issues. The patient needs to be evacuated.

Subconjunctival Hemorrhage

This is an accumulation of blood in the space between the conjunctiva and the sclera. This results in an extremely red-looking "bloodshot" eye but is not a serious condition. This condition may occur spontaneously or as a result of increased intrathoracic pressure, which occurs with straining or coughing and can occur at altitude. They normally resolve over a period of a few days to two weeks without treatment.

Conjunctivitis

The major causes of conjunctivitis are viral, bacterial, and allergic. Conjunctivitis is usually self-limiting and requires no treatment, but they are irritating. In the wilderness, the most practical treatment for the symptoms of these conditions is cold compresses using snow, ice, or a cool, wet cloth if available. You can try a topical antibiotic ointment or drops in case there is a bacterial cause. If topical antibiotics are unavailable in the wilderness, or if inflammation becomes worse after a few days of treatment, it may be appropriate to evacuate for evaluation and treatment

UV Keratitis

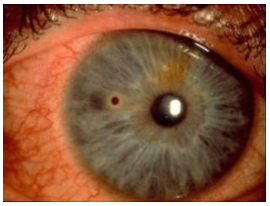
This is best described as a sunburn on the surface of the eye caused by UV exposure. Symptoms begin about 6 to 10 hours after sun exposure, and victims typically are not aware that damage is occurring during the time of actual exposure. People with this are usually very uncomfortable, and their pain is worse with light exposure. Sunglasses or eye patching may help with the discomfort. Prevention is the key to this type of exposure. When traveling on snow or water, it is essential to wear sunglasses or glacier goggles to prevent corneal damage. Altitude is a significant risk factor as UV damage is more significant at altitude.

Dry Eye

Dry eye is a frequent wilderness problem due to wind exposure, as well as the dry conditions associated with high altitude. It is a diagnosis of exclusion, and other conditions such as foreign bodies, ulcers, and abrasions must be ruled out before blaming dry eye for the patient's symptoms. There may be a history of a previous dry eye. Treatment is with artificial tears. Goggles and glasses that protect from the wind are also helpful.

Foreign Body

Foreign bodies are common in the eye in backcountry activities. When a person has one, it is important to find it and remove it. This includes everting the upper and lower lids. If you cannot find a foreign body, you can irrigate the eye with water. You can also sweep the eye with a cotton swab. After removal, the eye should be treated as a corneal abrasion. Evacuation will be necessary because corneal foreign bodies can cause permanent scarring, and conjunctival foreign bodies can become infected.



Chapter 13: Wilderness Management of Bites and Stings

There are numerous types of bites and stings that can occur in the wilderness, on land, and at sea. These bites and stings can come from wild animals, snakes, insects (such as mosquitoes, spiders, ticks, bees, and scorpions) to marine envenomation, such as jellyfish and Portuguese Man-of-War. All can be very dangerous.

The danger to a human who is bitten or stung is the type of disease that can be transmitted and/or the allergic reaction that can prove fatal. If you are an international traveler, you need to be even more careful because some of the contracted diseases can make you profoundly sick, and you may be far from definitive care. Animal bites can be very difficult to treat in the wilderness and can lead to profound underlying trauma or even death. (Side note: the majority of bites (80% to 90%) from domesticated animal bites are from dogs.)

Overall, the general management of a bite or sting is the same as a typical wound. You should conduct a primary and secondary survey to ensure the scene is safe and the victim is stable. Then, obtain hemostasis and apply wound-care techniques. Whether to close a bite wound, as well as the timing of the closure, is an area of discussion. Infection is common with animal bites. Bites are tetanus-prone wounds, so ensure that your tetanus immunization is up to date.

Rabies is another concern when a human is bitten by wild (or domestic) animals. Because of the risk of rabies, you should clean the wound using soap and water if possible. This is the one time that you would clean a wound with soap, as the positive effect of killing the rabies virus outweighs the risk of inhibiting wound healing. The wound should also be irrigated with an antimicrobial such as 1% povidone iodine. This can also eliminate the rabies virus before it enters muscle cells. Consider the need for rabies immune globulin and vaccination. While not a cause for immediate evacuation, the need for these treatments may necessitate shortening a trip considerably. The Center for Disease Control (CDC) has a 24-hour helpline that can assist in determining the need to administer the vaccine. The CDC can be contacted by clinicians at 1-877-554-4625 or via the web at http://www.cdc.gov/rabies.

The following describes the various types of bites and stings that one may encounter in the wilderness and suggestions for treatment.

TYPES OF BITES AND STINGS

Wild Animals

The number of wild animal bites is difficult to determine as many minor wilderness bites, and attacks are not reported. In Africa, many thousands of people are killed yearly by attacks from lions,

tigers, elephants, hippos, and crocodiles. However, in North America, large animals, like bears and cougars, kill very few people. Animal behavior holds the key to prevention for the majority of animal attacks. Most animals do not attack humans unless provoked. Even a timid animal can inflict a life-threatening injury if it is cornered. Observation of the animal's behaviors and cues should be undertaken to avoid mishap.

Bears

There are eight species of bears. They are widespread, appearing in a variety of habitants throughout the Northern Hemisphere and partially in the Southern Hemisphere. Bears are found on the continents of North America, South America, Europe, and Asia. The polar bear is the most carnivorous, while the panda bear feeds entirely on bamboo. The remaining six species are omnivorous with varied diets. When traveling, it is important to know what species of bear is native to that area and to know something about its behavior.

North American bears include the **brown bear** (Grizzly and Kodiak), American **black bear**, and **polar bears**. These bears are fast (running up to 40 mph), large (140 to 1,400 pounds), and have a keen sense of smell and hearing. A bear's sight is equal or less in acuity to that of a human. Bear attacks are more common in the summer months when wilderness visitors are more numerous, and bears are not hibernating. The most common scenario that ends in a brown bear attack occurs when there is a sudden and unexpected close encounter. Even so, the victims are rarely killed as the bear often inflicts the injuries and leaves without inflicting wounds to its maximum capability. Attacks that are more likely to be fatal include encroaching on a bear that is wounded, is with a cub, or is near a carcass.

In contrast to the **brown bear**, **black bears** rarely attack because of close encounters. If they attack, they typically are hungry and are looking for food.

There are a number of suggestions for preventing attacks. Hikers and explorers should make noise. There are hand clickers that can be used, but even talking will allow a bear to hear and move away from you. However, be extra cautious in environments where a bear may not be able to hear you, such as near loud streams and in uneven terrain. Hikers should avoid common bear areas, such as streams with spawning fish, berry groves, and carcasses. If spotted by a bear, allow it to see you as a human by stepping forward to allow the bear a full view of you.

Pepper spray can be useful if discharged directly at a charging bear's head when it is within thirty feet. Pepper spray is not to be used as a repellent. It is a specific aerosol bear deterrent. Its active ingredients are capsaicin. This is extremely irritating to the bear's lungs, and it will immediately retreat. Guns are ill advised as the bullet will often miss or injure the bear, which will only enrage it.

If you encounter a **brown bear**, it will likely think you are attacking it. Therefore, you should do the following:

- Do not look into the bear's eyes, as this is interpreted by the bear as a sign of aggression.
- Do not make any sudden movements and do not run.
- Do not act aggressively toward the bear. However, you should stand your ground, but be submissive.
- If attacked, quickly get into the fetal position with your neck protected, because attacking bears are "head oriented". If rolled onto your back, protect your face with your elbows.

If you encounter a **black bear,** it is likely attacking you for food. Take the following actions:

- Yell and throw things and act aggressively toward the bear. Black bears usually flee in response to aggression.
- If the black bear attacks, then you should continue to fight and kick against the bear as much as possible. The reason for this is that the bear is attacking you because he wants to eat you and has lost the fear of humans.

After a bear attack, the possibility of significant injury is high, so all bear attack victims should be considered blunt trauma victims and, therefore, candidates for immediate evacuation.

Mountain Lions

The mountain lion, also known as the cougar, puma, panther, or catamount, is a large cat species native to the Americas. The historic range of the mountain lion includes almost all of North and South America. They are coming into contact with humans with increasing frequency. They hunt by stealth, then pounce and break the victim's neck. They can be scared off by using aggressive behavior toward the animal, although this is less likely in the case of a mountain lion with a cub or one that is wounded. When confronted, face it, talk very loudly, and make yourself appear as a threat. Do not turn and run away from a mountain lion; they can run much faster and will chase you. If you have small children with you, pick them up, as they preferentially attack children. If a mountain lions attacks, fight back using anything available, including rocks, sticks, and bare fists. Be aware that they are close to urban areas as well, and attacks happen on trails used by bikers and hikers.

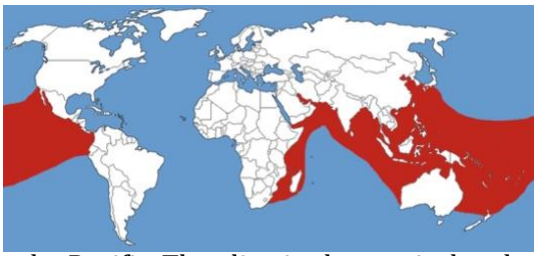
Snakes

The easiest way to classify snakes for medicine is by three families:

- Vipers
- Round Snakes
- Sea Snakes

		
Viper (rattle snake)	**Round Snake** (coral snake)	**Sea Snake**

Family	Classification	Description	Types
Viper	Cortalidae	Triangular head	Cottonmouths, rattlesnakes, copperheads, puff adder, gaboon
Round Snake	Elapidae	Round head	Coral, mambas, kraits
Sea Snake	Sub class of Elapidae	Found in oceans	



Snakes are found everywhere on land except the North and South Poles, the islands of New Zealand, and the islands of Hawaii. They are found in fewer numbers in places like Europe and Scandinavia. Snakes can live near the tops of mountains (Timber rattlesnake) or in grassy fields. Sea snakes are found in warm coastal waters from the Indian Ocean to the Pacific. They live in the tropical and warm regions, but not in the Atlantic Ocean, or the North American coast above the Gulf of California. All sea snakes are deadly. Knowing the location of snakes and whether or not they are venomous to humans is important medically.

In ancient times, snakes had legs, but these were shed as snakes evolved to slither through grasses. There are no plant-eating snakes. They evolved without teeth. The reason for this is unknown. This is important clinically as snakes must swallow their prey whole and digest it quickly before it putrefies. This would kill the snake. So, all snakes have specialized salivary glands that produce saliva that dissolves animal and human tissue. This is how they digest and eat their prey. However, about 15% of snakes have taken it further and developed venomous saliva that will kill their prey. Snake venom is a complex set of enzymes that can dissolve both muscle and red blood cells. It should come as no surprise that this is exactly what happens when they bite a human.

Snakes Around the World

Worldwide, it is estimated there are a minimum of 1 to 2 million annual snakebite "incidents". This number includes bites by non-venomous species. Of that number, roughly 50,000 to 100,000 bites result in fatalities worldwide. Many of the world's most venomous snakes have venoms that are very straightforward and 'easy' to treat effectively with the proper anti venoms. However, there are

some snake bites that cause a clinical explosion of problems for which antivenoms are not very useful.

The following is a list of the most dangerous and deadly snakes in the world. This list takes into account the potency of the snake's venom, the number of fatalities, and the aggressiveness of the snake. These bites must be treated aggressively, so it is essential to get to help quickly. Pressure dressings and tourniquets are appropriate. Antivenom should be administered as soon as possible, so immediate evacuation is essential. It is important to know where these deadly snakes are found and to be aware of appropriate treatments and where hospitals are located as a traveler goes to these various countries.

Black Mamba

The black mamba is found throughout most countries in Sub-Saharan Africa and is incredibly fast, traveling at speeds of up to 12 miles per hour. The Black Mamba is aggressive and territorial, characteristics not usually attributed to snakes. This snake is an olive-green color. The inside of its mouth that is black. Its poison is a very fast acting neurotoxin.

Russell Viper

This snake is found in Asia, throughout the Indian subcontinent, most of Southeast Asia, southern China, and Taiwan. It is responsible for more human fatalities than any other venomous snake. It is a member of the big four venomous snakes in India, which together are responsible for nearly all Indian snakebite fatalities.

Egyptian Cobra

This is the most common cobra in Africa and is responsible for many deaths there. It typically makes its home in dry to moist savanna and semi-desert regions, with at least some water and vegetation.

Mozambique spitting cobra

This is a type of cobra, native to Africa. It is considered one of the most dangerous snakes in Africa, second only to the Mamba. It can spit its venom.

Australian brown snake

This is a deadly Australian snake. One 1/14,000 of an ounce of this venom is enough to kill a person. It is the world's second most venomous land snake. Brown Snakes are very fast-moving and highly aggressive. When agitated, they will hold their necks high, appearing in a somewhat upright S-shape. The snake will occasionally chase an aggressor and strike at it repeatedly.

Death Adder

This snake is native to Australia. It is one of the most venomous land snakes in Australia and the world.

North American Snakes

North America has two native types of poisonous snakes. These are the Pit Vipers (Crotalidae) and the Coral snakes (family Elapidae). The overwhelming majority (over 99%) of envenomation are from pit vipers. Annually, there are approximately 9,000 snake bites reported to U.S.A. Poison Control Centers. This may be under the actual number as many victims do not present, and there is no mandatory reporting. Approximately 2,000 people are treated annually as envenomation victims. From 1991 to 2001, there were 57 deaths attributed to snake envenomation in the U.S.

Pit Vipers

In North America, pit vipers are found in 47 of the 48 contiguous states except for Maine. The pit viper includes multiple species of rattlesnake, copperhead and the cottonmouth (water moccasin). Pit vipers have specific recognizable anatomy including a triangle-shaped head, catlike, elliptical pupils, and heat-sensing pits between eyes and nose. Venom is dispersed from ducts in the fangs. About 25% of pit viper bites are "dry" or without injection of venom. Pit viper venom dissolves tissue, blood and nerve tissues. Therefore, they are very painful bites. Each snake has a varying potency of its venom based on multiple factors:

- Age of the snake
- Location of bite
- Size, age, and health of victim
- Depth of the bite
- Amount of venom injected
- Emotional state of snake
- Time of year that the bite occurs

These are painful bites with patients reporting severe burning at the bite site within minutes. Soft tissue will swell outward from the bite, and blood oozing from the bite is common. Bruising occurs as blood cells 'dissolve' and patients will feel weak. It is common to have various tastes occur in the mouth. Tingling will happen in the mouth, face, and extremities as fasciculations occurs while nerve tissues are destroyed.

The treatment of viper bites is simple. Evacuate all victims of bites from venomous snakes. Follow typical rules of treatment to support the airway, breathing, and circulation while transporting. Remove any tight-fitting jewelry and clothing to avoid a tourniquet effect. CroFab® has been shown to be effective and safe.

Coral snake

Coral snakes in North America have a very distinct color banding pattern. The bite of the coral snake typically involves a finger, toe, or fold of skin, because the coral snake is unable to open its jaws wide. These are not painful bites. There is minimal or no local swelling. It may be difficult to see the bite(s). Fang marks may be difficult to identify. Symptoms will often progress rapidly once they appear. These are nausea and vomiting, headache, abdominal pain, diaphoresis and pallor, paresthesias, and numbness. The treatment of a Coral snake bite is evacuation for definitive care. It

is a venomous snake bite and needs to be treated urgently. Pressure immobilization has been studied on animal models and is used in Australia for elapid snakebites but is not indicated for coral snake bites in the United States. Antivenom administration should be planned for all victims of elapid bites, as symptoms initially may be minimal but progress rapidly.

Snake bite treatment has been plagued over the years with poor suggestions and very bad information that has been adopted as fact. Here a list of things to avoid because they are either harmful to the victim or do not work:

- The Sawyer Extractor™ has been touted to remove venom if applied within two to three minutes of the bite. However, there is no evidence to support this at all. Therefore, the Extractor is NOT recommended.
- In North America, do NOT use pressure immobilization. Simple immobilization is fine, but it has no proven benefit.
- Electric shock therapy should NOT be used in any snakebite and can be harmful.
- Local application of ice is contraindicated, as it may worsen necrosis.
- Do NOT attempt to try to catch or kill the offending snake. Therapeutic recommendations for North American snake envenomation are the same for all species and attempts to capture a snake may result in additional envenomation and potentially another victim. Even a dead snake's jaw can clamp down and envenomate a human.
- Do NOT use aspirin, as it may worsen bleeding.
- Do NOT cut and suck on the wound, as this maneuver may infect the wound with oral bacteria and is ineffective at removing venom.
- Do NOT use a tight-fitting tourniquet that restricts arterial or venous flow.

Mosquitoes

Globally, there more than 3,000 species of mosquitoes, but only three species bear the primary responsibility for the spread of human diseases.

Anopheles	Malaria, filariasis (also called elephantiasis), encephalitis	
Culex	Encephalitis, filariasis, and the West Nile virus	
Aedes	Yellow fever, dengue, and encephalitis, chikungunya, Zika	

The **Anopheles** mosquitoes tend to prefer freshwater breeding sites and will bite at night in more remote settings. They are known to spread malaria.

The **Culex** mosquitoes breed in standing water. They can be quite persistent in their biting habits, and their bites tend to be painful.

The **Aedes** have particularly painful bites, and they can travel up to 75 miles away from the breeding habitat. They tend to bite during the day in urban areas.

Mosquitoes are attracted by CO2, lactic acid, warm skin, and moisture. They also move toward the smell of soap, detergents, and perfumes. Only female mosquitoes have the mouth parts necessary for sucking blood. When biting with their proboscis, they stab two tubes into the skin: one to inject an enzyme that inhibits blood clotting; the other to suck blood into their bodies. They use the blood, not for their own nourishment, but as a source of protein and iron for their eggs. For food, both males and females eat nectar and other plant sugars.

No other insect carries more disease or is responsible for more deaths on the planet than the mosquito. According to the World Health Organization in 2015 about 3.2 billion people, nearly half of the world's population, are at risk of malaria. Some of the most prominent diseases include:

- Malaria
- Dengue Fever
- Yellow Fever
- Eastern Equine Encephalitis
- Japanese Encephalitis
- St. Louis Encephalitis
- West Nile Virus
- Western Equine Encephalitis
- Rift Valley Fever
- Chikungunya
- Zika

A mosquito uses the sharp tip of its straw-like mouth (proboscis) to pierce a person's skin. It locates the blood vessel and draws blood up through its mouth. As it does this, it injects saliva that contains an anticoagulant. If the blood were to clot around the mosquito's mouth, it would stick in the skin. With the saliva comes the disease. Sometimes more than one disease will be injected into the human. So, every time an infected mosquito inserts its proboscis into the skin, that person is infected with the disease instantaneously, 100% of the time. Thus, the only way of being infected is to avoid being bitten.

Suggestions for avoiding a mosquito bite:

- Mosquitoes are most active at dusk, so staying indoors during that time will decrease contact.

- Choose a campsite that is above and away from standing water.
- Wear clothing with long sleeves and long socks with pants tucked into socks or boots.
- Wear clothing that is tightly woven, such as nylon, and is loose fitting so that a mosquito cannot bite through the clothing.
- Permethrin is a naturally occurring compound with insecticidal and some repellant properties that will remain on clothing for weeks when properly applied.

The United States Food and Drug Administration has approved three repellants for use in repelling mosquitos and other insects. They are DEET, Picaridin, and Lemon Oil Eucalyptus. These are applied to uncovered skin.

DEET is the gold standard for insect repellents. It is sold in formulations of 5% to 35%. Use formulations of 10% or less in children and avoid use altogether in infants under six months of age. You should use formulations of 30% to 35% in malaria areas on adults.

Picaridin 20% concentration has been shown to have a similar efficacy as 20% DEET for up to eight hours. Picaridin 7% has similar efficacy to 10% DEET. Picaridin has notably less malodor and less staining of materials than DEET.

Oil of lemon eucalyptus is a naturally occurring chemical, unlike DEET and Picaridin, which are synthetic man-made substances. Oil of lemon eucalyptus is generally considered to be the most effective natural repellent on the market. In 2005, the Centers for Disease Control added this to its list of recommended insect repellents. They found repellents with concentrations of at least 30% generally provide about two hours of full protection from mosquitoes and up to six hours under certain conditions, which is roughly equivalent to repellents with 10% to 15% percent DEET. However, it provides significantly less duration of protection than higher concentrations (20% to 50%) of DEET and Picaridin, which completely repel mosquitoes for five hours or more.

Multiple other repellants have been studied extensively. Noteworthy among them is IR3535, which is marketed by Avon as “Skin-So-Soft Bug Guard Plus”. Studies demonstrate a half-life of 20 min to 6 hrs. Overall, it’s less effective than 12.5% DEET

Spiders

Spiders are arachnids, a class of arthropods that also includes scorpions, mites, and ticks. There are more than 45,000 known species of spiders found in habitats all over the world. Spiders range in size from the tiny Samoan moss spider, which is 0.011-inch-long, to the massive Goliath bird eater, a tarantula with a leg span of almost one foot.

For most people, the thought of spiders conjures up images of fearsome creatures. Though all spiders have venom to one degree or another, only a handful are dangerous to humans. Those include the **black widow** and the **recluse**, both found in many places in the world. It's no longer

believed that hobo spider bites cause tissue damage or skin death (necrosis), according to the Centers for Disease Control and Prevention in the United States.

Most species are carnivorous, either trapping flies and other insects in their webs or hunting them. They don't have teeth and can't swallow their food whole, so they inject their prey with digestive fluids, then suck out the liquefied remains. This has clinical significance because if a spider 'bites' a human, there is often an allergic reaction to this fluid, which is often confused with an infection.

Though not all spiders build webs, every species produces silk. They use the strong, flexible protein fiber for many different purposes: to climb, to tether themselves for safety in case of a fall, to create egg sacs, to wrap up prey, and to make nests.

Black Widow

The black widow is a female of the *Latrodectus* species. It is characterized by shiny black skin and a red mark on the belly (often an hourglass shape). Black widows are found in temperate regions throughout the world, including the United States, southern Europe and Asia, Australia, Africa, and much of South America. In the United States, they exist primarily in the South and West. They may be found in dark, dry shelters such as barns, garages, basements, outdoor toilets, hollow stumps, rodent holes, trash, brush, and dense vegetation.

A sharp pinprick is usually felt when it bites. The bite area quickly becomes very painful and faint red bite marks may appear later. Muscle stiffness and cramps of the bitten limb may ascend to include the abdomen and thorax. People become horrified at the thought and often will become very excited or agitated. Additional symptoms include headache, chills, fever, heavy sweating, dizziness, nausea and vomiting, and severe abdominal pain. Most victims of black widow bites have excellent long-term outcomes.

The treatment begins with identification. Catch the spider, if possible, as even a smashed spider can sometimes be identified under the microscope of an experienced entomologist. Clean the bite with soap and water. These are painful bites. Achieve pain relief with a cold compress and oral medications. *Latrodectus a*ntivenin may be used in the hospital for children and the elderly, but it is rarely used. It has an extremely high allergic rate, and it is not always efficacious. The victim of a bite should be evacuated as soon as possible because envenomation can become very painful and the victim may warrant more medical attention than can be given in the wilderness.

Recluse

The most common and most famous recluse species is the brown recluse spider (*Loxosceles reclusa*). It is found in a large area of the Midwest to Colorado and east to northern Georgia in the United States. Sporadic records from other locations only represent incidental introductions, not established populations.

Other notable members of this genus include the Chilean recluse spider (*L. laeta*) which is native to South America. It is common in Chile but can be found in Perú, Ecuador, Argentina, Uruguay, and south and eastern Brazil. Also, the Mediterranean recluse spider (L. rufescens) which is considered a cosmopolitan "tramp" species, with widely scattered occurrences worldwide, including numerous sightings in the United States. All recluse spiders create small sticky webs under rocks and woodpiles and in warm human habitats including homes, warehouses, and sheds.

Most bites are unremarkable or mild. The initial bite is usually painless. The bite can become painful, red, and pruritic within hours after the bite. The majority of bites remain localized, healing within three weeks without serious complication or medical intervention. In more serious cases, the bite may become necrotic. In rare, more serious envenomation, recluse venom has a direct hemolytic effect on human blood. It also effects platelet aggregation. If the reaction becomes systemic, the victim will have hemoglobinuria within 24 hours that lasts for up to a week.

Treatment again begins with identification. Catch the spider if possible. Cleanse the bite with soap and water. Place a cold compress and give oral analgesics for pain control. The victim is in no immediate danger unless systemic signs begin appearing. These include fever or blood in the urine. Hospital management is only necessary if systemic symptoms occur. There is no need to evacuate the victim in the absence of systemic symptoms.

Ticks

Ticks are not insects, although they are often mistaken for them. Ticks are actually classified as arachnids, or relatives of spiders, scorpions and mites. They require blood for sustenance. Ticks don't jump or fly. Instead, they crawl up low brush or grass to find a host. Then, they clasp on with their back legs and reach their front legs out to grab onto a passing animal or human. This process is called questing. Ticks find their hosts by detecting animals' breath and body odors, or by sensing body heat, moisture, and vibrations.

Almost all ticks belong to one of two major families, the **Ixodidae,** or hard ticks, and the **Argasidae,** or soft ticks. Tick species are widely distributed around the world, but they tend to flourish more in countries with warm, humid climates because they require a certain amount of moisture in the air to undergo metamorphosis, and because low temperatures inhibit their development from eggs to larvae. A habitat preferred by ticks is the interface where a lawn meets the woods. They are ground dwellers.

Ticks are second only to the mosquito for being prolific at transmission of diseases. But unlike the mosquito which transmits disease instantaneously, transmission from a tick bite can take up to 2-3 days. So, if you can remove a tick within 24 hours, your chances of getting a disease is fairly low.

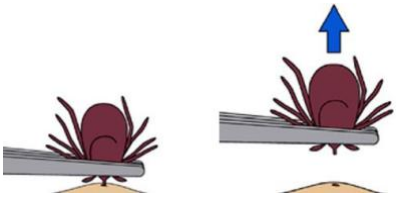
It's not unheard of for ticks to be carrying three different diseases at one time, making a diagnosis difficult.

