SEARCH AND RESCUE

A COURSE OF STUDY ON SEARCH AND RESCUE

UNIVERSITY OF UTAH
SCHOOL OF MEDICINE

SAR
Search and Rescue

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INDEX

Click on a chapter to advance

Introduction

The title of this booklet is Search and Rescue. What is the difference between a search and a rescue? A search is an unknown problem at an unknown location. A rescue is a known problem at a known location. Sometimes a search transitions into a rescue. However, since a search is an unknown problem it is always an emergency and generally requires some type of immediate response.

Though this manual focuses primarily on searches in the wilderness environment, it's with the understanding that rescues will need to be performed too. Medical professionals who venture into the back country may find themselves having to manage a search for one or more people. Others may be part of a search and rescue effort. Managing a search is more complicated than most people realize. To properly manage any type of search requires training, knowledge, resources and experience. From this manual alone, it's not expected that you'll be qualified to perform on a search and rescue team, but it starts the journey. This manual will provide you the fundamentals that are needed if you find yourself in a situation where a medical professional is required to organize a search for a lost person.

1. Wilderness Safety, Preparation & Survival

Many accidents in search and rescue operations are the result of a failure to adequately identify and manage risk. Risk management is a process that should be ongoing. Anytime a search is conducted, personnel go into places facing numerous issues that could potentially cause harm. Safety is a state of mind. We should not trust to luck. Most mishaps and injuries are caused by factors that can be controlled. Searchers should not pretend they are immune and think "It can't happen to me." Searchers should always expect the unexpected. The more mishaps that can be foreseen, the easier it is to guard against them. Use common sense. It is up to the Searcher to take control of the risks.

The role of searching personnel is often misunderstood. The highest priority is not the health and well-being of the subject. The highest priority is the health and well-being of self, then the team, and then the subject. When these priorities are scrambled, the possibility of a rescuer becoming a patient increases, turning an asset into a liability. If a Searcher becomes injured, then it takes time and vital resources away from the original objective of the search. There are common human errors which greatly contribute to Searchers getting into trouble:

- Fatigue - This is considered to be the number one contributor to human error.
- Lack of communication - A failure to exchange information.
- Complacency - Loss of awareness and the development of overconfidence.
- Lack of knowledge - Insufficient experience or training in the task.
- Distraction - Anything that takes your mind off the job.
- Lack of resources - Insufficient equipment and manpower to safely perform a task.
- Lack of assertiveness - Failing to speak up when things do not seem right.
- Stress - Being overwhelmed by stress leads to human error.

DEHYDRATION

The body is constantly losing water through three (3) normal functions: breathing, sweating, and eliminating waste through urination and bowel movements. In fact, a 150-pound (68 kg) person loses over 8 cups (2 liters) of fluid in a normal day. The same 150-pound (68 kg) person may lose more than a gallon (4 liters) of water hiking in the desert in one day. Dehydration occurs when water is not replaced as fast as it leaves the body. It