Upward of 20 diseases are known to be transmitted from ticks to humans. Ticks transmit pathogens such as bacteria, viruses, and protozoa. Species of the bacterial genus Rickettsia are responsible for typhus, rickettsial pox, boutonneuse fever, African tick bite fever, Rocky Mountain spotted fever, Flinders Island spotted fever, and Queensland tick typhus (Australian tick typhus). Other tick-borne diseases include Lyme disease and Q fever, Colorado tick fever, Crimean Congo hemorrhagic fever, tularemia, tick-borne relapsing fever, babesiosis, ehrlichiosis, Bourbon virus, and tick-borne meningoencephalitis, as well as bovine anaplasmosis and probably the Heartland virus.

Alpha-gal syndrome is a recently identified type of food allergy to red meat and other products made from mammals. In the United States, the condition is most often caused by a Lone Star tick bite. The bite transmits a sugar molecule called alpha-gal into the person's body. In some people, this triggers an immune system reaction, sensitizing the individual, that later produces mild to severe allergic reactions to red meat, such as beef, pork or lamb, or other mammal products. So, when the sensitized individual eats meat, they can have a hypersensitivity reaction. Food allergies are to proteins and are almost an immediate reaction. Since Alpha-Gal is a type of sugar, the reaction usually takes 2-5 hours to occur, so it is confusing to patients and clinicians. Symptoms include typical systemic allergic reactions, but there often are intestinal problems with this reaction also. The Lone Star tick is found predominantly in the southeastern United States, and most cases of alpha-gal syndrome occur in this region. The tick can also be found in the eastern and south-central United States. Alpha-gal syndrome also has been diagnosed in Europe, Australia, and Asia, where other types of ticks carry alpha-gal molecules.

Prevention of ticks attaching, and frequent tick checks is the best way to prevent the transmission of disease. Know which ticks and which diseases are present in the area where you are hiking and camping. For example, ticks in South Carolina in the United States have the highest incident rate of Rocky Mountain Spotted Fever in the world.

Shirts should be tucked into pants and then pants into socks. Permethrin should be applied to clothes and DEET, should be applied on the skin. People can limit their exposure to tick bites by wearing light-colored clothing as well.



Tick removal is simple. Pull it off the skin. You can use your fingers if needed, but if you have tweezers or some other tool, use it to grab the tick as close to the skin surface as possible. Then, pull the tick straight upward with steady even pressure. Ticks don't have a 'head', so the head can't be left in the skin. It has a small 'poker' called a hypostome. If for some reason this remains in the skin, the clinical consequences are non-existent. Watch for local infection and symptoms of tick-borne illness

(incubation period 3 to 30 days), especially headache, fever, and rash. If you suspect that the tick may have had a disease such as Lyme Disease, RMSF, tularemia, or ehrlichiosis, a tetracycline such as doxycycline can be initiated while in the wilderness. Treatment for other tick-borne illnesses is supportive.

Ticks will remain on clothing after a wilderness trip. Wash clothes in hot water and use high heat in the dryer for at least one hour to ensure that all ticks are removed from clothing.
The DO NOTS of tick removal:

- Do not use petroleum jelly
- Do not use fingernail polish
- Do not use rubbing alcohol
- Do not use a hot match
- Do not use gasoline
- Do not grab the rear end of the tick. This expels gastric contents and increases the chances of infection
- Do not twist or jerk the tick, as this will most likely cause incomplete removal of the tick

Hymenoptera

Hymenoptera is the order of insects that includes ants, bees, and wasps. More people die in the U.S. from bee, hornet, and wasp stings than from any other animal bites or stings. A single sting to an allergic person can be fatal in minutes to hours. Non-allergic victims may experience fatal toxicity if they sustain multiple stings. But this takes many stings, upward of 500 to 1,400 simultaneous stings to cause death by toxicity in the non-allergic victim.

A local reaction is the most common reaction from a sting. It consists of a small red patch that burns and itches. The generalized reaction consists of diffuse red skin, hives, swelling of lips and tongue, wheezing, abdominal cramps and diarrhea. Victims of multiple stings often experience vomiting, diarrhea, dyspnea, hypotension, tachycardia, and syncope.

Hymenoptera are attracted to sweet-smelling fragrances, such as certain after-shaves and perfumes. Bee and wasps are attracted by rotten fruit and fruit syrups. People who have allergies to hymenoptera should see an allergist for desensitization, and they should wear medical tags and carry an EpiPen® or other epinephrine auto-injector.

The treatment of stings is straightforward. Scrape away the stinger in a horizontal fashion as soon as possible by any available means. Wash the site with soap and water. Place ice or a cold compress on the site. Give oral analgesics as needed for pain relief. Topical steroid cream can be helpful for swelling, as are oral antihistamines.

If hives occur with wheezing and respiratory difficulty, then epinephrine should be given immediately. It is given as an intramuscular epinephrine (1:1,000) at 0.3 ml for adults and 0.01 ml/kg up to 0.3 ml for children under 12. This can be repeated 5 to 10 minutes after the initial injection. Beta agonist inhalers (e.g., albuterol) may help relieve the wheezing. Oral steroids and antihistamines should also be added, especially in situations when epinephrine is used.

Scorpions

Scorpions are found in desert and semiarid climates between 50 degrees north and south latitude. Most scorpion stings result in only local pain and inflammation. In the United States, the most medically important scorpion is the bark scorpion (genus Centruroides); found primarily Arizona and New Mexico. In North America, more serious scorpion stings occur in Mexico.

Scorpions may sting multiple times. Except for the bark scorpion, most sting symptoms are similar to hymenoptera stings. For the bark scorpion a neurotoxin released at the time of the sting is the cause of ensuing neuromuscular activity and autonomic dysfunction. Symptoms include paralysis, muscle spasms, breathing problems, vision problems, swallowing difficulty, and slurred speech. Evacuation is necessary.
Scorpions are not afraid of people and will crawl on a body and hide in clothing and shoes. Check for scorpions in clothing, shoes, life jackets (etc.) when in areas common to scorpions. Do not place your hands or feet into areas into which you cannot look into directly.

The treatment of a scorpion sting is to clean the sting site with soap and water. Ice should be used if available. There are studies that suggest ice will help to neutralize the pain. For the vast majority of stings, this is enough. If the scorpion is identified as a bark scorpion evacuate as soon as possible, because the victim may decompensate rapidly. The need for evacuation is more significant in children and elders.

MARINE ENVENOMATION

Jellyfish and Portuguese Man-of-War

These ubiquitous marine creatures cause envenomation through their stinging cells. When these cells contact skin, they fire venom-laden tubules into the victim's skin. The greater the number of the stinging cells that contact the victim, the greater the envenomation. Envenomation can range from mild, which is the most common, to severe and life threatening. Portuguese man-of-war (*Physalia species*) and the Indo-Pacific box jellyfish (*Chironex fleckeri)* have toxic venoms, with Chironex being the more dangerous.

Mild envenomation is seen with most common jellyfish types. Skin irritation is the primary symptom but can ruin a day on the beach. The man-of-war and the box jellyfish can cause envenomation from mild to severe, depending on the degree of exposure to the tentacles. Moderate envenomation has increased skin symptoms along with neurologic issues like headache, vertigo,

ataxia, nerve palsies, paresthesias, paralysis, coma, and seizures. People may become hypotensive and develop arrhythmias. Broncho spasms are common, and patients will have myalgias, arthralgias, and muscle spasms. Patients will have nausea and go on to develop renal failure.

The treatment of these stings is to first follow the MARCH primary survey. Rinse the wound with seawater. Then remove tentacles with a gloved or otherwise protected hand. Acetic acid 5% (vinegar) should be poured on the stinger and tentacles as it inactivates the nematocysts and toxin for jellyfish. Apply continuously until the pain resolves. Isopropyl alcohol can be utilized if acetic acid is not available. However, this should not be used for Chironex. Once inactivated, the nematocysts should be removed. This is best done by applying shaving cream or baking soda and shaving off the nematocysts. If nothing else is available, make a paste of sand and scrape it off with a straight edge.

In man-of-war stings, hot water (45˚C) may be utilized to effectively reduce pain AFTER removal of nematocyst and irrigation of the sting area. Cold packs may also decrease pain. Because of the severe toxicity of Chironex, antivenom is often used in the prehospital environment in geographic areas where the creature is ubiquitous. Anyone with more than a minor envenomation and anyone with Chironex envenomation should be evacuated.

The DO NOTs of jellyfish and man-of-war stings:

- Do not use freshwater to rinse the stings. Freshwater will cause more nematocysts to envenom.
- Do not rub the area, as this will discharge more nematocysts.
- Do not use isopropyl alcohol for box jellyfish sting.

Stinging Fish

"Stinging fish" include many different fish with spines that possess a venom apparatus. Stinging fish include stonefish, lionfish, scorpion fish, stingrays, and catfish. The spines stick into the victim, break off and inject venom. These creatures are found worldwide in saltwater, with catfish also found in inland freshwater.

Sea urchins, although not "stinging fish," cause similar envenomation. All have venom that is injected when one comes in contact with their spines, or in the case of a stingray, its barbed tail. All of these fish sting humans as a defensive measure, typically when accidentally grabbed or stepped on. The toxins of stonefish, scorpion fish, and lionfish can cause muscle and nerve paralysis.

Stonefish venom has hemotoxic, neurotoxic, and cardiotoxic properties and is of such great toxicity that it has been compared to cobra venom. An antivenom is available for treatment of stonefish envenomation. The extent of envenomation depends on the number of spines encountered and the type of fish. Some parts of the venom of this group are heat labile. Typically, the venom-filled spines break off into the wound, causing a dirty wound and retained foreign body, which lead to wound

infection. Sea urchin spines are brittle and break off easily, resulting in both envenomation and foreign bodies.

Immediate and severe pain is the common hallmark of a sting. Pain radiates centrally from the point of envenomation. The pain peaks in 30 to 90 minutes depending on the species and can last for hours to days if untreated. The wound areas may become ischemic, dusky, and cyanotic with surrounding areas of edema and inflammation. Stingray wounds also include a laceration component, as the tail has a serrated spine(s) that is thrust into the victim with significant force.

When treating, follow the MARCH primary survey. As soon as possible, the wound should be soaked in hot water at a temperature as high as can be tolerated; maximum temperature is 45° C. The high temperature decreases pain. The soaks should be done for at least 30 minutes. You can repeat the soaks if the pain returns. You might need to control the pain with narcotics. Some have used local anesthesia can be utilized for pain control. Victims of a sting should be evacuated as soon as possible.

Chapter 14: Infectious Diseases - Diarrhea

Diarrhea is the most common medical problem acquired in the wilderness. Most cases generally resolve spontaneously, with or without treatment, and the cause is typically unknown. It makes being in the backcountry very uncomfortable and difficult. It is estimated that up to thirty percent of adventure travelers will experience diarrhea during their expedition. The vast majority of these cases are passed through fecal-oral transmission. This includes the intake of contaminated food or drinking contaminated water as well as the inadvertent ingestion of contaminated river or lake water during recreational play. Diarrheal illnesses can be divided into four categories:

1. Staph
2. Non-dysenteric
3. Dysenteric
4. Protozoal

THE FOUR CATEGORIES OF DIARRHEAL ILLNESS

1. Staphylococcal Enteritis

Staphylococcal Enteritis is a common form of gastroenteritis. It is caused by eating food that has a heat-stable toxin produced by *Staphylococcus aureus*, a bacterium that is part of the normal skin flora. Unwitting chefs contaminate their food with these bacteria if they do not wash their hands during food preparation and service. Staph 'lives' primarily in the nostrils, so people preparing food might scratch or touch their nose and transfer staph to the fingers. Unrefrigerated high protein foods such as mayonnaise, milk, cream, meat, and custards are infamous for carrying this awful toxin. These foods should be suspect on any backcountry trip.

Symptoms typically begin one to six hours after ingestion, with an average timeframe of three hours. However, people can start to feel ill fairly quickly with an acute onset of nausea, severe vomiting, mild diarrhea, and abdominal cramps. It is miserable in the backcountry, and very common. There are often multiple victims. It is a self-limited disease, with symptom resolution within 24 hours, hence the name "24-hour flu". This is the time it takes toxins to pass from the intestines. People can be weak and still feel a little sick for another day or two.

For treatment, make sure people are receiving fluids. This is difficult if they are vomiting. Have them re-hydrate as soon as they can handle food and water. Anti-emetic medications may be used but will likely not be useful. Antibiotics will not help as it is a toxin already in the stomach that is causing the problem.

The best way to prevent staphylococcal enteritis is to use proper hygiene and sanitation with food preparation. Make sure people wash their hands with soap and water. Hand sanitation with alcohol

gel is alright to use. Wash dishes thoroughly and make sure there is no food 'stuck' to the dishes. Don't trust leftovers in the wilderness, even if they are refrigerated.

2. Non-Dysenteric Gastroenteritis

The main characteristic of non-dysentery is that there is no blood in the stool, and the patient typically will not have a fever. This is because these bacteria do not invade or enter into the wall of the intestine. When bacteria become invasive, blood is spilled into the lumen of the intestines, and the body will normally mount a fever. Non-dysenteric gastroenteritis is caused by a variety of organisms, including Enterotoxigenic E. coli (ETEC), Vibrio cholera, rotavirus, norovirus, and literally hundreds of other viruses. These pathogens are typically spread by fecal-oral contamination, with contaminated food and water as the most common vehicles for transmission.

Enterotoxigenic E. coli (ETEC) is by far the most common cause of diarrhea in developing areas, accounting for up to 70% of "Traveler's Diarrhea." When traveling to such countries, diligence in what is consumed must be maintained. Symptoms include profuse watery diarrhea, abdominal cramping, and malaise. Incubation times from ingestion to clinical presentation usually range from 12 - 72 hours, and is treated with an antibiotic. This means that a traveler will often have diarrhea while on their trip.

Vibrio cholera came from the ocean centuries ago and, like most bacteria, developed a toxin that is excreted to create profound diarrhea. This is a way for the bacteria to spread its progeny. The bacterium's natural habitat is brackish or saltwater and attaches itself easily to the chitin-containing shells of crabs, shrimps, and other shellfish. It has been virtually eliminated in the industrialized world. However, this disease will often appear in areas that have had a recent disaster. It is not clear where or when an outbreak will occur. Cholera infections are most commonly acquired from drinking water in which *V. cholerae* is found naturally or into which it has been introduced from the feces of an infected person. Cholera is most likely to be found and spread in places with inadequate water treatment, poor sanitation, and inadequate hygiene.

Approximately one in ten people infected will develop a serious case of this disease and could die due to dehydration. The rest will have a mild, self-limiting diarrheal illness. It is characterized by explosive "rice-water stools" produced at a rate of up to one liter per hour. A vaccine is available, but the CDC does not recommend it for most travelers. The best overall treatment for Cholera is to re-hydrate the victim. If you are in a place where Cholera is suspected, and it is severe, and if the patient is not able to replace the water and electrolytes that are lost, the patient should be evacuated. Antibiotics are also an option for treatment, but fluid replacement remains critical. The antibiotics that would be used are fluoroquinolones and tetracyclines.

Rotavirus is an enteric virus that is very common in young children and infants. Adults may also contract this disease, but they will usually have milder symptoms. Symptoms typically start about two days after a person is exposed to rotavirus, so you could feel symptomatic while still in the

wilderness. Vomiting and watery diarrhea can last from three to eight days. Young children and infants can spread rotavirus to family members and other people with whom they have close contact on a backcountry trip. People who are infected with rotavirus shed the virus in their stool. This is how the virus gets into the environment and can infect other people. People are more likely to infect others when they have symptoms and during the first three days after they recover. There is a vaccine for this but since this is a virus, antibiotics will not help.

Norovirus is by far the most common cause of acute gastroenteritis in the United States, Canada, and the industrialized world. Each year, it causes 19-21 million illnesses and contributes to 56,000-71,000 hospitalizations and 570-800 deaths in the United States. A person can contract the norovirus many times during their lifetime because there are many different strains of noroviruses. Infection with one type of norovirus may not protect you against another type. This may explain why so many people of all ages become infected during norovirus outbreaks. Also, whether you are susceptible to norovirus infection is also determined in part by your genes. Norovirus is extremely contagious. You can become infected by accidentally ingesting tiny particles of feces or vomit in your mouth. You don't have to eat food with the virus on it. If you contract the norovirus illness, you can shed billions of norovirus particles that you can't see without a microscope. It takes just a few norovirus particles to make other people very sick.

You are most contagious when you have symptoms, and during the first few days after you recover. However, studies have shown that you can still spread norovirus for two weeks or more after you feel better. Norovirus can easily contaminate food and water because it only takes a very small amount of virus particles to make you sick. Food and water can become contaminated with norovirus in many ways, including when an infected person touches food with their bare hands that has fecal or vomit particles on them. Or, if food is placed on a counter or surface that have fecal or vomit particles on it. Also, when tiny drops of vomit from an infected person spray through the air and land on the food. It is found on backcountry wilderness trips. It is a virus, so antibiotics will not help. Fluid replacement is essential.

Treatment for non-dysenteric diarrhea typically runs a self-limited course with symptoms resolving within three to four days. The mainstay of treatment is rehydration with the replacement of fluid and electrolyte losses. The oral intake should at least approximate fluid losses in the stool. Urine volume and color should be monitored as gross indicators of hydration status. Moderately dehydrated adults and most children may require a specially prepared solution to replenish their fluid and electrolyte losses. Sports drinks such as Gatorade or Powerade may be used if diluted to half-strength with disinfected or clean water. The most common is from the World Health Organization.

The World Health Oral Rehydration Solution (ORS) may be purchased as small packets. Simply add one packet to a liter of disinfected or clean water. You can make your own solution too. For a WHO ORS equivalent, add the following to one liter of disinfected or clean water:

- ¾ teaspoon of salt (two-finger pinch)

- ½ teaspoon baking soda (one finger pinch)
- 2 to 3 tablespoons of sugar (three-finger scoops)
- ¼ teaspoon potassium chloride salt substitute (small pinch), if available

Antimotility agents provide symptomatic relief and serve as useful adjuncts to antibiotic therapy. Loperamide (Imodium) may be used with non-invasive (non-bloody) gastroenteritis to reduce cramping and fluid losses. Bismuth subsalicylate (Pepto-Bismol) is an effective treatment for travel-related diarrhea and has comparable treatment results to antibiotic therapy in mild to moderate cases. An appropriate adult dose of bismuth subsalicylate is two tablespoons or two tablets by mouth every hour up to eight doses in 24 hours. Loperamide appears to have antisecretory properties as well. Antimotility agents are not generally recommended for patients with bloody diarrhea or those who have diarrhea and fever.

Antibiotics may be needed for more severe cases of travel-related gastroenteritis. The CDC in the United States recommends antibiotics if patients experience three or more episodes of diarrhea in an eight-hour period. The treatment of choice is a fluoroquinolone (ciprofloxacin or levofloxacin) for a single-dose or 1-day therapy; azithromycin 500 mg by mouth daily for three days.

Please know that, beginning in May 2016, the US FDA is advising against the use of fluoroquinolones for patients with sinusitis, bronchitis, and uncomplicated urinary tract infections who have other treatment options. This advisory does not include dysentery or GI disease but should be a consideration with prescribing. The safety review has demonstrated that fluoroquinolones are associated with disabling and potentially permanent serious side effects that can occur together. These side effects can involve the tendons, muscles, joints, nerves, and central nervous system.

3. Dysenteric Gastroenteritis

The main characteristics of dysentery are blood in the stool and fever. Sometimes the fever is very high. The fever occurs because the bacteria enter into the wall of the intestine. Blood is spilled into the lumen, and the body will typically mount a fever to help kill the pathogen. Approximately 15% of travel and wilderness related diarrhea is due to dysentery. The causative organisms include *Shigella*, *Campylobacter*, *Enterohemorrhagic E. coli* (EHEC), and *Salmonella*. Most organisms that cause dysentery are spread by a fecal-oral route, usually through contaminated food or water.

Shigella causes about 450,000 cases of diarrhea in the United States annually. The disease itself is called shigellosis and is found in the stool of sick people while they have diarrhea. *Shigella* germs are very contagious. It takes just a minimal number of bacteria germs to make someone sick. People can contract shigellosis when they swallow something that has come into contact with the stool of someone else who is infected with shigellosis. You can get *Shigella* germs on your hands after changing the diaper of a sick child or caring for a sick person. Eating contaminated food or swallowing lake or river water is another common way to become infected. Symptoms of

shigellosis typically start one to two days after exposure to the germ and include bloody diarrhea, fever, and abdominal pain. A person can quickly become symptomatic while still on a backcountry trip.

People who have shigellosis usually improve without antibiotic treatment in five to seven days. People with mild shigellosis may need only fluids and rest. People sick with shigellosis should not use medications that cause the gut to slow down and interferes with the way the body digests food, such as Imodium. Antibiotics for people with severe cases of shigellosis will help them get better faster. However, some antibiotics are not effective against certain types of shigella.

Campylobacter is the most common bacterial cause of diarrheal illness in the United States and Canada. Patients will have bloody diarrhea, fever, and stomach cramps. Nausea and vomiting may accompany the diarrhea. Symptoms usually start two to five days after infection and last about one week. Depending on how long a backcountry trip lasts, symptoms could develop within someone while still on the adventure.

Campylobacter comes primarily from birds, though cows and other animals can carry *Campylobacter*. In 2015, testing showed that *Campylobacter* was found on 24% of raw chicken bought from retailers, indicating that most *Campylobacter* infections are acquired by eating raw or undercooked poultry. In the Wilderness, birds defecate over the water, and cows defecate directly into the water that people drink from and play in. *Campylobacter* does not usually spread from one person to another.

Most people recover from *Campylobacter* infection without antibiotic treatment. Patients should drink extra fluids as long as diarrhea lasts. Antibiotics such as Azithromycin may be used, particularly if the patient is at risk. Some patients will continue to shed *Campylobacter* bacteria in their stool for weeks after recovery. One important fact to know is that *approximately* one in every 1,000 people who have *Campylobacter* will develop Guillain-Barré syndrome (GBS). People with GBS can have muscle weakness or sometimes paralysis that can last for weeks, and often requires intensive medical care. Estimates indicate that as many as 40% of GBS cases in the United States might be triggered by *Campylobacter* infection.

Enterohemorrhagic E. coli (EHEC) has over 100 different serotypes. The best known is 0157: H7. It causes fever and severe bloody diarrhea and sometimes hemolytic-uremic syndrome. In some parts of the United States and Canada, E. coli O157: H7 infection may be the most common cause of bloody diarrhea.

E. coli O 157: H7 comes from cows via food or water contaminated with cow manure. In 2011, with the European O104: H4 outbreak, the infection was transmitted by contaminated raw bean sprouts. The organism can also be transmitted by the fecal-oral route. It can be found in the backcountry river and waters where cows defecate.

After ingestion, the bacteria produce high levels of toxins in the large intestine. These toxins are closely related to those produced by Shigella as EHEC and Shigella are related genetically. About 5 to 10% of cases (mostly children < 5 years and adults > 60 years) are complicated by hemolytic-uremic syndrome, which typically develops in the 2nd week of illness. Death may occur, especially in the elderly, with or without this complication.

EHEC infection typically begins acutely with severe abdominal cramps and watery diarrhea that may become grossly bloody within 24 hours of exposure. Some patients report diarrhea as being "all blood and no stool," which has given rise to the term hemorrhagic E. coli. A low-grade fever occasionally reaches 39° C. Diarrhea may last one to eight days in uncomplicated infections. Diagnosis is with stool cultures with a pressing need for a rapid stool assay for Shiga toxin.

The mainstay of treatment for EHEC infection is supportive. Although *E. coli* is sensitive to most commonly used antibiotics, most antibiotics have not alleviated symptoms, or reduced the number of the organism, or prevented hemolytic-uremic syndrome. Fluoroquinolones (i.e. Cipro) are suspected of increasing release of enterotoxins and the risk of hemolytic-uremic syndrome.

Salmonella infection (salmonellosis) is a common bacterial disease that affects the intestinal tract. People become infected most frequently through contaminated water or food. Typically, people with *salmonella* infections have no symptoms. Others develop bloody diarrhea, fever, and abdominal cramps within eight to 72 hours. Most healthy people recover within a few days without specific treatment.

The risk of acquiring *salmonella* infection is higher if you travel to countries with poor sanitation. Salmonella infection is usually caused by eating raw or undercooked meat, poultry, eggs, or egg products. The incubation period ranges from several hours to two days.

The worst type of Salmonella is typhoid fever and is caused by the organism *Salmonella typhi*. Typhoid fever occurs worldwide but is most commonly contracted in developing nations. If you contract a fever while traveling, the most likely infectious cause is malaria, but the second most likely cause is typhoid fever. Humans are the only hosts for *S. typhi,* and transmission occurs most commonly through the ingestion of contaminated food and water. This disease is also spread by contact with chronic carriers where the disease lives in the gall bladder without causing symptoms. Once ingested, the bacteria penetrate the intestinal mucosa. From there, the bacteria invade the lymphatics, allowing it to spread systemically.

The incubation period of S. typhi is seven to fourteen days. "Pea-soup" diarrhea often occurs later in the course of the disease. Although less common, constipation may also occur. It is caused by swollen lymphoid tissue surrounding the ileocecal valve. The patient's temperature rises slowly during the first week of the disease to a high fever, up to 104º F (40º C). A characteristic rash of "rose spots" may appear on the trunk. After three weeks, the fever typically begins to abate, and symptoms start to resolve spontaneously in uncomplicated cases. Complications of typhoid fever

include intestinal perforation, gastrointestinal hemorrhage, sepsis with multisystem failure, and pneumonia.

Immunization is available in an oral or injectable form and is recommended when traveling to endemic areas. Treatment of typhoid fever involves supportive care and management of fluids and electrolytes. Antibiotic treatment reduces the duration of disease and decreases the complication rate.

Azithromycin, 1 g by mouth once daily for five days, treat this disease. Ciprofloxacin has been used but has untoward side effects now. There is a resistance to this agent that is increasing, particularly in Southeast Asia.

4. Protozoal Causes of Diarrhea

Common protozoal causes of gastroenteritis include *Giardia lamblia*, *Entamoeba histolytica*, *Cryptosporidium*, and *Cyclospora*. All are transmitted by the fecal-oral route via contaminated water and food.

Symptoms of protozoal infections vary widely from an asymptomatic carrier state to acute dysentery, and to chronic diarrhea. *Giardia* is by far the most common cause of protozoal illness. It contaminates water sources in both the developing and industrialized world. It is probably the most common cause of diarrhea for people backpacking in the United States, Canada, and Europe.

Giardia lamblia is a single-celled parasite that exists in a cyst form and a trophozoite form. Infected individuals and animals pass the cyst form in stools. These cysts can survive in the environment for three months or longer. Many animals have this disease, including beaver, deer, dogs, cattle, sheep, and rodents. Many natural water sources may have *Giardia* cysts present despite being in remote or "pristine" locations. Drinking contaminated water is the primary source of infection, with an infectious dose being as low as 10 to 25 cysts. Once the cysts are ingested, they are partially digested by gastrointestinal enzymes. Each cyst divides to form two trophozoites, which cause symptomatic disease.

About 50 percent of infected people will be asymptomatic. Some of these will go on to become chronic carriers. Incubation time is one to three weeks after ingestion. It's likely that most travelers will develop symptoms well after returning home. Diarrhea is the most common feature of Giardiasis and is present in up to 90 percent of symptomatic cases. Some people may have mild to moderate amounts of foul-smelling soft stools, while others may experience copious and explosive bouts of diarrhea. A characteristic "rotten egg" odor is associated with intestinal gas and feces. Other symptoms may include malaise, bloating, abdominal cramping, nausea, vomiting, and low-grade fever. Chronic diarrhea, lasting weeks to months, may develop and can have a cyclical pattern of worsening symptoms every few weeks.

Anyone who is suspected of having Giardia should be treated with antimicrobials. Tinidazole is the only drug approved for treatment of Giardiasis by the U.S. Food and Drug Administration. It is given as 2 g by mouth x 1 dose. It has fewer GI side effects than metronidazole and is more effective. Many clinicians will use Metronidazole, but it has significant side effects and is not as effective. Furazolidone 100 mg, by mouth four times a day for 7 days, may be used for children.

Amebiasis is caused by *Entamoeba histolytica*. This is a parasite found in water supplies around the world. It is particularly prevalent in tropical countries. Unlike *Giardia*, humans are the only reservoir for *Entamoeba*. Approximately 10 percent of the world's population is infected. The organism exists in cyst and trophozoite forms. Cysts are transmitted through fecal-oral contamination of food or water or through direct contact with an infected person. Ingested cysts become trophozoites that invade the colon wall and cause a variety of intestinal symptoms. Ingestion of as little as just <u>one</u> cyst can initiate infection.

Most individuals are asymptomatic, and many become chronic carriers. Symptomatic individuals may develop alternating constipation and diarrhea, abdominal cramping, weight loss, anorexia, and nausea. More severe infections may develop weeks to months after infection, resulting in the classic symptoms of dysentery. Trophozoites may migrate to other locations in the body, causing extra-intestinal metastases in the liver, skin, pericardium, and brain. The liver is the most common site for invasion. These "sterile" abscesses result in fever, right upper quadrant pain, and weight loss.

It would help if you considered treating for amebiasis in a patient with dysentery symptoms who do not respond to a course of antibiotics. Antibiotic therapy for symptomatic disease includes metronidazole 750 mg by mouth three times a day for ten days or tinidazole 2g by mouth daily for three days. This treatment should be followed by a course of iodoquinol, paromomycin, or diloxanide to eradicate the cysts and prevent the carrier state.

Cryptosporidium is a protozoan organism that is present throughout the environment, including up to 97 percent of large streams, lakes, and reservoirs in the U.S. Transmission occurs through the ingestion of contaminated water and food. The organism is resistant to iodine and chlorine disinfectants, but it can be killed by boiling water. Some water filters are also effective.

Symptoms include watery diarrhea, crampy abdominal pain, anorexia, malaise, and flatulence. Immuno-competent patients usually have a self-limiting course lasting a few days. Children are generally more severely affected than adults. Immuno-compromised patients develop a more severe infection that can last from months to years. These patients can lose more than three liters of fluid per day.

There is no effective treatment that has been found. Eradication of the infection is usually the result of the patient's own immune function. Supportive therapy consists of fluid and electrolyte replacement.

Cyclosporiasis is caused by *Cyclospora,* a protozoan parasite that is most commonly transmitted in fecally contaminated food or water in developing countries, particularly Central and South America. The incubation period is approximately one week, so people may develop symptoms after returning home from their backcountry vacation. Infection typically causes watery diarrhea that may last for weeks. Other symptoms include anorexia, weight loss, bloating, abdominal cramping, flatulence, nausea, vomiting, myalgias, low-grade fever, and fatigue.

Antibiotic treatment with TMP/SMX 160 mg/800 mg DS tablets by mouth twice a day for seven days is adequate. Water may not be reliably decontaminated by filtration or halide treatment and should be boiled.

Evacuation Guidelines for Diarrhea

Any victim with moderate to severe abdominal pain that does not improve over 12 to 24 hours should be evacuated. Victims unable to take sufficient oral rehydration fluids for more than 24 hours should be evacuated. Anyone experiencing mental status changes, signs of significant dehydration, hematemesis, or copious bloody stools should be evacuated immediately. Victims with signs and symptoms of dysentery who do not respond to appropriate antibiotic therapy within 24 to 48 hours should be evacuate.

Chapter 15: Wilderness Medical Kits

A frequent and relevant question asked in wilderness medicine is the type of first aid kit one should bring on a trip. It depends! This chapter covers helpful guidelines to assist us in choosing the appropriate items for that planned trip.

GENERAL GUIDELINES

General guidelines include asking yourself several questions to identify important aspects of your trip, such as:

- What type of activity or sport will your group engage in on this trip?
- How long is the trip going to be?
- How big is the group?
- Is this a group kit or your own individual kit?
- How far are you from help, and how easy will it be to evacuate if needed?
- What diseases are endemic to the area you're going to?
- What are the diseases and known conditions of the participants who are going?
- How far away from definitive care will you be on your trip?
    - For example, a backpacking trip of seven days over high, mountainous terrain far from civilization requires a medical kit that is lightweight and contains items that can treat emergencies related to high-altitude illness, cold exposure, trauma, geographically specific infectious diseases, and avalanches.
    - In contrast, a one-day river trip near a highway where weight is less of an issue and evacuation may be aided by a nearby vehicle would be entirely different. You would want items to treat emergencies related to water sports, cold exposure, and trauma.

Pre-Made Medical Kits

Premade medical kits are filled with items to cover general cuts and scrapes. They are not specific enough to cover a broad array of injuries. First aid kits tend to emphasize treatment, but they also deal with prevention items, such as water treatment material and gloves. First aid kits should emphasize improvisation and multiple uses. For example, duct tape can be used for numerous issues rather than one specific issue. If you are aware of the medical condition of the participants and recognize endemic or common diseases in the area, you can take the appropriate medicines with you.

Containers

Containers for first aid kits will vary along with the contents. For example, a six day trek over mountainous terrain far from cities will require a medical kit that is lightweight and contains items that can treat emergencies related to high-altitude illness, cold exposure, trauma, and geographically specific infectious diseases. A three-day river trip with four young, healthy people can be in a metal container, it can be more substantial, and can contain items to treat abrasions as well as items for a twisted ankle and splints.

Many commercial kits are available and carry essential supplies and equipment but do not contain prescription medications. Making your own kit is an option and can save money. Either way, you will need to adjust and bring items that pertain to the specific activities and location planned.

PAWS

Though it's not practical to list each item that should go in every type of medical kit, some general items are helpful to have. The acronym PAWS is an excellent way to remember the category of items to include in a first aid kit.

P	Prevention / Procedures
A	Analgesics / Antibacterials / Antiseptics
W	Wound care
S	Survival

Prevention/Procedures

Prevention

These are items for the prevention of illness and potential problems:

- Water filter and water purification tablets
- Gloves
- Sunscreen/lip balm
- Sunglasses
- Blister prevention and treatment
- Insect repellant and barriers (netting / treated clothes)

Procedures

There are specific tools of your trade that may be used in a variety of situations:

- Wound care material: steri-strips, tape, gauze, Medi-honey, sutures, etc.
- Scissors
- Dental repair material: Cavit, eugenol, etc.
- Blood pressure cuff and stethoscope
- Flashlight
- Syringe
- Flexible splints

- Safety pins
- Needles
- Tweezers

Analgesics, Antibiotics, Anaphylaxis

There should be medicine available in each kit that covers pain and infection that could be encountered. You should know what diseases are common in the area you're headed. As well, you should know the diseases and chronic conditions of the people traveling in your group.

Analgesics

Tylenol (also called Paracemetol and Acetaminophen) belongs to a class of drugs that relieves pain and lowers fevers. It does not prevent the clotting of blood, so it is safe to use in head injuries.

Aspirin prevents blood from clotting, which promotes bleeding. Therefore, it should not be used in any kind of head injury. Aspirin, also known as acetylsalicylic acid (ASA), is a medication used to treat pain, fever, and inflammation.

Ibuprofen is used to relieve pain from various conditions such as headache, dental pain, menstrual cramps, muscle aches, or arthritis. It is also used to reduce fever and to relieve minor aches and pain due to the common cold or flu. Ibuprofen is a nonsteroidal anti-inflammatory drug (NSAID). It works by blocking your body's production of certain natural substances that cause inflammation. This effect helps to decrease swelling, pain, or fever.

Antibiotics

Select antibiotics that cover a broad spectrum of pathogens. Here are some common broad-spectrum antibiotics to consider taking:

- Doxycycline: lung, skin, and tick/mosquito-borne infections
- Cipro: HEENT, enteric, lung, skin, and urinary infections
- Amoxicillin /clavulanic acid: HEENT, lung, skin, enteric
- Azithromycin: HEENT, lung, skin, enteric organisms

Anaphylaxis

Anaphylaxis is one of the true medical emergencies that one may see in the wilderness. You should always be prepared to treat an anaphylactic patient.

- EpiPen®

- antihistamines
- albuterol inhaler
- oral steroids
- Ranitidine

Wound Care

Regardless of the activity, abrasions and lacerations are among the most commonly experienced injuries. As a result, appropriate and adequate supplies for wound care are one of the essential parts of a medical kit. Having each person on the trip bring their own necessary wound supplies will help to ensure that enough wound care supplies are available. Below are different treatment options for primary wound care:

- Gloves
- Alcohol swabs, antiseptic wipes
- Gauze
- Steri-strips, benzoin
- Tape
- Ace bandages
- Irrigation equipment
- Band-aids
- Antibiotic ointment, Medihoney
- Gauze wrap
- Q-tips

Survival

The potential for the group members to be separated, and other worst-case scenarios need to be considered. Below is a list of items each group member should carry at all times.

- Map, compass, knife, fire starter, matches
- Communication equipment: satellite phones
- Space blanket
- Knives

Other Helpful Suggestions

The Centers for Disease Control (CDC)

The CDC website (www.cdc.gov) provides information for the preparation of a first aid kit for any location in the world. The information provided includes a list of antibiotics, items for a first aid kit that is specific to that area, and a list of other medicines important to have. It also talks about diseases endemic to that area and any required vaccinations. Look at 'Traveler's Health' and follow the links to first aid kits and medicines. Their information is current and up to date on the latest medical and health issues worldwide.

Documentation

Materials such as a pen and paper are an essential part of a first aid kit, though they are often left out. A pen and paper can be used to document illnesses and injuries. Write down essential data and document important facts. Instructions can be written down, and a history of what aid was rendered can be memorialized.

Expiration Dates

Check the medicines in your first aid kit often to see if their effectiveness has expired. The expiration date addresses medicine's highest effectiveness. It's a gauge of how close to its optimal efficiency a drug will function. That date is based on several factors, including how well the drug worked when it was tested and then sealed in its unopened container, and whether it was maintained at certain temperatures and moisture levels. Once the drug is opened, its expiration date isn't as useful to gauge its effectiveness. Typically, medicines will change into a brownish color when they lose effectiveness. However, EpiPen's are airtight. Experts think the expiration date is a good gauge of the injectable drug's highest potency.

Cleaning a Wound

You don't need any special liquid to clean a wound. Water is very effective. Due to its ability to kill bacteria, people have used hydrogen peroxide, iodine, and alcohol in the past. However, plain water with vigorous irrigation works just as well. Using alcohol and full-strength hydrogen peroxide can damage vital tissues. If a wound is significantly contaminated, and a person is immune-compromised, diluted hydrogen peroxide can be used. Hibiclens is a gentle cleaner but has shown to be about the same as cleaning with plain water. Iodine, in the form of betadine, is an appropriate antimicrobial for possible use if a wound is highly contaminated. Betadine is an excellent choice for your kit.

Honey

Honey has been used to treat wounds and speed healing as far back as ancient Egypt. Its use faded in modern times as a plethora of antibiotics were developed to treat infections. Honey is now making a resurgence as more bacteria strains develop resistance to overused antibiotic ointment.

So far, bacteria have not been able to develop a lasting resistance to honey. Honey has a wide variety of wound healing, and its antibacterial properties are recognized by the medical community. There are several preparations that have been formulated for medical use in the treatment of diabetic foot ulcers, leg ulcers, pressure sores, first and second-degree burns, and other cuts and scrapes. One of the most attractive attributes for honey as a wound treatment is its ability to fight off Methicillin-resistant Staphylococcus aureus (MRSA) and other resistant strains of bacteria where other antibiotics have failed. Ointments with sulfa, polymyxin B and neomycin as their base are good but are not recommended. There are high allergic rates to some of these ointments, which would be problematic on a back-country trek.

Hypoglycemia/Diabetes
Any time you plan to head into the backcountry with a diabetic person, insulin becomes an important component of your first aid kit. Newer insulins can be kept at room temperature, though they are best kept cool. Backcountry temperatures can be hot, and the temperature in first aid kits can rise beyond air temperature. It's essential to keep insulin cool, along with other types of medicine.

It's important to put a glucose source such as a piece of candy or some jelly in your first-aid kit, especially if the outdoor activity is physically demanding. Hypoglycemia occurs when a diabetic's blood sugar drops so low that the brain is starved of sugar. Unconsciousness will follow, and then possibly death.

Closing a Wound
Multiple modalities for closing a wound are appropriate. The type of wound, the type of outdoor activity and the ability of the provider to use the medical items all play a role in selecting what to bring. The primary goal of wound closure is to bring the wound edges together in order to improve the functional status of the victim. Suturing a wound requires the most skill. If you are comfortable with this and have the training, suturing a wound is appropriate. Sutures need to be removed after a period as they may increase the possibility of infection. Steri-strips are easy to use but have problems sticking. If the wound is bloody or becomes wet from water or sweat, the steri-strip(s) may come off. Skin glue is appropriate in some situations. If the wound is already approximated and not bleeding very much, then skin glue is appropriate. It is meant for small wounds

A common misconception regarding wounds is that closure of the wound decreases the chance of infection. However, closure of the wound may increase the likelihood of infection compared to packing the wound and dressing it appropriately. An important consideration is that there is generally no increase in scarring if one packs and dresses a wound and then closes it three-to-five days later, as opposed to closing it at the time of injury. Packing and dressing a wound with delayed closure is termed delayed primary closure. If one is in the wilderness for a period of five days or less, then delayed primary closure is a good option.

Additional Items to Consider

Other items for potential inclusion depending on the nature of your trip and your group:

- Equipment
- Pocket medical reference on paper or electronic
- Finger and toenail clippers
- Sewing kit
- Alcohol-based hand sanitizer
- Digital thermometer (expanded range for hyper/hypothermia)
- Urine pregnancy test
- Stethoscope
- Pulse oximeter

Medications

- Oxymetazoline (nose spray for nose bleeds)
- Silver nitrate cautery sticks
- Hemorrhoid ointment
- Albuterol
- Sting ointment

Chapter 16: Back County Water Treatment

It is not difficult or time-intensive to treat water while in the back country. Portable water purification devices are relatively inexpensive, self-contained, and are easily transported into the back country. Yet gastrointestinal illness from poorly treated water is a major cause of diarrhea and dehydration in the wilderness.

The purpose of water purification is to eliminate pathogens that will cause symptoms and disease in humans. Water purification techniques can also get rid of toxic compounds and unpleasant tastes in the water. There are multiple methods that are all effective at treating water. It's recommended that you use at least two methods to ensure that the water is safe to drink.

Terms and Definitions

To understand how to treat water, let's first review some Terms and Definitions:

Term	Definition
Purify	Removes taste, odor and smell
Disinfect	Removes or destroys pathogens
Sterilize	Destroys all life forms
Filtration	Mechanical process of forcing water through a membrane to remove pathogens.
Effectiveness	Specialist companies will often advertise a certain reduction 99.99% effective, instead of sterilization. This takes into consideration a phenomenon known as light and dark repair (photoreactivation and base excision repair) in which a cell can repair DNA that has been damaged by UV light.

ACHIEVING DRINKABLE WATER

The overall goal of wilderness water treatment is to achieve drinkable water. Water sterilization is not necessary, since not all organisms are enteric human pathogens. The goal is to remove pathogens that cause disease in humans. Water purification, besides removing pathogens, also removes bad tastes and odors. While making water more tasteful is not essential, it makes it more enjoyable. These definitions become important as you choose the method to treat water. The general public and outdoor retail stores often equate the term purification with disinfection. Advertising campaigns and promotions speak about the need to 'purify' water, when they should be saying 'disinfect.'

Overall, about 50-60% of the people who are infected by contaminated water become ill. It's important to know that illness and infection are not the same thing. A significant number of people who drink contaminated water will become infected but will not show any signs of illness. For example, most people who drink water contaminated with giardia never show symptoms at all but will still pass the cysts in their stool. For those that do exhibit symptoms, diarrhea is the most common, along with abdominal pain, bloating, and cramping. Fever and headache are also common.

The most common pathogens causing illness are:

- Bacteria
- Viruses
- Protozoa
- Parasites

The likelihood of encountering any of these microorganisms depends on the location and exposure of the water source to contamination. Watershed areas with animal grazing and human contact have higher risks than areas in which water comes from an underground source. In the wilderness, it can be very difficult to determine who or what has previously been in an area, and potentially contaminating water sources.

Finding the Best Water

The process of making water safe to drink starts with finding the best available water. Streams are able to purify themselves thanks to settling, UV rays, and predatory bacteria. Settling is when the dirt and harmful particles settle out to the bottom of the stream and aren't carried in the current. Because streams are so small, the UV rays from the sunlight are able to damage or destroy the pathogens that can exist in the water. If no stream is around, it is a reasonable choice to skim the top layer of a clear lake because the UV rays from the sun will still have cleaned the top layer. Whether you do or do not have methods to treat water, these are your best water sources.

A slow flowing river and a pond are the worst places to get water because bacteria and parasites tend to thrive in these environments. If your only choice is to drink from a water source that isn't flowing rapidly, be aware that blue-green algae can produce toxins that can make you sick. Water treatment will not get rid of the toxins. Even after an algae bloom has died off, the toxins can remain in the water if it's stagnant. The only way to avoid this problem is to plan your hike so don't have to drink from such sources.

The single most important aspect of finding good drinking water is to get close to the source. For example, you can look for a watercourse that is draining from a large snowbank high on a steep

slope. The second most important principle is to make sure the water is cold. Test the water with your hand to see if it is quite cold. Extremely cold water means it has not traveled far from its icy source. Also, look for fast-moving water. These streamlets very often drain a melting snowbank during the warmer months.

Pre -Treatment

Once the best source of water has been found, then pretreatment might be necessary. This is done if the water has contaminants such as sediment, leaves, small twigs or particles. It is important to understand that these pretreatment procedures do not disinfect water. However, they will enhance the disinfection process and drinking experience. Organic and inorganic particles can interfere with the disinfection process particularly with UV irradiation as sediment absorbs UV light. Bacteria, viruses and other pathogens are found on particles in water, so removing them is essential.

Screening

The screening process is the first step in the pretreatment of water and is intended to remove the largest of the contaminants. It involves using a primary filter as a screen to hold back dirt, plant, and animal matter. Many filtration systems already have a "pre-filter" attached. If filling a container by dipping or pouring, one can screen out unwanted debris by pouring the water through a cloth, such as a bandana, handkerchief, or even a T-shirt.

Standing

This is the second step, and allows particles that were too small to pass through the screening material to fall to the bottom of the container. Within as little as one hour, even muddy or turbid water will show significant improvement as the silt settles.

Flocculating

This is a method of removing particulate matter that are so small they would normally stay suspended in water indefinitely. You add specific chemicals to the water that cause agglomeration of the particulates until a complex forms-up, that is large enough to precipitate. This process takes a number of minutes. One common chemical used is "alum," often used in canning and pickling. It is easily found in grocery stores and is also a component of baking powder. As well, the fine, white ashes from burned wood are rich in mineral salts that can be used.

Water Treatment - Boiling

Boiling water will kill all human pathogens. The thermal effectiveness for killing pathogens depends on a combination of temperature and exposure time. Because of this, lower temperatures can be effective if the contact time is longer. However, without a thermometer, it is too difficult and risky to gauge temperature short of boiling.

The Centers for Disease Control in the United States (CDC) recommends boiling water for at least (3) three minutes if your location is above 6,562 feet (2000m). One important characteristic of boiling points is that they decrease in temperature with increased elevation. For instance, water boils at only 86°C (187°F) at an elevation of 14,000 feet (4,300m). The boiling point of water at sea level is 100°C (212°F). At this temperature, disinfection has generally occurred by the time the water boils. This is because most organisms are effectively killed at temperatures below this boiling point (see table). However, since it is difficult to determine the exact temperature of the water, boiling it for (3) three minutes is the safest way to ensure that the water has been treated.

The disadvantage to this is that the water is now hot and doesn't taste very good, unless you are making soup. If you are in a hot environment, it will never cool down. Another disadvantage is that the gear needed to boil water is usually heavy to carry.

Effective Times for Disinfection Using Heat

Pathogen	Thermal Death
Giardia lamblia, *Entamoeba histolytica* cysts	After 2 to 3 minutes at 60° C (140° F)
Cryptosporidium oocysts	After 2 minutes at 65° C (149° F)
Enteric viruses	Within seconds at 80° to 100° C (176° F to 212° F)
Bacteria	Within seconds at 100° C (212° F)
Hepatitis A virus	After 1 minute at 92° C (198° F)

Water Treatment - Filtering

Filters screen out bacteria, protozoa, and helminths, including their cysts and eggs. However, they are not reliable for eliminating viruses. Viruses tend to adhere to other particles, or clump together, which allows some of them to be removed by filtration. Nevertheless, because they are so small (less than 0.1 micron), viruses cannot be eradicated by filters alone. Some filters are impregnated with an iodine element in an attempt to destroy the viruses as they pass through the material. However, these additions are of questionable efficacy, lifespan, and are expensive. Most filters only filter things that are larger than 0.3 microns.

Because filters work by trapping small particles in their pore matrix, they clog and become less effective over time. Operating a pump as it becomes clogged can force pathogens through it and contaminate the water. Some new water filters will actually 'backwash' the filtering mechanism to help avoid this problem. Interpreting advertised filter specifications can also be difficult. The best way to evaluate a given filter is to ascertain its functional removal rate of various organisms. For example, a filter labeled "effective against pathogens" does not truly describe its efficacy.

For practical usage, filters could be utilized as the only disinfection method in areas where human and animal excrement is low, and in watershed areas that are protected. In these situations, recent rainwater that has landed in the middle of a trail has likely not been contaminated with human or animal waste. When uncertain, one should use an additional method of disinfection (i.e. halogenation) as a final step.

Chemical/Halogenation Treatment

Iodine and chlorine can be very effective as disinfectants against viruses and bacteria. Their effectiveness against protozoa and helminths, as well as their eggs and cysts, varies greatly. For example, while Giardia lamblia is effectively killed, Cryptosporidium cysts are extremely resistant to halogen disinfection. The amount of halogen required is impractical for drinking.

However, the major problem with chemical disinfection is improper treatment by the user. Disinfection depends on both halogen concentration and contact time. Factors that affect halogen concentration include water temperature, pH, and the presence of contaminants. Chlorine is more sensitive to these factors and is thus less suitable for cold, contaminated water. In these conditions, halogens require increased contact time and/or concentration. Turbid water should be allowed to settle before halogenation because particulate matter can deactivate the available halogen, rendering disinfection incomplete. Household cleaners, such as bleach, vary widely in concentration and are not a recommended chlorine source for disinfection of drinking water as they have some efficacy against bacteria, but not viruses.

Another challenge with chemical treatment, although not as serious a problem with halogens, is their unpleasant taste. This can be remedied in several ways but must be done after disinfection. A "pinch" of ascorbic acid (vitamin C) has been shown to neutralize taste, closely matching that of distilled water. Flavored drink mixes, especially containing ascorbic acid, can also help mask the unpalatable iodine or bleach flavor.

Iodine is an effective, simple, and cost-effective means of water disinfection for people who are in the wilderness and need to treat their water. However, there is considerable concern about its

potential effect on the thyroid gland. There is controversy about the maximum safe iodine dose and duration of use when iodine is ingested in excess of the recommended daily dietary amount. Most recommendations are that people should not exceed 2 mg/day for more than 3 weeks. However, these are not firm guidelines as there appears to be an individual response. Thus, the use of iodine for water disinfection requires a risk-benefit decision based on iodine's benefit as a disinfectant and the changes it induces in thyroid physiology. By using appropriate disinfection techniques and following guidelines from the manufacturer, most people can use iodine safely.

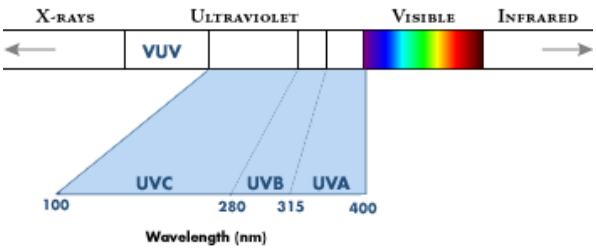
It is possible to use a much lower concentration of iodine if the contact time is longer or the water temperature is warmer. Colder water requires a higher concentration of iodine and longer contact time. The major health concern with excess iodine ingestion is thyroid toxicity. There has never been a link between the intake of iodine and cancer and there are no known allergies to this element. Iodine does not slow mental function.

Summary of Treatment Method Efficacy

Infectious Agent	Heat	Filtration	Chemical
Bacteria	+	+	++
Viruses	+	-	+
Protozoa and cysts	++	++	+
Helminths and oocytes	++	++	-

Ultraviolet Radiation (UVR) Treatment

UVR has recently gained popularity as a portable means of water disinfection. UV light is electromagnetic radiation. Ultraviolet (UV) rays penetrate harmful pathogens in water and destroy illness-causing microorganisms by attacking their genetic core (DNA). UV radiation has three wavelength zones: UV-A, UV-B, and UV-C.



It's this last region, the shortwave **UV-C**, that has the germicidal properties that cause disinfection. The effectiveness of this process is related to exposure time and lamp intensity, as well as general water quality parameters. Ultraviolet light treatment does not remove organisms from the water, it merely inactivates them. UV light acts on thymine, one of the four base nucleotides in DNA, preventing microbes from reproducing. Without reproduction, the microbes become far less dangerous. UV radiation does not improve the taste, odor, or clarity of water.

Disadvantages of UV Light Treatment

Dosage factors

Recent studies show that viruses present a limiting factor for UV treatment. Viruses require a dose of UV light that is (10) ten to (30) thirty times greater than for cysts (such as Giardia or Cryptosporidium), and bacteria. Another concern with UV portable water purification is that some pathogens are hundreds of times less sensitive to UV light than others. Protozoan cysts were once believed to be among the least sensitive. However, studies have proven otherwise, demonstrating that common cysts such as Cryptosporidium and Giardia are deactivated by low dose UV light.

Levels of Turbidity

Water must have a low level of turbidity for UV treatment to work effectively. Dissolved organic matter, such as natural organic matter; certain inorganic solutes, such as iron, sulfites, and nitrites; and suspended matter and particles will absorb UV radiation or shield microbes from UV radiation. This results in lower delivered UV doses and reduced microbial disinfection. Thus, a pre-filter step to rid water of particles might be necessary. UV water works as well in cold water as it does in warmer water. The number of bacteria has no effect on UV irradiation.

Reactivation of Pathogens

Reactivation of pathogens is a significant risk in water that has been treated with UV irradiation. Water treated with UV radiation still contains the microbes present in the water, with their means for reproduction having been turned "off". However, in the event that such UV-treated water containing neutered microbes is exposed to visible light for any significant period of time, a process known as photo reactivation takes place. In order to avoid ingesting reactivated and dangerous microbes, UV treated water must not be exposed to visible light for any significant period of time prior to consumption.

No Residual treatment

The other long-term disadvantage is that ultraviolet purification offers no residual treatment. Unlike chlorine which maintains a presence in the water after the treatment and continues to disinfect the water, ultraviolet radiation does not stay in the water. Any microorganisms that the radiation missed would remain in the water whereas chlorination would destroy them. For this reason, a chlorine compound should be added to water already purified by ultraviolet radiation.

Other drawbacks

Ultraviolet radiation has several other potential drawbacks to consider. Extra batteries may be needed for longer trips, and the lights themselves tend to be fragile if dropped.

Chlorine Dioxide Treatment

This compound has shown promising results. Liquid and tablet options are becoming increasingly commercially available. It has a wider range of effective pH and often does not require more than simple mixing.

Giardia lamblia and Cryptosporidium cause diarrhea in backcountry travelers. Their cysts are generally readily filtered from water, but chemical treatment of both cysts has proven problematic. Cryptosporidium is highly resistant to chlorine disinfection. Giardia cysts are much less responsive to chorine but somewhat more sensitive to iodine with high enough concentrations and contact time.

Recent studies have shown that both Cryptosporidium and Giardia inactivation will occur with chlorine dioxide treatment. Chlorine dioxide is very different from elementary chlorine. Despite the name, chlorine is not the chemical that ends up purifying the water. Chlorine dioxide releases a very reactive form of oxygen (similar to ozone) that neutralizes pathogens.

One of the most important qualities of chlorine dioxide is its high-water solubility, especially in cold water. Also, chlorine dioxide imparts a much less offensive taste than other halogens used to purify water. Chlorine dioxide has been used safely in industrial and municipal applications for over 70 years.

MSR MIOX Treatment

Unlike water filters, the MSR MIOX requires no pumping, virtually no cleaning, and does not have the potential to clog in the field. If operated correctly the MIOX adds little if any of the bitter or salty flavor produced by many tablets and drops. The device also kills more of the potentially dangerous microorganisms than most other water treatment options. Unlike ultraviolet treatment methods, MIOX treatment is unaffected by the cloudiness of the water, but it does not remove particles. The multi-step process that produces the treatment solution comes with a steep learning curve. Salt and water are added to their respective chambers, sealed, and shaken to combine through a screen that separates them. If not enough of either ingredient is added, the combination can fail.

MSR MIOX uses electrolysis to create a disinfectant that destroys biological contaminants in water. It is more effective against most microorganisms than chlorine or iodine. Though the MIOX treatment means certain death to the bad stuff living in water, the waiting time for this process can be a drawback. Most viruses and bacteria are killed within 15 minutes, with Giardia in 30 minutes. However, to ensure that Cryptosporidium is killed, the wait time is about 4 hours. If Crypto contamination is a possibility, proper water planning and rationing might be necessary with these wait times.

Purifying Water

Tannins and humics are natural organic matter that leach into wilderness water as plants decay, staining it a tea color. They're not harmful in small quantities, but they do impart odors and a bitter taste to the water.

Sediment in the water gives it a dirty appearance and is unpleasant to ingest. It usually isn't harmful in small amounts. Sediment is not seen in high amounts in clear mountain lakes.

Ordinary salts are the result of eroding natural deposits or seawater contamination, salts simply make water taste bad; though very high concentrations can dehydrate you. When exploring coastal and desert regions, avoid drinking sea and brackish waters. Salt is not likely seen in a mountain lake.

Using an activated carbon filter can remove bad taste and purify the water. Activated carbon has long been used in treatment devices because of its absorptive properties. Activated carbon is great for catching many contaminants that are so small they pass through a micro-filter. Simply put, it is tiny bugs or germs that are the primary focus of treatment because of their immediate and serious risk to health.

Beware of Ice

Several studies have recently suggested that mold and bacteria in ice machines are a much larger cause of illness than previously thought. The cold temperatures of a house freezer may make it harder for mold and bacteria to grow, but problems start when freezers are regularly turned off for extended periods of time. Owners don't always clean their freezers. In addition, when people take ice without washing their hands and then drop the scoop back into the ice, the cubes can become contaminated from the contaminants left by unclean skin. People can have a reaction after consuming a slug of mold or bacteria that was on the ice.

Water from the hotel drinking fountain could potentially be the source, but much less likely than that of the ice. Fruit typically does not carry bacteria that cause diarrhea.

If a person picks the ice out of a tray with unwashed hands, then the ice will become contaminated. In 2007, a study conducted in London found that nearly 20 percent of 49 restaurants and hotel bars had ice contaminated by high levels of fecal coliform bacteria. People must remember to wash their hands before meals, but they don't remember to wash their hands each time they grab ice. In 2012, a 15-year-old boy in Florida died from consuming contaminated ice, a death that could have been prevented by handwashing. Most people don't realize that death can be caused by contaminated hands.

The Table below categorizes some of the possible Waterborne Pathogens:

Bacteria	Viral Agents	Protozoa	Helminths
Escherichia coli *Shigella* *Campylobacter* species *Salmonellae* *Yersinia enterocolitica* *Aeromonas* species *Vibrio cholerae*	Hepatitis A Hepatitis E Norwalk agent Poliovirus Rotavirus	*Giardia lamblia* *Entamoeba histolytica* *Cryptosporidia* *Cyclospora* species *Blastocystis hominis* *Acanthamoeba* *Balantidium coli* *Isospora belli* *Naegleria fowleri*	*Ascaris lumbricoides* *Taenia* species *Trichuris trichiura* *Fasciola hepatica* *Strongyloides* species *Echinococcus* *Diphyllobothrium* species

Chapter 17: Diving Medicine

It is estimated there are between 2.7 to 3.5 million active scuba divers in the United States (US) with as many as 6 million active scuba divers worldwide. There are about 11 million snorkelers in the US and about 20 million snorkelers worldwide. Accurate data is difficult to obtain, as there is no official regulation of the industry. There are approximately 200,000 new dive certifications in the US annually, among the four largest dive organizations. The incidence of decompression sickness (DCS) is about 2.8 cases per 10,000 dives.

TYPES OF DIVING

Scuba Diving

Scuba diving is popular amongst recreational divers in the US and Worldwide. SCUBA is an acronym for **S**elf-**C**ontained **U**nderwater **B**reathing **A**pparatus. SCUBA diving uses an air-filled tank with a pressure regulator that supplies compressed air to an open circuit to the diver at a pressure equal to the ambient water pressure.

Breath-hold / Freediving

Breath-hold / Freediving is the simplest and oldest form of diving and uses no breathing apparatus or supplemental air. It is often used to get pearls and sponges from shallow ocean floors.

Re-breathing/Closed Circuit Diving

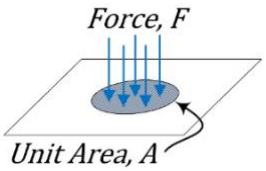
Re-breathing/closed circuit diving uses a device that captures a diver's exhaled breath, removes carbon dioxide, and replenishes oxygen before giving the air back to the diver to breathe once again. It has classically been used by military combat divers but is starting to gain some popularity in civilian diving.

Surface Supplied Diving

Surface supplied diving is where a diver's breathing gas is pumped via hoses from a surface source or from a submerged diving bell at a pressure equal to ambient water pressure. It has been most often used in commercial or military settings such as "hard hat diving," and is expensive and complicated to perform.

THE PHYSICS OF DIVING

In understanding the issues that happen underwater, a person must first know that it is the increased pressure that causes all of the problems. Pressure is defined as the amount of force acting per unit area. The International System of Units (SI) uses Pascal as its standard unit for pressure. In the United States, pressure is typically measured in pounds per square inch (psi). Atmospheres or atm is the international standard for pressure. All of these measurements are commonly used in diving.



Types of Pressure

As a person goes deeper underwater, the pressure increases. There are two kinds of pressure that affect a person underwater:

- The weight of the surrounding water (hydrostatic pressure)
- The weight of the atmosphere over that water (atmospheric pressure)

Hydrostatic Pressure

Pressure due to the weight of water is called hydrostatic pressure. The weight of water is cumulative. The deeper the dive, the more water there is above the diver, and the greater the pressure.

Atmospheric Pressure

Atmospheric pressure is the pressure exerted by the earth's atmosphere; it decreases with altitude above sea level. At sea level, atmospheric pressure is equal to 14.7 pounds per square inch (psi), or one atmosphere (atm). At sea level, atmospheric pressure is considered constant, and so pressure gauges are adjusted to read zero. Pressure gauges will increase their reading as depth increases.

Absolute Pressure

The sum of atmospheric pressure (weight of the atmosphere over that water) plus hydrostatic pressure (weight of the surrounding water) is called the “absolute pressure,” and is usually measured in ATA, which stands for absolute atmospheres. Absolute pressure can be expressed in several other ways, including "pounds per square inch absolute" (psia), feet of seawater absolute (fswa), feet of freshwater absolute (ffwa), or millimeters of mercury absolute (mmHg). At sea level, atmospheric pressure is equal to 14.7 pounds per square inch (psi), or one atmosphere (atm). To convert hydrostatic pressure to absolute pressure, add 14.7 psi.

Gauge Pressure

Gauge pressure is the difference between atmospheric pressure and the pressure at a depth of the dive. Pressure gauges read zero at sea level, as they have been adjusted to remove the effect of atmospheric pressure. Pressure gauges will increase their reading as depth increases to read ‘hydrostatic pressure.’ Reading the hydrostatic pressure indicates the pressure due to the weight of water. If you want to know absolute pressure (gauge pressure + atmospheric pressure), then add 14.7 psi.

Depth and Pressure

- Each foot of seawater adds 0.445 PSI of pressure to the atmospheric 14.7 PSI at sea level.
- Every 10 meters (33 feet) of seawater, therefore, adds 14.7 PSI or 1 ATA. At 33 feet of depth, the body experiences 2 ATA absolute pressure.
- At 66 feet of depth, the body experiences 3 ATA absolute pressure.

The Four Laws of Physics for Diving

Pascal's Law

Pascal's law states that pressure applied to any part of a fluid is transmitted equally through the fluid. Although liquids and gases are both considered fluids by Pascal's Law, liquids are non-compressible, while gases are compressible under pressure (see Boyle's law below). Most of the human body is a liquid and thus is not generally directly affected by the increased pressure underwater. The air-filled cavities are affected because of the compressibility of air (Boyle's Law).

Boyle's Law

Boyle's law states that the pressure and volume of a gas are inversely related. As pressure increases with descent, the volume of a gas bubble decreases, and as pressure decreases with ascent, the volume of that gas bubble increases. Air-filled spaces are affected, according to Boyle's law. This predominantly means the lungs, middle ear, sinuses, and gastrointestinal tract.

Pressure	Depth	Gas bubble volume	Gas bubble Diameter
1 ATA	Sea level	100%	100%
2 ATA	33 feet (10 meters)	50%	79%
3 ATA	66 feet (20 meters)	33%	69%
4 ATA	99 feet (30 meters)	25%	63%
5 ATA	133 feet (40 meters)	20%	58%

Dalton's Law

Dalton's law states that the total pressure of a mixture of gases is equal to the sum of the partial pressures of the gases. This law can be used in conjunction with Henry's law to make different mixtures of gases (Nitrox) to decrease or avoid gas toxicities during a dive.

Henry's Law

Henry's law states that, as the partial pressure of a gas increases, more of that gas will be dissolved in a given liquid. As depth increases, the amount of nitrogen dissolved in the body will increase and can lead to nitrogen narcosis. If the rate of ascent of a diver is too fast, the gases dissolved in the tissue, mostly nitrogen, will come out of solution as bubbles, resulting in decompression sickness.

Pressure in air-filled spaces of the body is in equilibrium with the pressure of the environment and other air-filled spaces. These spaces remain in equilibrium with the changing environmental pressure unless the passageway that allows equilibrium with the rest of the environment becomes obstructed. If this occurs, disequilibrium develops, and barotrauma can result.

Going to Depth-Compression Injuries

Dysbarism

Dysbarism refers to medical conditions resulting from changes in pressure. Diving injuries happen when going down to depth (descending) and then when returning to the surface (ascending). When going down to depth, divers experience barotrauma. When returning to the surface, divers can experience a number of issues, including decompression syndrome and gas toxicities.

Barotrauma

Barotrauma is tissue damage resulting from pressure disequilibrium when divers go to depth. The most common medical problems in diving are related to barotrauma. Types of barotrauma include mask squeeze, sinus squeeze, ear canal squeeze, middle ear squeeze, inner ear barotrauma, tooth squeeze, suit squeeze, lung squeeze, and GI barotrauma.

<u>Mask Squeeze</u>

As a diver descends, ambient pressure increases, and the volume of air in the facemask decreases, according to Boyle's law. Mask-pressure equilibrium is maintained by nasal exhalation during decent, which adds air to the facemask. Failure to exhale into the mask during descent results in a relative negative pressure within the mask, pulling the face into the mask, and rupturing capillaries. This results in skin ecchymosis, subconjunctival hemorrhage, lid edema, and (rarely) hyphema. This generally resolves over several days to a week without treatment. Cold compresses and analgesics may be used if symptomatic. A diver may return to diving when this is resolved.

<u>Barotitis Media (Ear Squeeze)</u>

This is by far the most common diving medical problem, affecting 10 to 30% of divers during any single dive and >90% of consistent active divers at some point in time. Symptoms include progressive ear pain during descent, a sensation of fullness, and reduced hearing in the affected ear after the dive.

At a depth of 2.5 feet (0.75m), a 60-mmHg pressure gradient is generated across the eardrum, resulting in slight pain from stretching and inward bulging of the tympanic membrane (TM).

A depth of 4 feet (1.5 m) results in a 90-mmHg pressure gradient. This collapses the medial one-third of the eustachian tube, resulting in the inability to maintain equal pressure within the middle ear, as well as increased pain. At this pressure gradient, attempts to equalize the middle ear to

ambient pressures by Valsalva or other maneuvers may not succeed, forcing the diver to ascend in order to reduce the ambient pressure.

Depths greater than 4 feet (1.5) - 17 ft (5m) are associated with 100-400 mmHg gradients, which may rupture the TM.

- TM rupture relieves the pain of ear squeeze, but cold water entering the middle ear will cause severe vertigo with nausea, vomiting, and disorientation underwater.
- Vertigo resolves within minutes to hours.
- Rupture of the TM with water entering the middle ear can lead to polymicrobial infections

Barotitis media is preventable by early (starting immediately upon leaving the surface) and frequent equalization maneuvers. Any eustachian tube dysfunction from an upper respiratory infection, allergies, or smoking predisposes a person to Barotitis media by interfering with equalization.

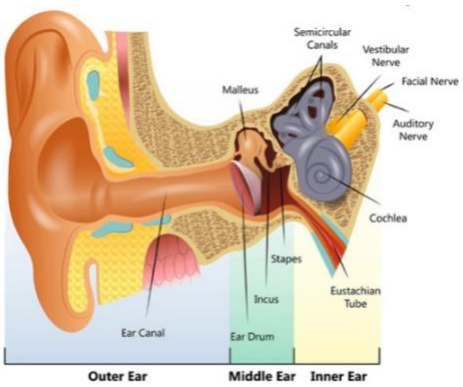
- Topical and oral decongestants may be used before diving to facilitate equalization.
- Any diver unable to equalize should not dive until they are able to do so.
- Combining an oral decongestant with a long-acting topical nasal spray (e.g., 0.5% oxymetazoline) for the first few days is most effective.
- Repeated gentle auto inflation of the middle ear can help to displace any fluid collection through the eustachian tube.
- Diving should be avoided until full resolution, including the healing of any TM perforation.
- The majority of TM perforations heal spontaneously within 1-3 months. Surgical repair can be considered if healing has not occurred within one month, and is most commonly performed for >10-20% rupture.

<u>Barosinusitis (Sinus Squeeze)</u>

Barosinusitis is caused by the same basic mechanism as barotitis media. If there is an inability to equalize the air pressure in any paranasal sinus (frontal sinus is most common, followed by maxillary) during descent, a relative vacuum develops in the sinus cavity. The relative negative pressure causes mucosal congestion, edema, and hemorrhage, along with severe pain. The process may be reversed on the ascent, resulting in a "reverse squeeze," with expanding air volume in a sinus, causing pain and tissue damage if not released. This will usually "self-correct" by blowing the obstruction out and relieving the pressure. Blood and mucus in the mask are telltale signs of reverse sinus squeeze. Treatment for barosinusitis is the same as for barotitis media; systemic antibiotics are indicated for signs of sinusitis, including fever and purulent nasal discharge.

Labyrinthine Injuries

Labyrinthine injuries involve the inner ear. It is a severe but rare form of barotrauma, resulting from an overly forceful Valsalva maneuver or very rapid descent, which may lead to permanent deafness or vestibular dysfunction. It may result in inner ear hemorrhage, Reissner's membrane rupture, oval or round window fistulas, and perilymph leaks. The classic triad of symptoms is roaring tinnitus, vertigo, and hearing loss. Other symptoms may include fullness of the ear, nausea, vomiting, nystagmus, pallor, diaphoresis, disorientation, and ataxia. Treatment includes bed rest with the head elevated to 30 degrees, avoidance of strenuous activity or straining, and symptomatic therapy. Any suspected inner ear barotrauma should be evaluated by an ENT specialist as soon as possible.



Rising to the Surface-Expansion Injuries

Pulmonary baratrauma occurs when gas within the lungs begins to expand with an ascent, with the highest volume change occurring at the shallower depths. If the diver does not allow the expanding gas to escape, a pressure differential develops between the intrapulmonary space and ambient pressure. This results in over-distention and rupture of the alveoli and allows air to escape into the local tissues or systemic circulation, causing various forms of pulmonary overpressure sequelae. This most commonly occurs in divers with a history of a rapid and uncontrolled ascent. This might happen as a result of running out of air, panicking, sudden uncontrolled positive buoyancy (e.g., dropping a weight belt, or inadvertent inflation of buoyancy control device), or breath-holding during ascent in inexperienced divers. There are reported cases of fatal pulmonary barotrauma that resulted from breath-holding during ascent from depth as shallow as 4 to 6 feet.

Mediastinal Emphysema

This is the most common form of radiographically evident pulmonary overpressure syndrome (POPS), and results from air dissecting along perivascular sheath and bronchi into the mediastinum. This condition may actually be asymptomatic. There might be substernal chest pain (most common symptom when symptoms are present), or it may be palpable in the neck and anterior chest. Dyspnea is typically not present except in severe cases. Hoarseness and fullness present if air dissects from mediastinum into the neck. Radiographs will confirm the diagnosis. The treatment is conservative. Divers should not dive or go to altitude. There is no need to recompress if no other symptoms are present.

Pneumothorax

Rupture through the visceral pleura, with the accumulation of air in the pleural space, can occur. This is uncommon since the visceral pleura is stronger than the pulmonary interstitial. Signs and symptoms may include pleuritic chest pain, dyspnea, and decreased breath sounds on the affected side. The treatment is the same as for pneumothorax of any other cause.

Arterial Gas Embolism (AGE)

AGE is the most feared complication of pulmonary barotraumas and is the most common cause of death and disability among sports divers. AGE results from air bubbles entering the pulmonary venous system from ruptured alveoli. These bubbles then migrate via the left atrium into the left ventricle, aorta, and arterial system, then shower distally and can obstruct blood flow in the distal vessels. Most of the body's blood enters the brain, so bubbles coming into the carotid or vertebral arteries may result in an ischemic stroke. Since the brain receives the majority of the blood supply, most symptoms are neurological. Other neurologic symptoms that occur depend on where the air obstructs the brain. Thus, they can be myriad, multi-focal, and deadly.

AGE typically develops during ascent, or may develop up to ten minutes after surfacing, but is often evident within two minutes. Any symptoms, especially the sudden loss of consciousness occurring immediately to a diver upon surfacing, are due to AGE until proven otherwise.

Urgent recompression is the immediate treatment for Arterial Gas Embolism (AGE). No adjunctive therapy should delay this. Treatment with recompression may be effective for AGE even if the recompression cannot be performed until up to 24 hours later. Recompression reduces bubble diameter and volume, allowing the return of hyper-saturated blood to the obstructed areas. Even if neurological symptoms have resolved, the patient should still be treated with recompression. High-flow supplemental oxygen is useful but should not delay recompression. Maintain the patient in a supine position. Lidocaine may be given, but research data is limited to its effectiveness. The consensus is that it might be helpful.

Decompression Sickness (DCS)

If a diver ascends too quickly, nitrogen will come out of solution and form bubbles in tissue and venous blood. Nitrogen will also form within both the intravascular and extravascular spaces, which leads to cellular distention and rupture, mechanical stretching of tendons and ligaments, intravascular and intra-lymphatic occlusion, congestive ischemia/infarction, and lymphedema. Intravascular bubbles also produce activation of intrinsic clotting, kinin, and complement systems, resulting in platelet activation, lipid embolization, microvascular sludging, increased vascular permeability, and interstitial edema.

DCS is best known as a hazard of underwater diving but may occur in other decompression events such as caisson (underwater bridge) work, flying in unpressurized aircraft, and extra-vehicular activity from spacecraft. Since bubbles can form in any part of the body or migrate via the bloodstream to any part of the body, DCS can produce a wide range of symptoms. Its effects may vary from joint pain and skin rashes to paralysis and death. Symptoms can appear one hour or more after resurfacing. The table shown indicates an

Time to onset	Percentage of cases
Within 1 hour	60%
Within 3 hours	40%
Within 6 hours	98%
Within 24 hours	99%
Within 48 hours	100%

onset of first symptoms. The table does not differentiate between types of symptoms.

Symptoms of Decompression Sickness (DCS)

Typical symptoms of Decompression sickness (DCS) start shortly after surfacing. These include unusual fatigue, skin itch, pain in the joints and muscles of the arms, dizziness, vertigo, ringing in the ears, numbness, tingling, and paralysis, shortness of breath, blotchy rash, muscle weakness, difficulty urinating, confusion, personality changes, bizarre behavior, amnesia, tremors, and staggering.

Muscular Skeletal System

However, it is the muscular-skeletal system that is most affected by decompression sickness (DCS). It accounts for about 70% of all cases and is often referred to as "the bends." It can involve any joint, although shoulders and the elbows are the most common. The pain is often referred to as boring or deep, or a dull ache. Movement worsens the pain, which makes it difficult to differentiate from other musculoskeletal causes based on history or exam. Some studies suggest inflating a blood pressure cuff to above 200 mmHg over the joint as it may partially relieve the pain of DCS but not musculoskeletal pain. However, a lack of pain relief does not rule out DCS.

Spinal Cord

The spinal cord is commonly involved in divers who are also aviation personnel, where it most often affects the lower thoracic to lumbosacral segments. It may start insidiously as back pain then progresses to paresthesia and paralysis as they ascend to altitude.

Skin Rash

The mildest form of cutaneous DCS is a rash, most commonly on the torso: the chest, belly, back, shoulders, arms, or buttocks. Such outbreaks may look like sunburn and are usually itchy. Some people say it feels as if tiny insects are crawling on their skin. Most of these rashes typically go away in a few hours.

A condition called *cutis marmorata* is characterized by a marbled pattern on the skin. It is a more severe form of cutaneous DCS. Such lesions typically appear on the same parts of the body as milder DCS rashes but are usually bright red, purplish, or even bluish, with an uneven pattern. *Cutis marmorata* may be extremely itchy, and affected areas sometimes feel tender to the touch. It is indicative of a more severe DCS and indicates more rapid recompression.

Risk Factors for Decompression Sickness (DCS)

Flying

Flying after diving is an undisputed cause for decompression illness (DCI). Ascent to altitude following diving favors nitrogen bubble formation and causes DCI. Ascent to as little as 300m (100 feet) soon after diving has precipitated DCI in sports divers leaving dive sites by road. However, the

most troublesome altitude issue is the prescription of a safe interval between diving and flying in passenger aircraft, most of which are pressurized to the equivalent of approximately 2,400m altitude. DCI has occurred in sports divers with no pre-flight symptoms, and who delayed flying more than 48 hours after diving.

Obesity

Obesity has been suggested as a risk factor since nitrogen is more soluble in fatty than watery tissues, resulting in higher nitrogen loading and more bubble formation. It is probably fair to call this "controversial" and conclude that divers are better off with a healthy body mass index.

Dehydration

Dehydration may exacerbate DCI because blood will tend to be "thicker" and flow less easily through any small blood vessels damaged by bubbles. However, despite the conviction with which this theory is taught, there are no supportive data from actual diving. Nevertheless, it remains appropriate to encourage divers to maintain good hydration actively.

Advancing Age

Advancing age may increase the risk of DCI, perhaps because of a general decline in physical fitness and the ability to compensate for damage. Several studies appear to confirm this, but it is not considered a major risk factor.

Exposure to Cold

Exposure to cold is often cited as a risk factor for DCI. A possible explanation is not so much the cold but the change in the diver's temperature during the dive. If the uptake of nitrogen occurs while the diver is warm and elimination occurs while the diver is cool, then nitrogen elimination will be slower in colder water (than uptake), and the risk of DCI increased. Thus, divers are best advised to keep their temperature as stable as possible through the dive. In cold water, this is best achieved by wearing a dry suit.

Other Effects of Pressure

Nitrogen Narcosis

Nitrogen Narcosis is also known as rapture of the deep, the narcs, or inert gas narcosis. The development of intoxication is due to increased partial pressure of nitrogen in compressed air, which dissolved into tissues at increased depth. As the partial pressure of nitrogen increases with depth, cellular membranes, specifically neuronal membranes, are affected by the absorption of the inert gas into their lipid component. The higher the lipid solubility, the higher the narcotic potency of that gas. Nitrogen narcosis causes anesthetic-like euphoria, overconfidence, and diminished judgment and cognition, which can lead to serious errors in diving techniques, accidents, and drowning.

Typical Nitrogen Narcotic/Anesthetic Effects by Depth

Depth	Symptoms
70 - 100 feet	Lightheadedness, loss of fine sensory discrimination, giddiness, and euphoria
>150 feet	Increasingly poor judgment, impaired reasoning, overconfidence, and slowed reflexes
250 - 300 feet	Auditory and visual hallucinations, and feelings of an impending blackout
400 feet	Loss of consciousness

Though diving with someone is essential, and while a buddy can help rescue someone with nitrogen narcosis, it will not prevent this condition. The best way to prevent nitrogen narcosis is to avoid deep dives. Diving beyond 40 meters (130 feet) is typically outside the scope of recreational diving. Below this depth, some specialist training is required in the use of various helium-containing gas mixtures such as trimix or heliox. These mixtures prevent narcosis by replacing some of the breathing gas with non-narcotic helium. Helium, due to its low lipid solubility, is essentially non-narcotic and therefore is commonly used as a substitute for nitrogen in deep diving.

One problem with helium gas mixtures, however, is that sound travels faster in heliox than in air, making divers' speech very high-pitched and hard to understand. Surface personnel often employ a piece of communications equipment called a "helium de-scrambler", which electronically lowers the pitch of the diver's voice as it is relayed through the communications gear, making it easier to understand. The treatment of nitrogen narcosis consists of ascent to shallower depths (<70-100 feet or 20-30 meters), where symptoms will usually clear quickly.

Oxygen Toxicity

Oxygen Toxicity can be a problem because high partial pressures of oxygen are toxic. This may result from breathing oxygen-enriched mixtures during diving, receiving oxygen therapy in hyperbaric chambers, and using regular air at great depth. Oxygen toxicity is a function of time and partial pressure of oxygen. The treatment is to remove the oxygen mask in the hyperbaric chamber at the first signs of toxicity.

Pulmonary Toxicity

Pulmonary Toxicity is theorized to primarily result from tissue damage due to the formation of oxygen-free radicals. Symptoms of pulmonary toxicity are substernal chest discomfort on inhalation that progresses to burning pain and persistent coughing.

Central Nervous System (CNS) Toxicity

CNS Toxicity is thought to come from oxidation of enzyme systems. CNS toxicity requires much higher oxygen exposure than that causing pulmonary toxicity and occurs at 2 ATA or higher of the partial pressure of oxygen. The earliest symptoms are typically twitching of the facial muscles and small muscles of the hands, but unconsciousness and seizures may occur without warning.

FreeDiving

Freediving is considered an extreme sport, and submergence is limited to the time the diver can hold his or her breath. The world record for depth achieved on a breath-hold dive is 214 meters / 702 feet in 2007, using a weighted sled to speed descent and a lift bag to assist ascent. The record for a completely unassisted free dive is 101 meters / 331 feet in 2010.

Blacking out for Freedivers typically occurs on ascent near the surface. In fact, over 90 percent of blackouts in freedivers happen in the last ten meters of ascent. When a freediver descends, the lungs compress, and oxygen molecules take up a greater proportion of the lung space, increasing the partial pressure of oxygen in the lungs. On the ascent, the pressure reverses, the lungs expand, and there is a rapid drop in the partial pressure of oxygen in the lungs. Therefore, as the freediver nears the surface, they experience hypobaric hypoxia and blackout. It can be lethal, but divers take it as normal and routinely spit up blood when they wake up. Those who free-dive regularly tend to develop scar tissue in their lungs from repeated compressions.

Contraindications to Diving

Relative Risks

Relative risks to diving are upper respiratory infections, hypertension, history of overpressure syndromes, and a patent foramen ovale. Pregnancy is a relative contraindication to diving. Women are encouraged to stop diving during pregnancy. For ethical reasons, experiments with pregnant women are very limited. Available literature indicates that, while the effect may be small, diving during pregnancy does increase the risk to the fetus, and the consequences could be devastating to all involved. The prudent course is to avoid diving while pregnant. While it is possible that some diving could be completed without impact, the absolute risk of any given exposure cannot be determined from the available data. Given the ethical challenges of research on diving during pregnancy and the fact that diving represents an entirely avoidable risk for most women, it is unlikely that studies will be conducted to establish the absolute risk in the foreseeable future.

Absolute Risks

Absolute risks to diving include symptomatic coronary heart disease, history of pneumothorax, COPD, and seizures. Someone should be seizure-free for at least five years before attempting to dive.

Divers Alert Network (DAN)

DAN is a group of not-for-profit organizations dedicated to improving diving safety for all divers. It was founded in Durham, North Carolina, USA, in 1980, providing 24/7 telephone hotline diving medical assistance. Since then, the organization has expanded globally and now has independent regional organizations in North America, Europe, Japan, Asia-Pacific, and Southern Arica.

The DAN organizations provide similar services, some only to members, and others to any person on request. Member services typically includes a diving accident hot-line, and diving accident, and travel insurance. Assistance to the general public usually include diving medical advice and training in first aid for diving accidents. DAN America and DAN Europe maintain databases on diving accidents, treatment and fatalities, and crowd-sourced databases on dive profiles uploaded by volunteers, which are used for ongoing research programs. DAN should be consulted in dive injuries and can provide the location of the closest hyperbaric chambers.

Chapter 18: Legal Concerns in the Wilderness

Background

When encountering an accident victim or a person experiencing some other medical emergency in the back country, one's instinct is to provide medical care. In fact, medical professionals are directed by their national and international associations to provide emergency medical care. According to the World Medical Association's International Code of Medical Ethics, "… a physician shall give emergency care as a humanitarian duty …" In addition, physicians should "respond to the best of their ability in cases of emergency where first aid treatment is essential" (Op. 8.11, Council of Ethical and Judicial Affairs, AMA).

The most important aspect of treating a patient in the wilderness is providing optimal care in any given situation. Sadly, because of an increasingly litigious world, concerns about legal liability are always a concern of a well-meaning caregiver. Those liability concerns, however, can be eliminated or reduced by both understanding and following a few legal principles. This chapter presents those legal principles by examining Good Samaritan laws, contract laws, tort laws and defenses to a tort law claim. The goal of law is to provide certainty and predictability in order for citizens to conduct themselves properly. This legal review demonstrates that the law is rational, helps to define what actions are necessary in an emergency situation, and protects those providers who do their jobs well and provide care in accordance with accepted standards.

WILDERNESS MEDICINE LAWS

Good Samaritan Laws

Most laws, such as Good Samaritan laws, have an intended purpose. In this case, when citizens have an emergent injury, society wants to encourage those with the ability to help and render to aid, to do so. The law provides liability protection to remove the deterrent of litigation as long as someone is not grossly negligent.

A. Affirmative Obligation to Help

In the United States, the most extreme reactions to this common law rule are found in Minnesota, Rhode Island and Vermont, where each has enacted a statute requiring a person to render aid, under certain conditions, to a stranger found in an emergency situation. Actual fines may be imposed if there is a failure to render aid. The Minnesota statute, quoted in part below, is a good example of this type of legislation.

> *A person at … an emergency who knows that another person is exposed to or has suffered grave physical harm shall, to the extent that the person can do so without danger … to self or others, give reasonable assistance to the exposed person …*

The Province of Quebec in Canada and virtually every country on the European Continent have similar statutory requirements. Therefore, when traveling the back country in Europe, Quebec, Minnesota, Rhode Island and Vermont, remember that one is obligated to give reasonable aid and assistance to a stranger suffering or exposed to grave physical harm or otherwise found in an emergency situation. Depending on the circumstances and the particular jurisdiction's law, that obligation might be satisfied by immediately reporting the situation to the proper authorities who can provide help and aid to the victim. Most jurisdictions that impose an affirmative obligation to render emergency care generally also have a limitation of liability statute as described below.

B. Limitation of Liability

In all of the U.S. and many other common law jurisdictions (Canada, Alberta, British Colombia, Nova Scotia and Ontario) have enacted Good Samaritan laws, which provide that, under certain circumstances, a person who voluntarily renders emergency care will not be liable for ordinary negligence or simple carelessness. Although these statutes differ in language among jurisdictions, all are very similar in purpose, rest upon the same fundamental principles and have the same requirements. The Utah statute quoted below is a good example of these laws.

> *A person who renders emergency care at or near the scene of, or during an emergency, gratuitously and on good faith, is not liable for any civil damages or penalties as a result of any act or omission by the person rendering the emergency care, unless the person is grossly negligent or caused the emergency*.

Examples of potential gross negligence by a physician would be removing an object out of an impaled person, giving a medication that the patient had stated an allergy to, or pulling a person with a likely neck injury out of a car by their head. In short, literally no one would perform in this way.

For a provider to be protected under the Good Samaritan Doctrine, in any jurisdiction, the following five general guidelines must be met:

1. **The person rendering emergency care must not have caused the emergency**, **either in whole or in part.** For example, if you run over someone or cause them to fall over a cliff, then you are not protected from being litigated against later for the injury and outcome.

2. **The person rendering emergency care must act in "good faith**." (The care provider must sincerely intend to help and must have a reasonable opinion that the care should not be postponed until the patient is hospitalized.)

3. **The emergency care must be provided gratuitously, without any compensation**. (The care provider should not accept anything in return for rendering the emergency care. One

should never send a bill for services if they intend to utilize Good Samaritan law.)

4. **The provider must not commit gross negligence when rendering emergency care**. (To list all possible acts or omissions that might constitute gross negligence is impossible. Be advised, however, that once initiating emergency aid in the back country and then either terminating treatment or transferring care of the patient to an inadequately trained person before the patient is adequately stabilized or evacuated to a medical facility can be considered abandonment constituting gross negligence.)

5. **The person rendering emergency care must not have a preexisting duty to care for the patient**. (For example, a guide would have a preexisting duty to render emergency care to a customer where that customer had contracted with the guide to be taken on a hike and the guide had agreed to provide care to the customer in case of injury while hiking. In this situation, the Good Samaritan law would not apply to the guide in the event of injury to the customer during the hike.)

The nuances of Good Samaritan laws vary among jurisdictions. For example, Pennsylvania's Good Samaritan law covers only those who have received some training in first aid and then only to the extent trained. Courts in certain other states have suggested that Good Samaritan law protections apply only if the care given is limited to that necessary at the emergency scene. Consequently, in a backcountry emergency a person might decide to render only such aid as one is competent to provide and then only to the extent required at the scene. Multiple states do not allow Good Samaritan laws to apply in a hospital setting as the environment provides the resources to provide accepted medical care. A higher standard of care may be present if the care is provided with the resources of an EMS vehicle and its equipment or in a field/ship clinic setting.

If any one of the five conditions above is not satisfied, then the Good Samaritan law, with all its protections, will not apply. While there are many ways in which these principles can be violated (inadvertently accepting payment or rendering aid in a clumsy manner amounting to gross negligence), the most frequent violation arises from the presence of a preexisting duty on the part of the care giver to provide aid to the patient. A preexisting duty usually exists because of contract law.

Contract Law

A contract is an agreement, or in effect a promise, between two or more parties for performing, or not performing, certain specified acts in exchange for adequate consideration. To be a legally binding contract, there has to be 3 elements: (1) an offer, (2) acceptance of the offer, and (3) some form of consideration must be exchanged. Consideration is defined as any benefit or item of value received by parties that reasonably and fairly induces them to enter the contract. Contracts can be either "express" or "implied-in-fact." The terms of an express contract are explicitly stated in words, either written or oral, leaving little or no doubt as to its existence and terms. An implied contract is not expressly set forth, either orally or in writing. Rather, the existence and terms of an

implied contract are created by conduct or circumstances that "imply-in-fact" a contract exists. For example, if someone delivers milk to a doorstep and the other party leaves an envelope with payment, even though there may not be a formal contract, both parties are behaving like there is one in place.

Contracts, letter agreements, and even brochures from summer camps, expedition companies or adventure guides sometimes expressly state they have a trained person available to provide medical care to customers in emergencies arising during the adventure activity. Alternatively, the oral sales presentation or even the brochure may well "imply" that the summer camp, expedition company or adventure guide will provide such medical aid to customers under its care. Whether express or implied, a court may find that the complaining customer stayed at the camp or took the adventurous expedition in part because the company or guide contractually agreed to provide medical aid during back country emergencies, thereby creating a preexisting duty on the part of the company or guide. Thus, the Good Samaritan law will not be of protection from liability.

If the Good Samaritan law does not apply, because one or more of the principles are broken, then litigation could possibly able to be pursued under contract law or tort law. In a famous legal case, *Guilmet v. Campbell* (385 Michigan. 57, 188 N.W.2d 6-1 1971), a patient sued his surgeon who operated on him for an ulcer and guaranteed that he would be able to "eat as you please and throw away your pillbox." The patient remained symptomatic after surgery. The jury did not allow an award for malpractice but did allow an award for breach of contract. Thus, it would behoove a medical provider on an expedition, to avoid being involved in a contract which in any way gives the belief or guarantees that safety and health are ensured during the trip.

Litigation could also proceed under the area of tort law.

Tort Law

Tort law sets civil standards for people's behavior, imposing on everyone the duty to exercise reasonable care to avoid causing harm or injury to others and providing legal recourse and the possible recovery of money damages for those who suffer harm or injury as a result of a breach of this duty. Torts are legally defined civil (non-criminal) wrongs that might result in harm or injury and, thereby, constitute the basis for a claim (or lawsuit) by the harmed or injured party against the person who allegedly committed the tort. An injured party can claim under any of three general categories of torts: (1) an intentional tort (where one person intentionally harms or injures another); (2) a strict liability tort (making and selling an obviously defective product); and (3) a negligent tort (a careless and unintentional act, such as an automobile accident, which harms or injures another person or another person's property). Among harms or injuries suffered by a party for which it could recover a monetary award in tort litigation are compensation for (1) lost income and lost or damaged property, (2) pain and suffering and (3) reasonable medical expenses. Although a person allegedly harmed or injured when receiving emergency aid in the back country might conceivably claim an intentional tort, most often law suits arising from such circumstances claim that the tort of "negligence" occurred.

In order to prove that a person who provided emergency medical care in back country (the "defendant") committed a tort of negligence, the person who claims to have been harmed or injured by that emergency medical care (the "plaintiff") must prove the following four elements of a negligence claim.

Four Elements of a Negligence Claim

1. Duty to Provide Care at the Standard of Care

The plaintiff must demonstrate that the defendant had a duty to provide aid to the plaintiff which met a specified standard of care. Normally, a health care provider will not be held to have been negligent if good care is given in accordance with the prevailing standards of the medical profession. The issue then becomes, "what are the prevailing standards?" Although training courses such as this are making great progress in defining and refining the standard of care in wilderness medicine, that standard is not yet well established in the law. When in doubt, courts will rely upon the traditional legal definition of the standard of care, which is the "behavior of a reasonably prudent person in the same or similar circumstances." In applying the traditional legal definition, courts commonly look to the following factors to determine the applicable standard of care:

1. The defendant's education
2. The defendant's training
3. Government or organization medical protocols that apply to the particular situation
4. Industry practice
5. Private business protocols that might apply

A duty to provide aid meeting a specified standard of care also generally requires that the informed consent of the patient be obtained before treatment is given. A parent or guardian must provide that consent when the patient is a child. Informed consent can be given only if the patient is first advised of the medical problem, the proposed course of treatment, any potential risks associated with that course of treatment and what to expect if no treatment is given. Then the patient, or parent or guardian, must give actual consent. A care provider might rely upon "implied consent" in an emergency situation where most would reasonably assume that the patient would have agreed to the care offered under the emergency circumstances if they were able to. For example, an injured traveler may be unconscious and unable to give consent but most would assume that anyone would want help in this situation so "implied consent" is utilized.

2. Failure to Perform the Duty

The plaintiff must next prove the defendant failed to perform the duty of providing aid consistent with the specified standard of care. This proof can take several forms. In most wilderness medicine litigations, the plaintiff asserts that the defendant failed to act at all (an omission) when the defendant had a preexisting duty to provide care to the plaintiff. The plaintiff might, however, claim the defendant provided care (a commission) that did not meet the prevailing medical standard or

did not perform as would a reasonable person with defendant's background, education and training. The premature termination of care or the transfer of care to a less qualified provider before the patient has been stabilized or evacuated can, as mentioned above, be considered abandonment and constitute negligence or even gross negligence. Consequently, one must remain well informed of prevailing medical standards and protocols and be well trained in wilderness medicine to ensure that any care provided meets applicable standards.

3. Loss or Injury

The plaintiff must next demonstrate that he or she sustained a loss or injury, which can include loss or damage to property, medical expenses, fright, emotional trauma, personal injury, pain and suffering, and loss of life.

4. Causation

Finally, the plaintiff must demonstrate that the loss or injury sustained was caused or contributed to (the "proximate cause") by the defendant's failure to perform the duty of providing aid meeting the specified standard of care.

Defenses to a Tort Law Claim

Defendant can defeat plaintiff's claim by demonstrating that plaintiff failed to carry the burden of proof on one or more of the four elements of a negligence claim. For example, defendant might demonstrate that he or she satisfied the duty of performing in accordance with the applicable standard of care or that plaintiff's loss or injury was caused by another person or event. The best strategy always is to keep a contemporaneous, complete and accurate written record of the events surrounding and the medical care given in response to a back country or wilderness emergency. Such records should include dates and times, a patient history, a description of the scene, your physical assessment, treatment given and any changes in the patient while in your care. Experience teaches that such a record is an essential element in any successful defense.

Jurisdiction

Another consideration with regards to law and wilderness expeditions would involve jurisdiction. It is important for a provider to understand, if there is any legal action, under what laws, the issue will be argued. Laws can widely vary from country to country and even state to state. Knowing ahead of time, what the jurisdiction is will allow for maximum protection from litigation and optimal conduct. The jurisdiction may be spelled out when the contract/agreement is signed by the customer before the journey. For example, a statement such as "both parties agree that any litigation will utilize the laws of California in resolving a dispute" could be included. Otherwise a trek in Utah, with a customer from Nevada, using a company from Arizona, can open the door to argument over whose laws apply. Or a dive expedition on a boat in international waters with a citizen from the U.S. and a physician from France, on a boat registered in Norway, can open the same host of considerations.

Malpractice Insurance

Finally, providers would be wise to investigate, before undertaking a trip, whether they will be covered by their usual insurance provider when rendering support during expeditions in various jurisdictions. This is especially important when they are accompanying a group as contractually provided medical support as the Good Samaritan laws will be of no protection, as mentioned above.

Chapter 19: Wilderness Nutrition

As a wilderness healthcare provider, it is important to gain an understanding of how to meet nutritional and hydration needs. Proper nutrition will aid in maintaining both the physical strength and mental stamina required for the environmental extremes you may face in wilderness rescue situations.

- Recognize the importance of adequate nutrition for the rescuer(s) and patient(s).
- Understand how to plan food and fluid intake to achieve your total daily energy and fluid requirements.
- Identify appropriate nutrition protocols for refeeding the starved rescue victim, as well as other medical situations where nutrition is an important concern.

FOOD IN THE WILDERNESS

Energy Requirements

Caloric requirements for wilderness rescuers and users vary depending on gender, body type and size. Additionally, type, intensity, and duration of physical activity are important considerations in determining daily nutrition requirements.

- **Total daily energy expenditure** is made up of four primary components: resting metabolic rate, thermic effect of food, thermic effect of exercise, and non-exercise activity thermogenesis.
    - Resting metabolic rate (RMR): baseline energy requirement to maintain normal bodily functions at rest. Basal metabolic rate (BMR) is often used interchangeably with RMR. RMR is an estimate of BMR. It is commonly used for practical purposes, and is typically 10% greater than BMR.
    - Thermic effect of food (TEF): energy necessary to absorb, transport, store, and metabolize food.
    - Thermic effect of exercise (TEE): energy used to support exercise. TEE can increase if a person engages in physical activity or exercise.
    - Non-exercise activity thermogenesis (NEAT): energy used to produce heat in response to overfeeding, shivering in cold temperatures, and spontaneous non-exercise activity such as fidgeting.

- **The Harris Benedict** equation is commonly used to estimate RMR in healthy individuals (use kilograms and centimeters in the equation):

- Males: 66.5 + (13.75 x wt) + (5.003 x ht) - (6.775 x age)
- Females: 655.1 + (9.563 x wt) + (1.850 x ht) - (4.676 x age)

- To estimate total daily energy needs, RMR is multiplied by an activity factor:
  - **Very Light Activity** (mostly sedentary):
    RMR x 1.3 for males and females = total calories needed per day

  - **Light Activity** (easy, short (1-3 hours) and slow day hike, easy climbing or skiing):
    RMR x 1.5 for females or 1.6 for males = total calories needed per day

  - **Moderate Activity** (moderate intensity exercise of longer duration; brisk day hiking, skiing or climbing with little or no extra pack weight; equivalent to jogging 5-6 miles):
    RMR x 1.6 for females or 1.7 for males = total calories needed per day

  - **Heavy Activity** (hard exercise; moderate to high intensity exercise of longer duration such as hiking, climbing, skiing that involves hills and carrying a heavy pack; equivalent to jogging 9-13 miles):
    RMR x 1.9 for females or 2.1 for males = total calories needed per day

  - **Exceptional Activity** (very hard exercise; training for an ultra-endurance event, long, strenuous day of variable terrain hiking, scrambling, backcountry skiing or climbing with a heavy pack; equivalent to jogging 14-17 miles):
    RMR x 2.2 for females or 2.4 for males = total calories needed per day

- **Sample RMR calculation:**
  - Male: 35 years old, 170 pounds 6'0": 66.5 + (13.75 x 77.11kg) + (5.003 x 182.88cm) - (6.775 x 35) = 1,805 kcal/day x appropriate activity factor = total calories needed per day
  - Female: 35 years old, 135 pounds, 5'6": 655.1 + (9.563 x 61.23kg) + (1.850 x 167.64cm) - (4.676 x 35) = 1,387 kcal/day x appropriate activity factor = total calories needed per day

Macronutrients

Water

- Water is essential to sustain life, and adequate hydration is critical in the wilderness setting. Water serves as a transport medium, maintains body temperature and muscular functioning. It also acts as a solvent for chemical reactions, a lubricant and shock absorber, and cleanses and removes waste product.

  Daily requirements: the amount of fluid you need per day varies greatly by the amount of

activity performed, environmental conditions, and the amount of water in your foods.

Fluid Dietary Recommended Intake (DRI): sedentary males and females 19-50 years old 3.7 Liters (L)/day for males, 2.7 L/day for females. Wilderness users may have higher fluid needs, especially in hot weather, high altitude, and during high intensity and/or long duration physical activity.

General guidelines:

- Pre-hydrate: drink 14-20 oz (plus an additional 8-16 oz in a hot environment).
- During physical activity in the wilderness: drink 200-300 mL every 15-20 minutes.
- Recovery/Rehydrate: replace 150-200% of body weight (BW) lost. Drink 24 - 32 oz (3 - 4 cups) of fluid per pound lost. For example, if you lose two pounds of water during activity, rehydrate with 48 oz (2 x 24 oz = 48 oz) of fluid containing electrolytes (eg. sports drink).
- At altitude fluid needs are increased: insensible water losses may not be noticed by the individual, but are greater because of increased ventilation.

Ideas to achieve optimal intake

- Consider a sports drink for moderate to intense activity lasting greater than 60-90 minutes. Sports drinks:
  - Add flavor to encourage drinking
  - Provide carbohydrates and electrolytes
  - Aid in rehydration
- Electrolytes help retain fluid by drawing water into cells. An electrolyte supplement or sports drink with electrolytes is beneficial if you are drinking a large volume of fluid, and/or sweating heavily. This is especially important for rehydration following exercise.
- Recommended sports drink composition: Carbohydrate concentration is typically between 5–8%, sodium concentration between 500–700 mg/L, and potassium concentration varies between 120-600 mg/L.
- To rehydrate, if you don't have a sports drink with you, it's easy to make your own. For example, first bring 16 oz of water to a boil then steep with one caffeine free lemon bag. Dissolve two tablespoons of sugar and 1/8th teaspoon of salt in the tea and let it cool. Mix the tea with four tablespoons of orange juice. Eight ounces of this drink has 60 calories, 15 g carbohydrates, 130 mg sodium and 62 mg potassium.

Maintain a fluid balance

- Be familiar with your sweat rate. Calculate your sweat rate by weighing yourself before and after physical activity. Add the amount of fluid consumed during exercise and also add any urine amount to the losses.

- Example: Pre-exercise weight (72.7kg) – Post-exercise weight (70.4kg) = 2.3kg = 2.3L= 2300ml. Total fluid consumed during exercise = 32 oz = 960ml. 2300ml + 960ml = 3250 ml = total fluid loss. Divide by total hours to determine hourly sweat rate.

- Are you a heavy or light sweater, what is your body type, and what is your exercise intensity? Keep in mind heat acclimatization increases water loss but lessens sodium loss.
- Before you plan to be physically active, or are preparing for a wilderness rescue, drink before you are thirsty to prevent dehydration.
- Although it's important to drink enough water, you can also drink too much. This can result in hyponatremia, when blood sodium levels are less than 135 mmol/L. In order to prevent hyponatremia, include sufficient dietary sodium in your diet, ingest sodium during activity in the wilderness by eating salty foods and drinking a sports drink, and drink according to your sweat rate.

Dehydration

- A good test to see if you are getting enough fluid is to ensure that your urine output is clear to pale yellow and that you are voiding frequently.
- Remember that vitamins such as riboflavin and certain foods such as asparagus, carrots, and beets can also affect urine color and reliability of this test.

Carbohydrates

Carbohydrates are the body's preferred source of fuel. They are the main source of energy for moderate and high intensity physical activity in extreme environmental conditions such as heat, cold, and high altitude. Adequate glycogen stores, and intake of carbohydrate during exercise delays fatigue, decreases perceived effort, and improves concentration and reaction time. Carbohydrates are a required energy source for the brain, as well as red and white blood cells.

Daily requirements: the minimum level of glycogen required to maintain adequate glycogen stores for an active individual is 5 g/kg of BW per day.

General guidelines

- For physical activity, including wilderness rescue recommended carbohydrate intake is between 6-10 g/kg of BW per day.
- For moderate intensity and duration (30-60 minutes) daily carbohydrate recommendation is 6-8 g/kg of BW. This would apply to a rescue mission lasting between 30-60 minutes that requires hiking, running and/or traveling and working in technical terrain.
- For moderate intensity activity lasting longer than 60 minutes, daily carbohydrate recommendations are between 7-10 g/kg of BW. This would apply to a rescue mission lasting longer than 60 minutes that requires hiking, running, and or/traveling and working in technical terrain.

- During exercise longer than 60 minutes or if inadequate pre-exercise nutrition (eg. no breakfast or lunch) recommended carbohydrate intake is 30 to 60 g/hr based on the maximal oxidation rate of glucose. Carbohydrates during exercise helps maintain blood glucose concentration and delays central fatigue. They may also help spare glycogen stores.
- After exercise the recommended intake is 1-1.5 g/kg/of BW within 30-60 minutes (approximately 50-100 g, equivalent to 1-2 sports bars or 32 oz of sports drink). If you will be hiking/exercising the next day, repeat intake above two hours later to maximize glycogen stores.
- Carbohydrate recommendations vary with exercise intensity and duration and must be replenished daily for optimal performance.

TIP: it may be difficult to consume as many carbohydrates as recommended, and it's important that your diet is composed of a variety of nutrients, not just carbohydrates. Adjust your diet appropriately and focus on timing of meals. Make sure to eat before, during, and immediately after physical activity and always keep some easily digested carbohydrates in your 24-hour kit/backpack such energy gels, honey, jelly and hard candies.

Ideas to achieve optimal intake

- Two to four hours before physical activity, consume a meal or snack that is easily digested. It should contain 2-4 g/kg of BW of carbohydrate, be moderate in protein (15-20 g), and low in fat. For example, a 70kg male could eat a turkey and cheese sandwich on a whole wheat bagel, with a banana or orange, a low-fat yogurt and 25-30 whole wheat crackers.
- While in the wilderness consume a banana, sports chews, a slice of bread with peanut butter and jelly, or fig newton cookies. You can consume a sports drink in addition to any of these foods.
- Following wilderness activity, choose carbohydrate and protein foods to minimize recovery time. For example, trail mix and chocolate milk or cheese, a bagel with peanut butter or tuna, or cereal with milk.

Hypoglycemia

- The following foods contain at least 15g and are appropriate for the treatment of hypoglycemia (refer to Chapter 10 for more on hypoglycemia)
  - 4 glucose tabs/paste
  - 2 Tablespoons raisins
  - 5-6 LifeSavers
  - 1 Tablespoons honey
  - 1 Tablespoons jelly
  - 1/3-3/4 cup fruit juice
  - 2 Cliff Shot Blocks

- ½ medium banana

Protein

Protein builds and repairs muscle tissue, maintains fluid balance, increases immune function, promotes satiety, and serves as a minor energy source. When total calorie and/or carbohydrate intake is low and/or glycogen is depleted protein becomes a more significant source of energy.

Daily requirements: The Recommended Dietary Allowance (RDA) for sedentary males and females is 0.8 g/kg of BW per day.

General Guidelines

- Athlete specific recommendations apply well to wilderness rescuers:
  - Recreational athlete: 1.0 g/kg/ of BW
  - Endurance athlete: 1.2-1.4 g/kg of BW
  - Ultra-endurance: 1.2-2.0 g/kg of BW
- After physical activity: recommended intake is ~ 20 g of intact protein, and 50 – 100 g carbohydrates (~ 1.0 -1.5 g/kg) in the form of sports drink with electrolytes within 30 minutes of exercise.
- During caloric restriction protein needs are increased to maintain lean body mass and preserve nitrogen retention. Twice the usually recommended RDA of 0.8 g/kg of BW (1.6 g/kg/d) is recommended.
- In the wilderness timing of meals is most important for muscle repair. Focus on small frequent meals.

Ideas to achieve optimal intake

- Carry chicken or tuna pouches and make your own trail mix with a combination of nuts, dried fruit, pretzels and chocolate. Bring jerky and use powdered milk and eggs to add protein to your meals.

Lipids and Fats

Lipids and Fats serve as the main source of energy during prolonged low intensity exercise and are important for immune health, hormone production and fat-soluble vitamin transport. Fat provides twice as many calories per gram as carbohydrate and protein, and can help you to stay warmer at night and in cold environments. Additionally, if you have to carry a heavy pack with medical supplies, weight and space become a concern. Foods high in fat are an excellent choice as they are calorically dense.

Daily requirements: fats should make up 20-35% of your daily diet.

Ideas to achieve optimal intake

- Choose healthy omega-3 Fatty Acids that may help with reducing inflammation: walnuts, soy nuts, green pumpkin seeds, and fish.
- Choose healthy monounsaturated fatty acids (MUFA's) and polyunsaturated fatty acids (PUFA's): nuts, seeds, oils, grains, legumes, and nut butters.
- For general health, foods containing unsaturated and trans fats such as cookies, chips, pastries, many packaged snack foods, marbled meats, and high fat cheese should be limited. These foods have their place in the wilderness setting. Desserts can be a great way to enjoy a satisfying meal and add calories. Similarly, cheese and salami can be a satisfying snack, and are also an excellent way to add calories to your daily intake.

Nutrient Density & Energy Density

Nutrient density is a measure of nutrients provided per kcal of food. Foods with a high nutrient density are rich in nutrients relative to their energy (kcal) content. Nutrient density is used to assess nutritional quality of food. Examples of nutrient dense foods include whole grain bread, nonfat milk, and fruits and vegetables. Energy density compares the energy content of food with its weight. Foods that are energy dense are high in kcals, but weigh little. They are a good choice if you are trying to gain weight or are traveling in the wilderness and have limited space, but need to pack a lot of calories. Examples of energy dense foods include: cookies, nuts, chips, chocolate, oils, nut butters, and fat free snacks and pretzels.

Considerations for Refeeding

Patients who have been chronically starved or severely malnourished, and are refed on scene may be at risk for refeeding syndrome.

Refeeding Syndrome: in a starved or severely malnourished patient the body aims to prevent muscle and protein breakdown. As glycogen stores are depleted, fatty acids become the primary source of energy. Insulin is suppressed, while glucagon and cortisol secretion is increased. When provided nutrition the body attempts to reverse its adaption to the catabolic, starved state. Insulin levels increase inhibiting gluconeogenesis and promote glycogen, fat, and protein synthesis. This shift to the anabolic state from a reliance on fat oxidation depletes critical electrolytes and micronutrients needed for carbohydrate metabolism. The uptake of glucose, phosphorus, potassium, magnesium, and thiamin into cells, leaves little in the blood. This causes hypophosphatemia, hypokalemia, hypomagnesemia, thiamine deficiency, and sodium and water retention, resulting in refeeding syndrome.

Complications are serious and may include: arrhythmia, heart failure and sudden death, kidney failure, metabolic acidosis, delirium, paralysis, muscle cramps, Wernicke-Korsakoff syndrome, and sepsis.

Risk Factors: The guidelines at the National Institute for Clinical Excellence (NICE) for patients at risk for refeeding syndrome are as follows. Guidelines may be difficult to assess in a wilderness setting, but you can evaluate physical appearance and how long the patient has been without food.

ONE or more of the following: -OR-	**TWO** or more of the following:
BMI < 16 kg/m^2	BMI <18.5 kg/m^2
Unintentional weight loss of > 15% in the previous 3-6 months	Unintentional weight loss of >10% in the previous 3-6 months
Little or no nutritional intake for >10 days	Little or no nutritional intake for >5 days
Low levels of potassium, phosphorus, or magnesium before refeeding.	History of alcohol abuse or drugs including insulin, chemotherapy, antacids, or diuretics.

Wilderness nutrition refeeding protocol: while there is no standardized care for refeeding in the wilderness setting, suggestions are listed below. Most importantly resolve any life-threatening medical issues prior to addressing nutrition concerns. Begin by assessing risk for refeeding syndrome by following NICE guidelines. As a general rule, don't allow the patient to gorge. In all circumstances, make sure the patient's kidneys can process fluid by monitoring how frequently the patient is voiding. In order to appropriately feed a patient, the rescuer should:

- Assess how long the patient has been without food and/or water
- Assess length of transport to a medical facility
- For both short and extended length of transport, if the patient has been without food and/or water for a shorter period of time (3-5 days) without significant weight loss and is at low risk for refeeding syndrome, the rescuer should offer small frequent feedings of normal food. Providing food will assist the patient to become ambulatory. An ambulatory patient is easier to transport than a non-ambulatory patient. Assess for dehydration and hypoglycemia and provide fluid and snacks as needed to assist the patient. Good choices include: sports drinks, juices, soups, instant oatmeal, granola bars, banana chips, and small pieces of jerky.
- If length of time to a medical facility is short (less than a few hours) and the patient has been without food for ≥5 days and medical history suggests significant weight loss indicating risk for refeeding syndrome, administer 200-300 mg oral or IV thiamine prior to any administration of food or dextrose solution. A multivitamin can be used if thiamine is not available. If the patient is dehydrated and/or hypoglycemic restore fluid and blood glucose levels carefully with dilute Gatorade or similar drink or low concentration (10%) IV dextrose. No other food need be administered until reaching the medical facility. Alert the medical facility of possible risk for refeeding syndrome. If you don't have thiamine, or a way

to monitor electrolytes, do not refeed the patient in the field. Wait until the hospital, where electrolytes can be monitored and hospital staff can properly begin refeeding the patient.

- If length of time to a medical facility is extended beyond a few hours and the patient is at risk for refeeding syndrome, administer 200-300 mg oral or IV thiamine. Following thiamine, follow the above protocol for dehydration and hypoglycemia. Minimal food should be introduced, as refeeding should primarily be conducted at the medical facility where electrolytes can be monitored. NICE recommendations specify no more than 10 kcal/kg/d and for the critically malnourished victim no more than 5 kcal/kg/d. High fat, high protein foods are generally well tolerated.
- If the length of time to a medical facility is extended beyond a few hours and the rescuer does not have thiamine or a multivitamin to administer to the patient, avoid giving any food and if necessary, provide only the lowest dextrose concentration possible to treat hypoglycemia. Refeeding syndrome has been known to occur within a few hours in some patients.

Conclusion

As a wilderness healthcare provider, you may travel and work in stressful physical environments such as mountainous or technical terrain, high altitude and extreme temperatures. These environments increase the need for adequate nutrition. Unfortunately, stressful physical environments and crisis situations often coincide with decreased availability of food. Planning nutrition needs along with fueling and hydrating properly for wilderness rescue operations will allow you to maintain the concentration and physical stamina required for a wilderness rescue. In addition, you will be able to evaluate nutritional concerns of patients, and follow appropriate protocols of nutrition intake, refeeding and other medical situations where nutrition is an important concern.

An easy way to prepare ahead of time for a wilderness rescue is having a 24-Hour Pack ready to use. Examples of nutrition related items include:

- Adequate fluid and a means of water purification (iodine tablets, a water filter, or UV water purification pen)
- If traveling in remote areas with the likelihood of an extended rescue mission consider carrying a military ration such as the Meals Ready to Eat (MRE). They are lightweight, calorie dense, and can provide adequate nutrition for a longer duration rescue operation
- Trail mix (nuts, seeds, chocolate and granola)
- Jerky
- Hard candies
- Honey packets
- Granola or sports bars
- Sports gels

- Thiamine (oral)
- Multivitamin
- Single portion of drink mix
- Glucose tabs

Chapter 20: High-Velocity Sports Injuries

Skiing, snowboarding, and mountain biking are popular sports, and where people move at fast speeds. With high velocity comes an inherent risk for injury. But with the progression of technology of such sports, participants now feel more comfortable at higher speeds and maneuvering through more technical terrain. This trend in the progression of velocity and technicality causes a greater risk for injuries. The injuries which occur at higher speeds can often be more serious and laced with greater complications.

HOW TRAUMA HAPPENS

Bones are strong. The average healthy mid-shaft femur can support a force of around 12,000 pounds (53,000N) for fracturing. But even though they are so strong, bones will break because of the momentum involved. The mass, direction, and velocity of an object determines its momentum. For example, the bigger and faster an object is moving, the greater its momentum. A baseball flying through the air has a lot of momentum. When it hits a baseball bat, the force needed to change the baseball's direction (that is, its momentum) is huge and is done almost instantaneously. What this means is that the shorter the time of impact, the greater the force. In other words, what matters most is not so much how fast you are going when you stop, but how quickly, or abruptly, you stop.

To reduce the force of an impact, and thereby reduce the likelihood of a bone fracture, it is necessary to stop movement gradually. For the human body, a gradual stop is accomplished in a number of ways. When a person jumps, he or she instinctively creates a system of shock absorbers through the bending of toes, ankles, knees, and hips. This bending motion is essential as it increases the time it takes to stop, thus decreasing the overall force on the body. Crashing, while skiing or mountain biking, can have devastating consequences if that person stops quickly. Rapid release bindings on skis and helmets are designed to help with this problem.

The three ways in which bones can break are by forces of **tension**, **compression**, and **shearing**, with shearing and tension being the most common mechanisms through which the break occurs. Factures can often occur as a combination of the three force vectors. However, a shear fracture can be particularly dangerous because the fracture often results in a spiral break in which the bone is apt to puncturing through

the skin, which can cause excessive bleeding along with the increased risk of infection. An example of a mechanism of injury that could cause such a spiral fracture is having one's foot locked into a specific position, then falling while twisting one's leg around the anchored foot.

Mountain Biking Injuries

Since its start in the later 1900's mountain biking has quickly accelerated to become one of the fasted growing sports in the world. There are nearly Nine million mountain bikers in the United States, and about that many in Europe. With such a growth of the sport, the technology surrounding mountain biking has grown as well. With the inventions of geared and full suspension bikes, along with larger tires and improved traction, participants are tempted to test the edge of speed and ruggedness, leading to an increase in injuries.

When people think of mountain bike injuries, they first think of fractures and dislocations. However, those types of injuries are low on the list, accounting for just a few of the total injuries. Most fractures and dislocation occur while mountain biking happens in the upper extremity, where they can be subject to high compressive forces. Injuries involving the distal radius, clavicle, scaphoid, and hamate are among the most common biking fractures, while common dislocations involve the shoulder.

Type of Cycling Injury Percentage	
Wound	35%
Bruise	25%
Strain	15%
Tendinitis	7%
Fracture	4%
Dislocation	3%

Body Part Percentage			
Neck	50%	Thighs	8%
Knees	42%	Elbows	5%
Groin	35%	Head	4%
Hand	31%	Hips	4%
Shoulders	31%	Ankles	4%
Back	30%	Achilles	4%
Feet	30%		

Wounds and bruises are the most common types of injuries people tend to sustain when biking. The most common parts of the body that are injured for which bikers seek medical care are the neck, knees, buttocks/groin, and upper extremities. Head injuries are common and can be very serious. High speed, technical terrain, and proximity of other bikers in races all increase the likelihood of head injuries. Thus, bikers should ALWAYS wear a helmet. The style, shape, and size of helmets can vary. Mountain bikers should always check with the manufacturer's recommendation when determining which type of helmet is correct for their given style of riding. As well, any time a fall involves an impact to the head, the integrity of the helmet should be checked to make sure it is still suitable for continued use.

Head Injuries

Head injuries from biking can result in a concussion. Clinical findings of a concussion depend on the severity and location of the injury. Look for CSF leaking from the ears or nose, as this may be a sign of a skull fracture and would constitute a medical emergency. The treatment of a concussion (Traumatic Brain Injury, or TBI) varies with the severity.

With a mild concussion, there is no specific treatment, and patients are usually monitored for 24 hours. More severe concussions can require intensive monitoring, care, and even surgery, depending on the extent of the injury. A cranial CT scan is often used to help the care team with the assessment.

One should use extreme caution when treating a concussion in a wilderness setting. A general rule is if symptoms worsen and last longer than 15 minutes evacuate the patient. A patient evacuation may also be required if other symptoms present. Head injuries are often accompanied with neck and spinal cord injury. Thus, caution and proper evacuation technique should be used when moving a patient that has suffered a head injury to ensure that no neck and spinal cord damage is caused.

Common Signs of a Concussion	
Headache	Vertigo
Slurred speech	Nausea
Vomiting	Vacant stare
Delayed speech	Delayed motor
Disorientation	Confusion
Memory deficits	Loss of consciousness
Intense emotions	Dizziness

Other Biking Injuries

Not all biking injuries are the result of a hard crash. Some injuries come from small micro-injuries over an extended period of time. For example, **Micro-Whiplash** syndrome is the result of tail vibrations on the neck. We all recognize that the human head is heavy. Placing a helmet on it makes it heavier, and then it vibrates up and down while riding. Micro-Whiplash syndrome, along with generalized neck and back pain, can be avoided by ensuring the bike is properly fitted and adjusted for the rider. Massaging, ice, stretching, and non-sedating pain relievers can help in the management of such injuries.

Saddle associated symptoms are also common among bike riders. Proper saddle height and positioning can help avoid many of the saddle associated symptoms and injuries. If the saddle height is too low, patellar tendonitis and quadriceps tendonitis can occur, often presenting with patellar pain, swelling, and joint tenderness. Thus, correcting the saddle height can aid in the alleviation of the pain. Conversely, if the saddle is positioned too high, saddle sores and chafing are common and can present as localized skin irritation. Keeping the area clean and dry, and wearing

seamless shorts can help prevent and alleviate the symptoms associated with saddle sores and chaffing. A pudendal nerve compression injury is also possible from too high of a saddle. As well as correcting saddle position, standing intermittently, when completing long bike rides, can help avoid pudendal nerve injury.

Proper Bike Set Up to Reduce Medical Problems	
1. The rider should sit on the seat with their heel on the pedal. The height should then be adjusted so the leg on the pedal is straight. That is the proper seat height.	
2. When adjusting the seat angle for males, generally the level is slightly elevated in the back, and for women generally the seat angle is depressed in the back. Handlebar adjustments are usually necessary as well.	
3. The handlebar is generally positioned one to four inches below the level of the saddle, and the rider's nose should be directly over the handlebar. The proper adjustment should allow for about one third of the rider's body weight to be resting on the arms. However, the height and positioning of the handlebars can be adjusted during long rides to help with back and neck pain.	

Skiing Injuries

Worldwide, there are about 130 million skiers and snowboarders. Skiing is another high-speed sport leading to an increased probability of injury. Natural obstacles such as trees, rocks, poor visibility, and snow conditions can make for an increased possibility of trauma. However, other human-made features such as ski lifts, along with snowboarders and skiers, can increase the likelihood hood of sustaining an injury.

Improper Equipment Maintenance

The overall occurrence of skiing related injuries has decreased by 50 percent since the 1970's. This is in large part due to the improvement of the equipment with safety release bindings and hard-shell boots that allow for better control.

Nearly half all downhill skiing accidents are a result of improper equipment maintenance.

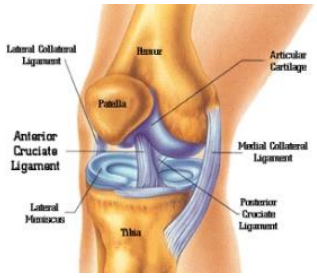
However, while the number of lower limb fractures has decreased, the number of soft tissue injuries has drastically increased. This trend is most likely associated with the newer equipment being used. Even though the equipment has continued to improve, the need for constant maintenance of equipment is always required. Nearly half of all downhill skiing accidents are the result of improper equipment maintenance. Though the newer mechanisms of binding release are much better than the historical binding, issues still arise. About 70 percent of the lower leg fractures and knee injuries that have occurred while skiing is a result of improper binding release. Thus, it is crucial that the settings on the bindings be adjusted to the skier.

Though rare, skiing fatalities do exist. Most skiing related deaths are the result of the skier colliding with a stationary object such as a tree or piece of equipment. Of the deaths reported due to skiing, 60 percent of them involved head injuries. A skier should always ski in control and choose terrain that is within their own ability.

> Based on 52.8 million total skier/snowboarder visits during the 2015-16 season, the fatality rate converts to less than one fatality per one million skier visits (or 0.74 fatalities per one million skier visits during the 2015-16 season, slightly above the 10-year average rate of 0.67 fatalities per million skier visits).

Soft Tissue Knee Injuries

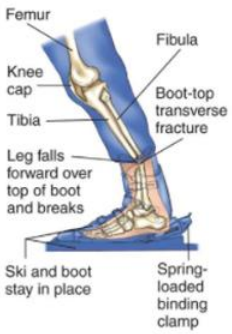
Soft tissue knee injuries are the most common within the sport. Beginner skiers are especially suspectable **to medial collateral ligament (MCL)** injuries because most beginner to low-intermediate skiers are taught to use the "snowplow," or "wedge" technique. If they turn too sharply, or one ski catches, the MCL is subject to high stresses. To assess a possible MCL injury, place valgus stress with the knee in 30-degree flexion with the foot internally rotated. If a knee injury is suspected, the patient's knee should be immobilized with a splint, and the patient taken off the hill.



The most commonly injured structure of the knee is the **anterior cruciate ligament (ACL)**. The ACL's role is to prevent backward motion of the femur on the tibia, as well as hyperextension at the knee. An injury to the ACL is often the result of a movement such as cutting or twisting that places too much stress on the ligament. Many skiers who suffer from an ACL injury report hearing an audible "pop" or "snap" just prior to the knee giving out.

The "phantom foot fall" is an iconic position of strain which leads to an ACL injury. As depicted in the picture this type of fall typically occurs when the skier is off balance toward the back of their skis. Their hips are below their knees, and their weight on the inside edge of the downhill ski which is planted in the snow. As the body falls backward, the femur is pulled backward on the tibia. The ACL is unable to support the weight of the body and will 'snap' off. There are certain knee assessments such as the Lachman test or the anterior drawer test that can be used to assess an ACL Injury. However, ultimately an MRI is needed in order to make a diagnosis. When an injury is suspected, the patient's knee should be splinted in the position of function, and the skier taken off the hill.

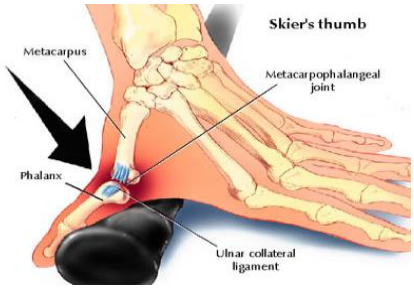
Although soft tissue knee injuries encompass the majority of lower extremity injuries, fractures still occur. In particular, the advancement of equipment from soft shell to hard-shelled boots has brought an increase in tibial and fibula fractures. These fractures typically occur at the top of the boot because the hard shell of the boot provides support wherever the boot covers. Such an injury has coined the term "boot top" fracture. When dealing with a boot top fracture, the injury needs to be exposed to ensure that there is no bleeding as a result of a compound fracture. Then CSM should be checked before the injury is immobilized and splinted.



Upper Extremity Injuries

Upper-extremity injuries are also frequently seen in skiing related injuries, with the frequency of these injuries increasing during icy conditions. Injuries to the arm and shoulder account for 30 to 40 percent of all skiing injuries, according to the American College of Sports Medicine (ACSM). Among the most commonly seen upper-extremity injuries are dislocated shoulders, fractured humerus, and wrist injuries.

The skier's thumb injury is the most common upper extremity injury and typically occurs on hardpacked snow. It happens when the skier falls on their ski pole, which acts as a lever between thumb and index finger. It can also occur when the thumb catches some snow during a fall. Symptoms are tenderness in the area with deep throbbing pain. The treatment is to splint the hand in a functional position and seek definitive help.



Anterior shoulder dislocations usually result from abduction, extension, and external rotation, with forces typically coming from the front as the arm is outstretched. Common indications of a shoulder dislocation include exquisite tenderness within the joint, along with a visible step-off of the joint. While it is not uncommon for patients and friends to reset the shoulder without medical assistance, evacuation is necessary for definitive care. Depending on the position of comfort for the patient, a sling and swath are often beneficial in stabilizing and protecting the injured joint. Be sure to check perfusion and sensation before and after the application of the splint.

Just like mountain biking, skiing also should be done with a helmet. However, helmets of any sort only offer protection to a certain extent. The CPSC suggests helmets offer little protection beyond 12 mph. Unfortunately, the use of helmets can give patrons of sports a false sense of security, leading to reckless behaviors. When assisting a patient who has fallen, one should always be suspicious of a head injury and vigilant for the common signs of concussions, as discussed previously. As with any suspected injury, the sight of the injury needs to be exposed in order to properly assess the severity and type of injury. This can be particularly difficult for skiing injuries

given the weather conditions and the likely scenario in which the patient is wearing multiple layers of clothing.

Re-cap of Common Ski Related Injuries	
Head Injury	At worst, head injuries can cause a bleed in the brain. Most other injuries will be less severe and may require suturing. Generally, head injuries are severe, could become worse, and will need proper management off of the slope.
Medial Collateral Ligament Tear	Found on the inside of the knee, its ultimate purpose is to prevent the knee from bending fully inwards. While skiing or snowboarding, an MCL tear may occur because of the impact caused by the force of one leg falling on another. As a result of this injury, skiers will likely experience severe pain, as well as bruising and swelling. While standing with this injury is possible, it will be painful.
Anterior Cruciate Ligament Injury	This is one of the most common sports injuries. The ACL is subject to injury in any sport that involves rapid maneuvering. Skiing and snowboarding both involve sudden turns that could potentially cause an ACL tear. Located in the center of the knee, the ACL controls how far the femur can move in relation to the tibia. ACL injuries occur when people pivot while standing, hyperextend, or stop suddenly. Often, people suffering from an ACL injury will hear a popping sound.
Shoulder Injury	Depending on the way a skier and/or snowboarder falls, a shoulder injury may be common as well. Because the shoulder connects the arms to the torso, there are plenty of body structures that may be affected. The ligaments, muscles, and tendons may be affected by the fall as well, and as a result, become weakened. Shoulder injuries require individualized treatment.
Wrist Fracture	This is a common injury for skiers. During a fall, it's instinctual to attempt to catch your balance by reaching out a hand for support. If you are suffering from a wrist injury while skiing, then it's imperative to stop skiing.
Skier's Thumb	The thumb is an especially vulnerable joint. Thumb ligament injuries are the second most common skiing injuries, surpassed only by MCL injuries in the knee. Skier's Thumb is an acute injury that often happens when falling with your hand in the ski pole strap. Your thumb can get caught and pulled away from the hand, which can cause a ligament tear. This can result in difficulty with grasping.
Boot Top Fracture	One of the worst ski injuries that can occur to the lower extremity is the boot top fracture. These fractures occur as the tibia and/or fibula fracture above the

	top of the boot. They almost always require surgical intervention as the tibia has the highest rate of non-union among all bones in the body.

Snowboarding Injuries

Snowboarding is another high-velocity sport where injures are common. Since the equipment and technique required for snowboarding are different from skiing, so too are the commonly seen injuries.

A toe side fall on a snowboard happens when the snowboarder falls face forward toward the ground. These types of falls can be violent and come unexpectedly to the snowboarder. Because of the suddenness, there often is a delayed response in being able to reach out their hands to brace the fall. This can lead to clavicular fractures, shoulder separations, and/or facial and head injuries.

However, in the circumstance where the snowboarder does have time to reach their arms out to brace for the fall, the violent nature of a toe side fall can result in a severe wrist or humeral fractures. The most common wrist fracture seen among snowboards is the "dinner fork" fracture.

Wrist guards have become more prevalent in the protection against wrist injuries seen in snowboarding. However, while the wrist guards are effective at preventing wrist injuries, the equipment may result in the transfer of forces to more proximal joints and bones, leading to forearm fractures, posterior elbow dislocations, or shoulder injuries.

The other common type of fall associated with snowboarding is a heel side fall. This occurs when the snowboarder falls back towards the ground. Because the snowboarder is falling backward, they are usually unable to use their arms to brace the fall. Consequently, this leads to buttock contusions, spinal compressions, and head injuries.

Chapter 21 - General Principles of Evacuation

The Evacuation Decision

Whether or not an injury or illness requires evacuation depends on several factors. These factors include the following:

1. The severity of the injury or illness.
2. The potential risk(s) to the patient, party, and/or rescuers.
3. The medical management and evacuation capabilities of the party.
4. The ability to communicate with and mobilize additional resources.
5. The terrain and distance over which the patient must be evacuated.

Such decisions to evacuate or not are often imperfect and made using incomplete information amid changing conditions. As such, these decisions must be constantly re-evaluated. Although such decisions can be difficult, they are based upon information obtained from the patient assessment and guided by some basic principles. This chapter seeks to provide basic evacuation guidelines for commonly encountered situations.

The Evacuation Plan

Once it has been decided that the patient needs to be evacuated in order to receive a higher level or definitive medical care, the group must collaboratively come up with an evacuation plan. There are three basic types of evacuation plans:

1. The patient **stays in place** and awaits evacuation by helicopter or another vehicle. This is most likely if the patient is severely injured or is located in steep or other dangerous terrains that precludes simple evacuation. This also can occur if the group is too small to carry a patient any distance. If you are alone with an injured person, you may need to leave the patient and go get help. In such a scenario, the patient should be place on their side in a "recovery" position, with the mouth facing downward to minimize aspiration risk, the chin tilted up to keep airway open, and with the arms and legs stabilizing the patient's position. The patient should be insulated and protected from the environment as much as possible. The ability to signal for help is also critical in such situations. While cell phones may be used in many places to call for help, in mountainous or remote terrain they may be useless. If possible, have two members of the group leave to get help. Avoid going alone if possible. Also, rescue teams are aided in finding a stationary patient by lights, smoke, or signal mirrors.
2. The patient is **carried or assisted a short distance** to rendezvous with a helicopter or other vehicle. An injured or ill patient may be able to move or be moved to meet with rescuers on helicopters, ATVS, snowmobiles, snowcats, or other vehicles. Rather than staying in place and awaiting rescue, the patient's party may close the

distance and shorten the time of evacuation by moving to a clearing where a helicopter may land, or by slowly and safely moving down the trail until met by rescue teams or other assistance. The patient can also be moved to a safer, more sheltered location to await a more definitive evacuation. However, if moving the patient is decided to be the best plan, care should be taken not to exhaust the group or take unreasonable risks.

3. The patient is **carried or assisted all the way out** to meet with an ambulance or other means of transport to definitive care. If the distance is relatively short, the terrain is mild, or the group is large enough, it may be possible to evacuate the patient out of the wilderness to meet EMS at roadside, or transport to a hospital by other means. Carrying a patient over a trail requires enormous effort, and carriers should be relieved often by other group members. This requires a large number of people to execute effectively.

Executing the Evacuation Plan

During every evacuation, a patient must be protected from the environment. While those carrying the patient may not feel cold, a motionless patient may become hypothermic. In a hot environment, it is important that carriers avoid heat illness themselves, as well as see to it that the patient does not become overheated or sunburned if covered or exposed to sunlight. Take care to pad the patient, especially around any injuries, and avoid rocks and roots along the trail. Patient positioning should be constantly reassessed, and it should be anticipated that even a well-secured patient will shift over the course of being carried over any distance. Special care should be taken if the patient has an altered mental status or is unable to notify the group of changes. The status of the patient's injury or illness should also be reassessed during transport. Distal to any injury, the circulatory, sensory, and motor functions should be evaluated frequently.

Situational awareness is paramount. This means being aware of changing environmental hazards, diminishing daylight, falling temperatures, or rescuer fatigue. Be aware that slopes above you may expose you and the patient to rockfall or avalanche. Consider the consequences of slips and falls and avoid unprotected edges or exposure. A group must adapt to these changes and adjust their plan as needed. If an evacuation plan becomes unfeasible with changing or unforeseen conditions, the group should stop and reassess their plan under the new circumstances and create a new evacuation plan as needed. Additionally, if patient care is transferred to another group or to professional responders, it is important that information about the patient be transferred as well. Documentation using a SOAP (subjective, objective, assessment, plan) note format is simple and useful. If the group does not have the means to write a note, the information should be transmitted verbally in this format to the team receiving the patient.

While these general principles may help guide evacuation decisions and planning, each situation is unique, and specific injuries or illnesses may have specific considerations. The remainder of this chapter addresses evacuation guidelines of specific types of illness or injury.

EVACUATION GUIDELINES FOR SPECIFIC TYPES OF ILLNESS OR INJURY

Bites and Stings

- Bite wounds pose a higher infection risk than other types of wounds, and thus often require evacuation. Any bite of the hands, feet, face or genitalia should be cause for evacuation. Rabies is also a serious concern. Any bite from a raccoon, skunk, bat, or dog (especially outside the United States) should be a reason to evacuate to definitive medical care for rabies post-exposure prophylaxis.
- Any patient bitten by a snake should be promptly evacuated as well. Suspected or known black widow spider bites should be evacuated for pain control and further medical attention, although brown recluse bites need only be evacuated if systemic symptoms develop.
- Alternatively, most tick bites do not require evacuation, especially if the tick is removed within 48 hours.
- A patient stung by a bee must be evacuated if the patient is allergic or received an Epi-Pen injection. The patient suffering an allergic reaction may walk if able and should be given an antihistamine and monitored closely. A bee sting to a non-allergic patient may not need evacuation.
- Scorpion stings rarely require evacuation but should be evacuated if it is suspected to be a bark scorpion or if the patient has an allergic response.

Fractures and Dislocations

As a general rule, any suspected fracture or dislocation should be evacuated, especially if there is loss of circulation, sensation or motor function distal to the injury. Some dislocated joints (e.g., shoulder, finger) may not require evacuation if the joint is easily reduced and has good color/circulation, sensory, and motor function. If pain persists, or the joint's function is affected, the patient should be evacuated.

Head and Spine Injuries

Rescuers should have a low threshold for evacuating a patient with a suspected head or spine injury. The severity of head injury can be estimated in the field by loss of consciousness. A head injury with brief loss of consciousness has a low probability of serious brain injury, and evacuation may not be necessary unless signs of brain injury arise, such as confusion, memory problems, severe headache, bizarre behavior or seizures. Any suspected skull fracture, facial fracture, or penetrating head wound should be evacuated.

Any suspected spinal injury should be evacuated, especially if there are changes in sensory or motor function. Spinal injuries should be evacuated with spinal stabilization using whatever means available (padding, bulky clothing, rigid litter, etc.).

Infectious Diseases

Even small wounds can evolve into serious problems if they become infected. Wounds typically become infected within 24-36 hours after the injury. Any wound with signs of infection should be evacuated. Signs of infection include worsening pain, redness expanding out from the wound, red streaking away from the wound, swelling of the wound and surrounding tissue, pus, or fever. To prevent infection, wounds that are grossly contaminated or unable to be fully cleaned should be evacuated before infection sets in. Other infectious process may also require evacuation. Viral pharyngitis, or the "common cold" may not require evacuation, but travel plans may need adjustment to allow for rest. Cough, shortness of breath, and fever may be signs of pneumonia, which may require evacuation as well. Untreated infections may progress to sepsis or septic shock, so there should be a low threshold for the evacuation of patients with infectious symptoms. Other dangerous infections exist worldwide (e.g., Malaria, Dengue, Ebola, etc.) that may require evacuation. As a precaution, region-specific hazards, preventive measures, and evacuation pre-plans should be determined prior to travel in these areas.

Abdominal Problems

As a general rule, any patient with a serious abdominal illness or injury should be evacuated. Nausea, vomiting, diarrhea, and abdominal pain or cramping are common, and may not require evacuation if the patient is able to stay hydrated and does not exhibit signs of more serious illness. Signs of serious abdominal illness requiring evacuation include blood seen in the urine, vomit or feces, and pain persisting longer than 24 hours, pain localized in a single part of the abdomen, high fever, or abdominal pain in a pregnant patient (or a patient who might be pregnant). Additionally, any patient with a rigid or distended abdomen or signs of shock should be promptly evacuated.

Medical Problems

Worsening of a patient's medical problems may also require prompt evacuation:

- Chest pain - Any patient with chest pain should be considered for evacuation, particularly if the chest pain is associated with nausea, vomiting or shortness of breath.
- Diabetes - Hypoglycemic patients with a history of diabetes may require evacuation depending on the situation. If the patient responds to treatment, evacuation options should be discussed with the patient. If the decision is to stay, the patient should be given sugar and food and should be monitored closely. Severely hyperglycemic patients should be evacuated.

- Difficulty breathing - Any patient suffering a medical emergency that involves difficulty breathing should be promptly evacuated. Patients with a history of mild asthma treated successfully with full resolution of symptoms do not necessarily require evacuation.
- Neurological - Any patient with an altered mental status should be evacuated. Any patient with signs or symptoms of stroke (localized weakness, imbalance, or facial droop) should be immediately evacuated. Any patient who has had a seizure should be evacuated as well, especially if they have no prior history of seizures.

Wounds and burns

- Wounds that are large, deep, or dirty should be evacuated. Additionally, any wound with significant bleeding or bleeding that cannot be stopped or requires a tourniquet should be immediately evacuated.
- The evacuation of burns depends on the extent and depth of the burn. As a general rule, full thickness (3rd degree) burns that are larger than 1% TBSA should be evacuated. Partial thickness (2nd degree) burns that are larger than 10% TBSA should likewise be evacuated. Any severe burn of the face, airway, hands, feet, genitalia, or burns from electricity should be promptly evacuated.

Altitude

Acute mountain sickness (headache + mild nausea) does not necessitate evacuation if symptoms resolve. If symptoms progress to ataxia/incoordination, especially while walking, or altered mental status, then the patient is likely developing high altitude cerebral edema (HACE) and must be immediately evacuated to a lower elevation. Likewise, any patient at altitude who develops shortness of breath should be suspected to have high-altitude pulmonary edema (HAPE) and should be immediately evacuated to a lower altitude. If evacuation is not possible due to weather conditions or other factors, a portable hyperbaric chamber (Gamow bag) may be considered.

Submersion injuries

Any patient involved in submersion or drowning should be evacuated for medical evaluation, especially if there was a loss of consciousness. As well, evacuation should be done if CPR or rescue breathing was administered, or the patient has any degree of difficulty breathing.

Heat Illness

- Patients suffering heat cramps or mild heat exhaustion do not require evacuation and can be cooled, hydrated with salt repletion, and monitored. Patients who have fainted (heat-related syncope) and who have only a brief loss of consciousness with quick recovery may be monitored and may not need evacuation.

- If a patient suffers a prolonged loss of consciousness (>1 minute), faints more than once, or has persistent pre-syncopal symptoms, they should be promptly evacuated. Patients with heat exhaustion who can adequately be cooled, hydrated, and closely observed may not require evacuation.
- Evacuation of a heat exhaustion patient is necessary if the patient develops altered mental status, behavioral changes, rising temperature (if able to measure), or any other concerns of progression to heatstroke.
- Heatstroke is a medical emergency that necessitates immediate evacuation and cooling.

Hypothermia and Frostbite

- A patient with mild hypothermia who has recovered does not need to be evacuated. Means should be taken to prevent hypothermia from moving forward, and if circumstances make it likely that the patient will become hypothermic again, the patient should be evacuated.
- Any patient with moderate to severe hypothermia (severe confusion to unconscious) should be carefully and promptly evacuated. During the evacuation of hypothermic patients, care should be taken to avoid jarring movements of their body and extremities, as these patients are very sensitive to cardiac arrhythmia. Do not move their extremities excessively. During transport, patients should be protected in a "hypothermia wrap", providing a vapor barrier and insulation from the cold exterior environment. Active rewarming should be initiated by placing large heat packs on the chest, back, and axillae. Commercial hand-warmers do not provide enough heat to provide core rewarming, and may cause burns due to high surface temperatures, and thus should not be used.
- All frostbite should be evacuated as the extent of tissue damage is not able to be determined until after rewarming of the tissue. Rewarming of the tissue should not be started in the field unless evacuation time is greater than 2 hours, and there is no chance of re-freezing.

Lightning

Any patient struck by lightning, either directly or indirectly, requires immediate evacuation for medical evaluation. Evacuation should be prompt, in any case, but should be expedited if the patient required CPR.

Chapter 22: Point of Care Ultrasound

Portable ultrasound is increasingly utilized in wilderness and austere environments because it is easy to use, lightweight, durable and battery powered. Portable ultrasound devices may be particularly useful for extended expeditions and remote clinics where specialty resources and advanced imaging is not available, or where evacuation would be difficult or dangerous.

Since ultrasound has better specificity than sensitivity, its greatest utility in austere settings is in ruling out emergent pathology, thereby expediting the decision to evacuate to definitive care. Importantly, ultrasound should be used as an adjunct to support clinical findings and increase suspicion for a diagnosis but should be used with caution to rule out potentially dangerous pathology.

Point of care ultrasound (POCUS) is also operator dependent and requires significant training to become proficient in both image acquisition and interpretation. This chapter provides an overview of handheld POCUS and describes how this modality can be used to guide diagnostic and management decisions in the wilderness, but is not an adequate replacement for a formal training program.

PRINCIPLES OF PORTABLE ULTRASOUND

Ultrasound devices function by transmitting high frequency sound waves into tissues and creating an image from those that are reflected back to the probe. Air and dense tissue, such as bone, are considered **hyperechoic** compared to other tissues because they reflect sound waves well, appearing bright grey or white. **Hypoechoic** tissues such as fat and muscle, reflect fewer sound waves and appear darker in comparison. Fluid is **anechoic**, **appearing black**, because it transmits all sound waves. Additionally, abrupt changes in tissue density produce unique artifacts in the reflected sound waves which may be diagnostically helpful.

Fundamentals

Select the transducer best suited to what is being imaged **[Fig 1]**:

- **Curvilinear**: Low frequency, lower resolution, but better penetration (maximum 25+ cm). Ideal for abdominal, pelvic and deep lung windows.
- **Linear**: High frequency, higher resolution but less penetration (maximum 8 cm). Ideal for procedures, skin and soft tissue, vascular structures, and superficial lung windows.
- **Phased Array**: Low frequency, but smallest footprint. Ideal for cardiac and abdominal windows with a maximum depth similar to curved probe. Can be substituted for a curvilinear probe in a remote setting.

Fig. 1: Ultrasound transducers from left to right: curvilinear, linear and phased array
(Image courtesy of Dr. Zachary Soucy, Dartmouth Hitchcock Medical Center)

The **probe marker** should be oriented to the top left of the screen to maintain anatomic orientation. In cardiac windows, the probe marker may be oriented to the top right. For most studies, the probe marker will point toward the patient's head or right side. The **image depth** is appropriate when the area being evaluated is centered on the screen with at least 2 cm depth behind the organ of interest.

Gain should be adjusted to optimize image brightness contrast at all depths.

Ultrasound has several modes:

- **B (Brightness) Mode** is the default setting most commonly used, generating a 2D greyscale cross sectional image. It is used for visualizing structures and performing US-guided procedures.
- **Color Doppler** shows flow toward the transducer in red and away from the transducer in blue and is most often used to detect blood flow.
- **M (Motion) Mode** displays a single scan line graphically. It is commonly used to detect pneumothorax, to determine fetal heart rate or help estimate cardiac ejection fraction.

Device Considerations

Compared to larger radiology ultrasound units, point of care handheld ultrasound devices are smaller and lighter, but traditionally have had inferior image quality. However, image quality of recent generations of devices has improved significantly. Considerations for selecting a device for an austere setting should include portability, durability, power, data storage, and telemedicine capability.

Portability: Portable devices vary from large laptop units to handheld devices that connect to a smartphone or small tablet. Smaller handheld devices equipped with 1-2 transducers weigh about one pound and are ideal for wilderness expeditions. Silicon based transducers can mimic different transducer frequencies, eliminating the need to carry multiple probes. Larger laptop devices with

multiple transducers tend to have better image quality and limited portability, and can be great options for stationary rural clinics or base camp settings.

Durability: Prior to device selection, consider the durability of every component of the device. Transducers of many handheld devices have been drop tested up to three feet but it may be wise to consult device manufacturers for expeditions where rough handling of the device is likely. Transducers can be stored in a protective case or wrapped in clothing or a sleeping bag for protection during travel. In addition, care should be taken to handle the cord carefully if it is permanently attached to the transducer. Transducers that connect wirelessly via Bluetooth or have detachable cords that are easily replaced upon return if damaged may be preferable for wilderness settings. Waterproofness of devices should also be considered. Some smart phones or tablet devices may be waterproof while others may benefit from a waterproof protective case, especially for maritime or high humidity environments. Transducers and dedicated devices operate best in temperature ranges of roughly 10°C to 40°C (50°F to104°F) and can be stored in temperatures of -20°C to 50°C (-4°F to 122°F). For travel in extreme environments, consult the device manufacturer and be aware that certain devices may malfunction in extreme heat, cold, and high altitude. In extreme cold, one can keep the device functioning by sleeping with cold batteries or soaking the transducer in warm water.

Power: Device battery life commonly ranges from 2-4 hours of continuous scan time, although some units may overheat if used continuously for extended periods. For longer expeditions, solar panels may be useful to re-charge batteries. Expect 0.1% to 0.6% charge per minute depending on cloud coverage. The interfacing device must also be adequately charged if not a dedicated device. In cold environments where run time is decreased, chemical foot warmers can prolong run time up to 30%.

Data Storage: Many portable ultrasound devices can encrypt and store scans securely on the dedicated device or in an iOS or Android application in areas with no Wi-fi or cellular service. Many devices require a product subscription to scan and store data.

Telemedicine Capabilities: With WIFI or cellular connectivity, many portable ultrasound platforms upload to a secure Cloud server to store and transfer scanned data. Devices that have a USB port can be used to export files directly to a PC. Most devices can be configured to be DICOM compatible and interface with an institution's imaging system to upload scans to a medical record. Some devices offer telemedicine guidance where a remote expert can advise on a scan in real time. This option may be useful for remote clinics where clinicians have limited experience. If sharing scans in a non-secure environment, check that your device is equipped to de-identify patient data. If your device does not have this capability, use a screen recording application that will provide complete de-identification including background embedded patient metadata.

Gel Substitutions: Single gel packets are easy to carry for short expeditions. For longer expeditions with limited space, glucomannan powder can be used to create gel by adding ½ tsp glucomannan

powder to a cup of water. A water bath eliminates the need for gel and is a good option for extremities or painful soft tissue injuries. If other gel medium is unavailable, cooking oil such as olive oil may be a good transmission medium and is safe for transducers.

ULTRASOUND IN TRAUMA / SHOCK ASSESSMENT

A POCUS exam can be used as an adjunct to the primary or secondary survey of a victim who has withstood wilderness trauma and can identify emergent pathology and expedite lifesaving evacuation. For victims in shock, POCUS can provide additional information towards determining the underlying etiology and guide short term management and stabilization.

Extended Focused Assessment with Sonography for Trauma (eFAST)

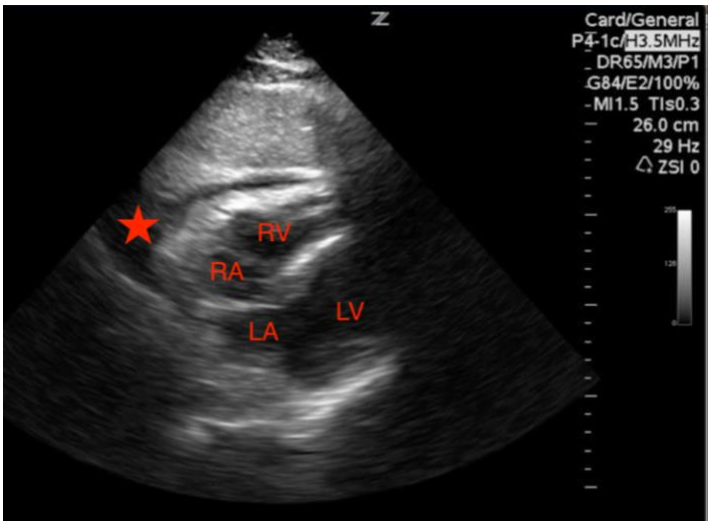
eFAST evaluates for pericardial tamponade, pneumothorax, hemothorax, and peritoneal free fluid that typically represents internal bleeding. Indications for eFAST include victims with unstable vitals, recent blunt trauma, or sudden shortness of breath after swimming or diving. Use a curvilinear or phased array probe. Curvilinear has a wider footprint, and may offer a clearer image and penetrates tissue better but is more likely to be affected by rib shadowing. The linear probe is best for pneumothorax assessment.

eFAST assess for pathology in five windows **[Fig 2]**. The **subxiphoid window [Fig 2a]** is a 4-chamber cardiac window that assesses for the presence of pericardial effusion or tamponade. Normal pericardium is a single hyperechoic line surrounding the heart. Abnormal pathology will appear as an anechoic stripe, often with chamber compression in tamponade. In an abnormal **right upper quadrant (RUQ) window [Fig 2b**], an anechoic stripe between the liver and kidney or kidney and diaphragm confirm free fluid. Patients may also have isolated free fluid at the liver tip. In the **left upper quadrant (LUQ) window [Fig 2c],** the spleen should be directly adjacent to the kidney and diaphragm. An anechoic stripe separating these structures or in the colic gutter implies free fluid. In an **abnormal pelvic window [Fig 2d],** free fluid in a male can be seen as anechoic region posterior or superior to the bladder. In females, free fluid will be posterior, anterior, and/or superior to the uterus. Lastly, the **thoracic window [Fig 2e]** examines lung pleura to assess for pneumothorax or hemothorax. Normal, non-pathologic respirations will show shimmering **lung sliding** between visceral and parietal pleura. The absence of lung sliding suggests there is air in the pleural space and is suspicious for a pneumothorax. **A lung point,** the exact point where lung sliding stops, is pathognomonic for pneumothorax. Anechoic fluid superior to the diaphragm confirms pleural effusion which may represent a hemothorax in the setting of trauma.

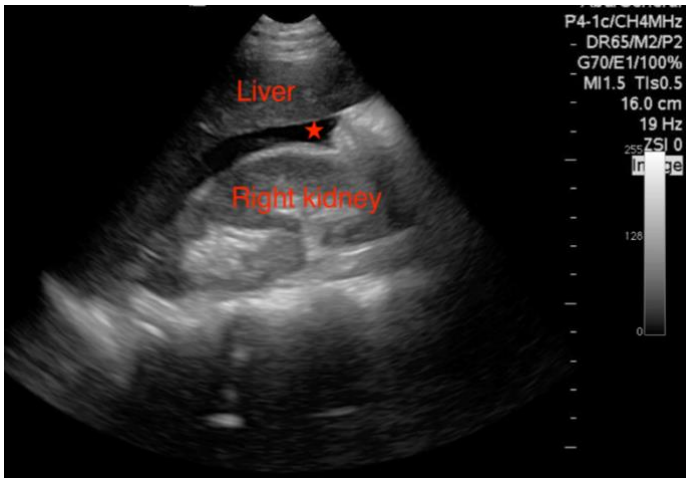
A positive eFAST should support a faster evacuation decision or quicker field stabilization efforts such as US-guided pericardiocentesis, decision to start an IV, or thoracostomy. The sensitivity of eFAST increases with the volume of free fluid. Even for experienced operators, eFAST can be falsely negative if there is minimal free fluid or if there is bleeding in the retroperitoneal space. If eFAST is negative or inconclusive in a hemodynamically unstable patient, search for another cause or repeat the scan periodically while waiting for emergent evacuation. Absence of lung sliding may also be

seen in patients with chronic obstructive pulmonary disease (COPD) or asthma, so consider a victim's underlying medical conditions.

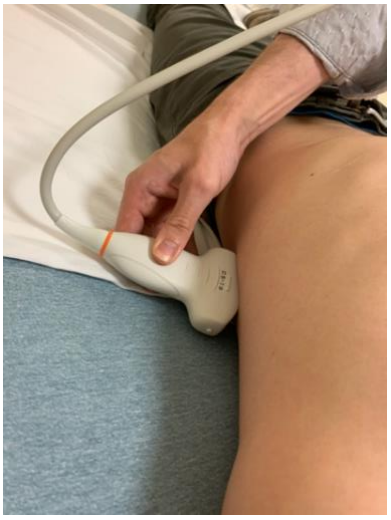
(a)

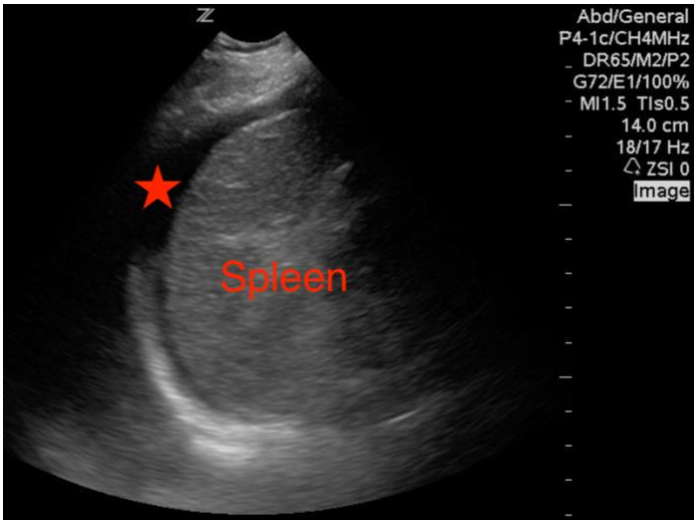


(b)

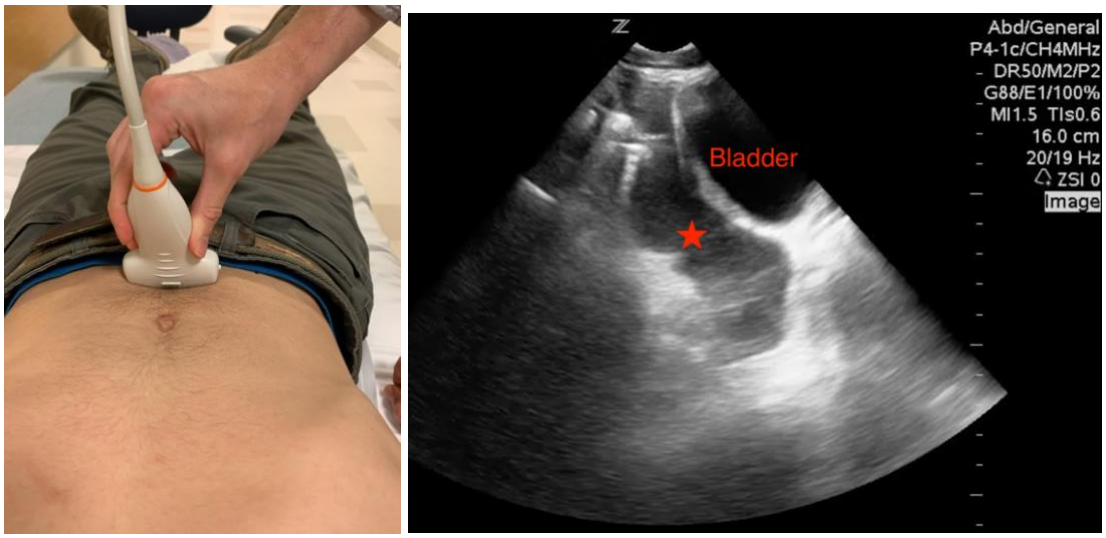


(c)





(d)



(e)

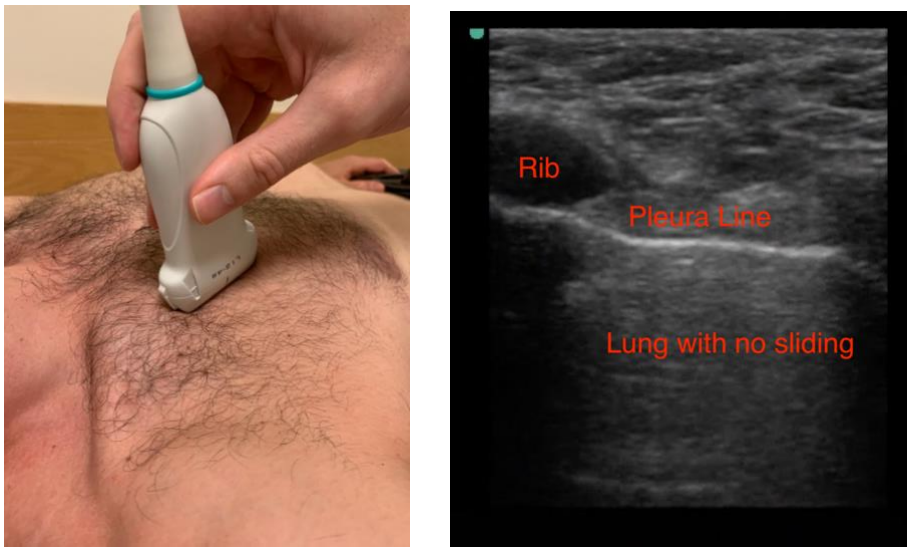


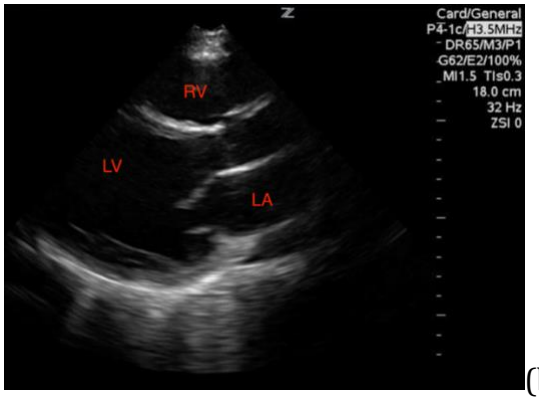
Fig. 2: The eFAST windows (from top to bottom) are (a) subxiphoid, (b) RUQ, (c) LUQ, (d) pelvic and (e) thoracic. Pathologic free fluid is indicated with a star.
(Images courtesy of Dr. Zachary Soucy, Dartmouth Hitchcock Medical Center)

Cardiac Exam

In addition to assessing for tamponade in eFAST, a rapid cardiac exam can be useful to assess left ventricular (LV) function and to check for signs of an obstructive process such as pulmonary embolism (PE). POCUS can also be helpful in shock, pulseless electrical activity, syncope, dyspnea, chest pain and trauma. Use the phased array probe to reduce rib shadowing on exam. Global cardiac function is best assessed from obtaining windows in subxiphoid, **parasternal long axis (PLAX) [Fig 3a], parasternal short axis (PSAX),** and **apical 4 chamber [Fig 3b**].

Interpretation improves with increased number of windows for comparison. In a hypotensive patient, depressed LV function can indicate a primary cardiac problem such as myocarditis,

underlying or preexisting myopathy, poor perfusion or myocardial infarction. Hyperdynamic LV function can indicate hypovolemia from acute blood loss, sepsis or dehydration. A PE should be suspected in a patient in acute shock with an enlarged right ventricle. The cardiac exam can also be useful to guide or discontinue resuscitation in cardiac arrest patients. This is especially important for hypothermic victims. Emergent evacuation should be strongly considered for most cardiac pathologies identified with POCUS.

(a) 

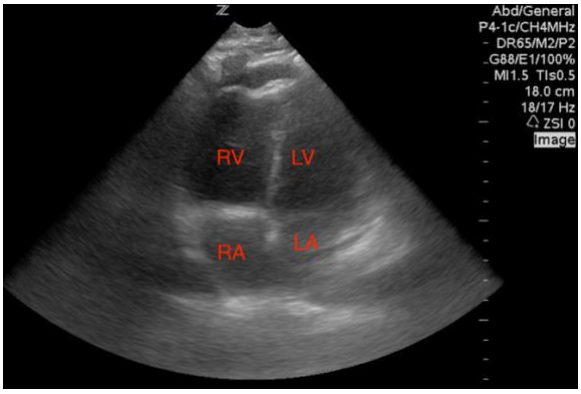
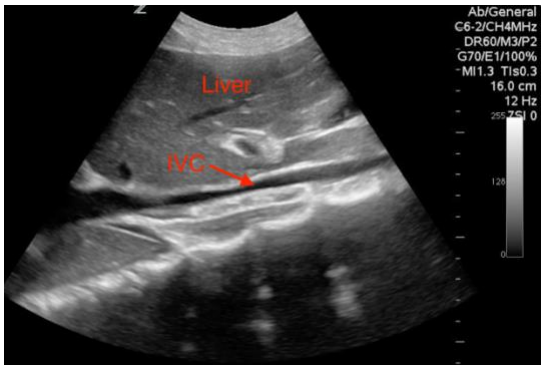
(b) 

Fig 3: Standard cardiac windows include (a) PLAX and (b) apical 4 chamber
(Images courtesy of Dr. Zachary Soucy, Dartmouth Hitchcock Medical Center)

Inferior Vena Cava (IVC) Exam

POCUS can be used to assess the IVC diameter in the subxiphoid to right subcostal area and help differentiate the underlying cause for a victim in shock. Use the curvilinear or phased array probe for this exam.

A flat IVC with complete collapse when the victim inspires suggests a volume depleted process such as hemorrhage, **dehydration or sepsis. [Fig 4a].** In this instance, fluids administered orally or via peripheral vascular access may stabilize the patient during evacuation. A large IVC that does not collapse significantly when the victim inspires suggests an obstructive state such as **cardiac tamponade or PE [Fig 4b]**. The study can be repeated to gauge success of the fluid intervention. In a wilderness setting, the IVC diameter and collapsibility are most helpful at extremes, while M mode is used to make finer measurements.

(a) 

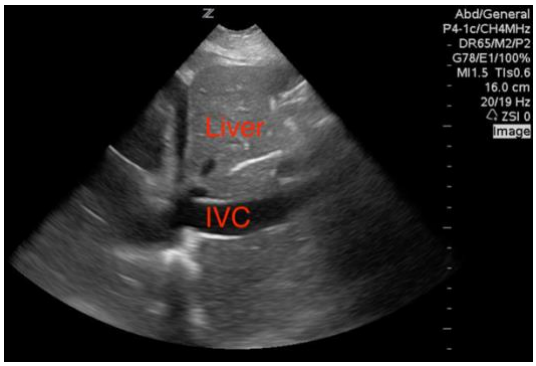
(b) 

Fig. 4: On inspiration, the IVC may be (a) completely collapsible or (b) plethoric and non-collapsible
(Images courtesy of Dr. Zachary Soucy, Dartmouth Hitchcock Medical Center)

Musculoskeletal Exam

In a wilderness trauma setting, POCUS can assess for long bone fractures, joint dislocations, and joint effusions in areas of pain or injury. A linear probe is used for most orthopedic injuries; however, a curvilinear probe may be useful for deeper injuries. Long bone fractures on ultrasound are seen as discontinuities in hyperechoic bone. In an anterior shoulder dislocation, the probe is placed on the posterior aspect of the shoulder. An anechoic space is seen in the glenoid where hyperechoic bone should be.

If POCUS identifies a long bone fracture or shoulder dislocation, the victim should be stabilized and transported to a facility with more specialized imaging modalities after consideration of field reduction. Reductions, arthrocentesis, or nerve blocks can be done in field with or without ultrasound guidance to stabilize the victim or avoid a dangerous evacuation. If there is a low probability of fracture in the victim and an abnormality is not seen on ultrasound, consider conservative management to avoid evacuation. Fractures on ultrasound are harder to detect if they are deep, nondisplaced, incomplete, or in joints. If the likelihood of fracture is high but no pathology is seen, proceed with treatment as if a fracture were present.

Ocular Trauma

In trauma patients with sudden vision change, POCUS can be performed to assess for lens dislocation, retinal detachment, and evaluation of a foreign body. POCUS should not be performed if there is a risk for globe rupture, such as an irregularly shaped pupil. In the scenario of suspected **Increased Intracranial Pressure (ICP**), **Optic Nerve Sheath Diameter (ONSD)** can be measured as a proxy. However, **Acute Mountain Sickness (AMS)** and **High-Altitude Cerebral Edema (HACE)** are clinical diagnoses and ultrasound findings do not have demonstrated utility in managing these victims.

ULTRASOUND IN PATIENTS WITH DYSPNEA

POCUS can accurately identify several types of lung pathology and when viewed in the context of the clinical scenario, can confirm appropriate management and evacuation plans. Potential etiologies include pneumothorax, pneumonia, pulmonary contusion, pulmonary embolus, or heart failure.

Thoracic Exam

The curvilinear probe best visualizes most lung pathologies. POCUS typically examines 4 lung windows per side for irregularities in the pleura line and for the presence of interstitial findings **[Fig 5].**

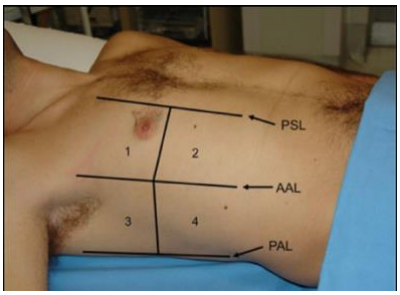


Fig. 5: 4 lung windows per side of thoracic ultrasound, for a total of 8 windows
(Image courtesy of Dr. Nicholas Weinberg, Dartmouth Hitchcock Medical Center)

When investigating the pleura line, evaluate for the **mirror sign**, where the echotexture above and below the diaphragm appear similar as if a reflection. This is normal and suggests no pleural effusion. The **spine sign [Fig 6]** suggests pathologic fluid in the pleural space when the spine is seen extending past the diaphragm. Evaluate for a pneumothorax by assessing for **lung sliding** and **lung point**, as discussed above. Pleural effusion, which is fluid within the pleural space, is diagnosed with the absence of mirror sign and presence of a spine sign. Pleural effusion can be seen in pneumonia, trauma, heart failure, or cancer. Lung pleura cannot always be well visualized on ultrasound, such as in trauma victims with air in subcutaneous tissue.

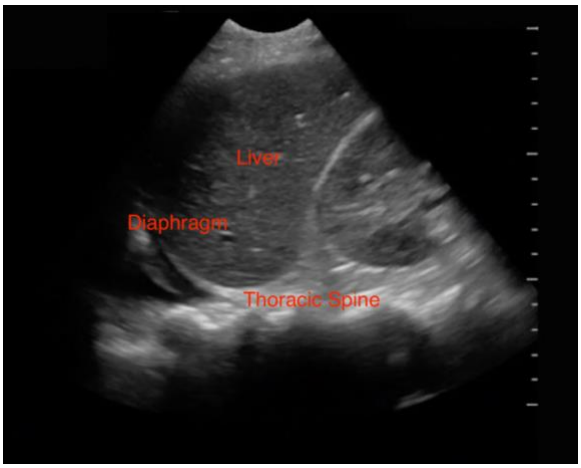
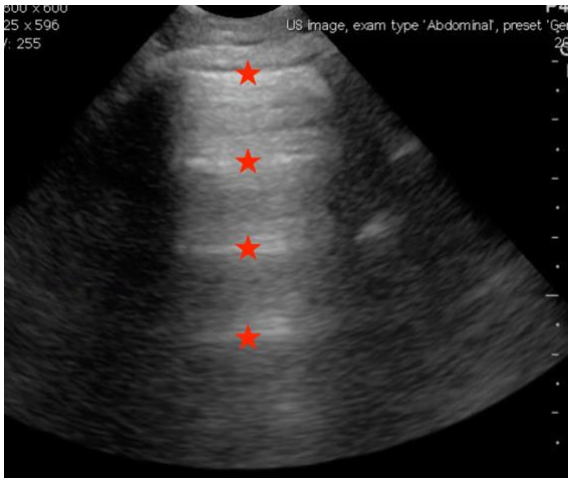


Fig. 6: Positive spine sign extending above the diaphragm
(Images courtesy of Dr. Nicholas Weinberg, Dartmouth Hitchcock Medical Center)

Interstitial lung findings include **A Lines [Fig 7a],** which are horizontal reverberation artifacts that may be normal or pathologic in a pneumothorax. **B lines [Fig 7b]** are abnormal vertical, bright white artifact originating from the pleura line that propagate to the edge of the screen (at least 6 cm deep). They arise because of increased lung density such as edema, inflammation, or fibrosis, and are often described as having a "flashlight in the fog" appearance.

A lung zone with three or more B lines is abnormal. Increased lung density should be classified into diffuse or focal. Two or more positive zones per side is classified as diffuse. Diffuse B lines are suggestive of a diffuse interstitial process such as congestive heart failure, or high-altitude

pulmonary edema. Focal B lines suggest pneumonia, or, in a victim with recent trauma, a pulmonary contusion. POCUS should be repeated to confirm findings. Some causes of dyspnea will not show lung findings on ultrasound, such as a COPD exacerbation, asthma or anaphylaxis.

(a) 

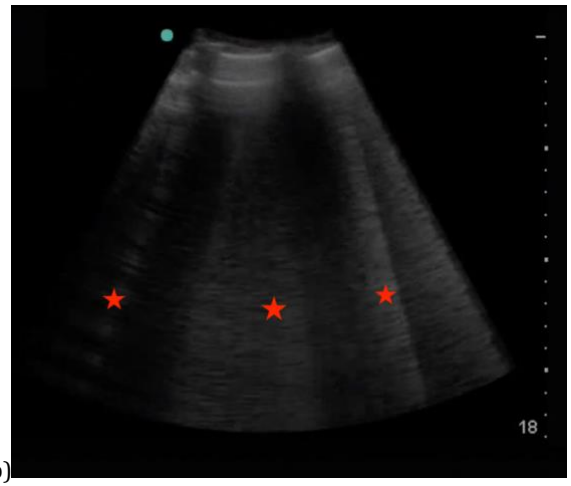
(b) 

Fig. 7: (a) A normal lung with A lines (starred). (b) B lines (starred) are pathologic.
(Images courtesy of Dr. Nicholas Weinberg, Dartmouth Hitchcock Medical Center)

High Altitude Pulmonary Edema (HAPE)

POCUS can be used to diagnose high altitude pulmonary edema by detecting diffuse B lines in symptomatic patients with shortness of breath. More B lines indicate more severe disease. In the asymptomatic patient at altitude, POCUS can be used to detect subclinical HAPE and B lines, but these patients do not always develop clinical disease. POCUS should therefore only be used to prevent HAPE development in select circumstances.

ULTRASOUND IN SOFT TISSUE INJURIES

Cellulitis vs Abscess

POCUS improves accuracy of assessing for abscess and cellulitis compared to physical exam alone. The linear probe should be used for superficial injuries. Apply minimal pressure to decrease discomfort. **Cellulitis** will demonstrate anechoic edema that has a cobblestone appearance within the **superficial soft tissue [Fig 9a].** Keep in mind that all edematous tissue (not just cellulitis) may demonstrate this appearance. An **abscess** is typically demonstrated by an anechoic, hypoechoic or heterogenous mass with irregular borders. Look for echogenic purulent material which moves like fluid, “swirl sign” when gentle pressure is applied, or for posterior acoustic enhancement behind the **abscess [Fig 9b**]. Use color Doppler to confirm that the abscess is not and does not contain a blood vessel. A **deep vein thrombosis (DVT)** can present with similar clinical findings to cellulitis. On ultrasound, a DVT will demonstrate a non-compressible deep vein beneath **superficial soft tissue [Fig 9c]**.

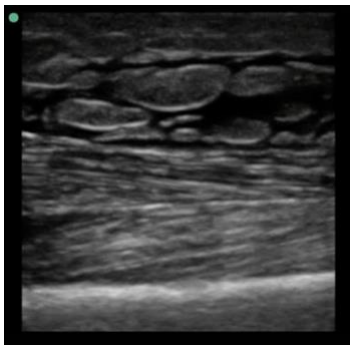
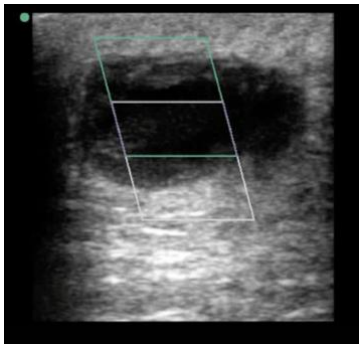
(a)  (b)  (c) 

Fig. 8: From left to right: (a) cellulitis, (b) abscess, (c) DVT
(Images courtesy of Dr. Nicholas Weinberg, Dartmouth Hitchcock Medical Center)

Foreign Body Identification and Removal

POCUS is reliable for diagnosing and removing foreign bodies made of wood, plastic, glass and organic material. A linear probe is placed over the entrance site, and a needle can be inserted to the object and used as a guide for the scalpel to be cut down directly to the foreign body. Submerging the affected area in a water bath can help visualize the structure and minimize discomfort. The foreign body should appear hyperechoic and may cause shadowing or ring down artifact posterior to the object. Look for other signs such as the halo sign, which is a hypoechoic rim around the foreign object that suggests an immune response such as edema or granulation tissue. Foreign body detection and removal with ultrasound can be obscured if the foreign body is very small, or if air in the subcutaneous tissue limits visibility.

ULTRASOUND IN UNDIFFERENTIATED ABDOMINAL PAIN

POCUS may be a helpful diagnostic tool in assessing the patient with abdominal pain and can expedite evacuation if emergent pathology is seen. While POCUS can rule in these pathologies, they may still be present even if not visualized. Therefore, the clinical correlation is critical in management decisions.

Potential etiologies for undifferentiated abdominal pain include [Fig 9]:

- **Ectopic Pregnancy [Fig 9a]:** Assess for abdominal free fluid on FAST in a woman of childbearing age with lower abdominal pain and vaginal bleeding.
- **Gallstones [Fig 9b]**: Assess for hyperechoic stones in the gallbladder, thickened wall, and anechoic fluid around the gallbladder in the RUQ.
- **Small Bowel Obstruction [Fig 9c]**: Dilated small bowel, greater than 2.5cm with bidirectional peristalsis +/- bowel wall thicker than 3 mm.
- **Appendicitis [Fig 9d]**: A non-compressible, non-peristalsing, blind ending tubular structure, greater than 7mm in diameter with hyperechoic surrounding fat in the RLQ.

- **Kidney Stones**: A kidney with dilated pelvis filled with anechoic urine (hydronephrosis) suggests backup and a possible obstructing stone in the ureter.
- **Abdominal Aortic Aneurysm (AAA)**: Assess for an aortic diameter > 3 cm (measured outer wall to outer wall) in an abdominal scan from the mid-epigastrium down to the bifurcation at the umbilicus.

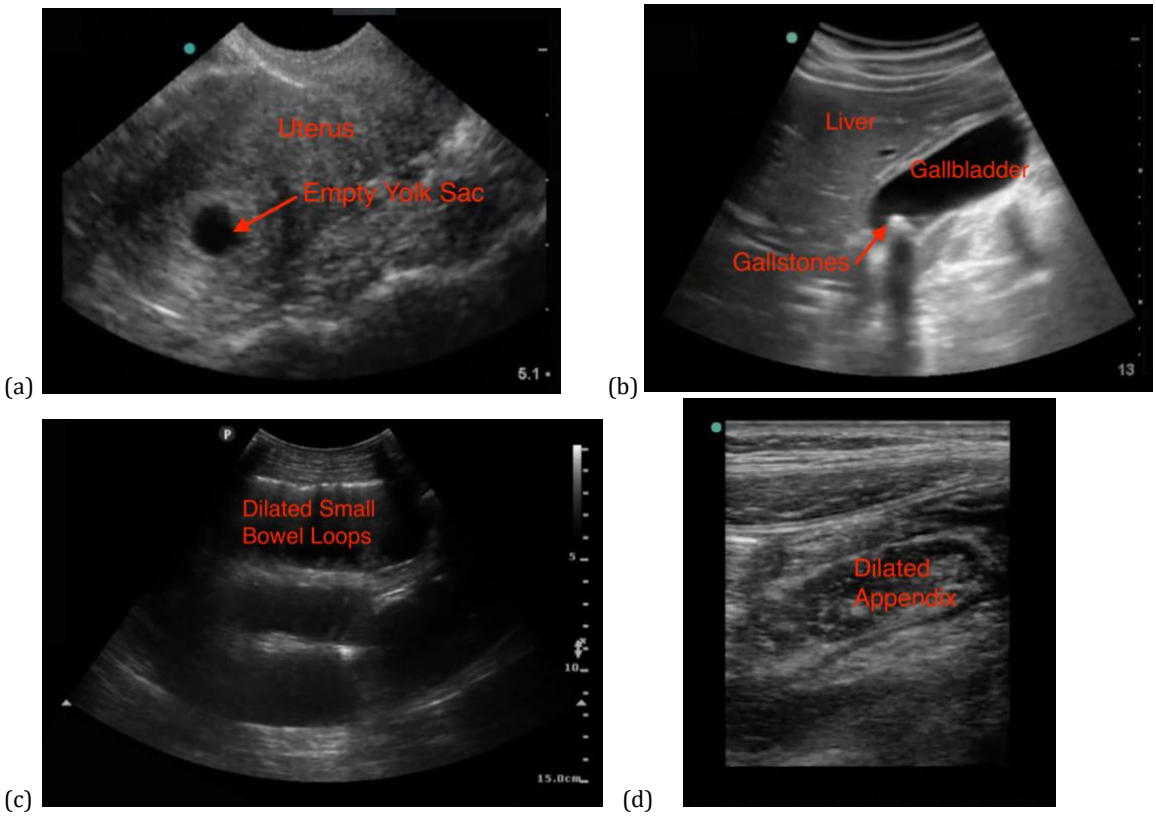


Fig. 9: (a) Ectopic pregnancy, (b) gallstones, (c) small bowel obstruction, (d) appendicitis
(Images courtesy of Dr. Nicholas Weinberg, Dartmouth Hitchcock Medical Center)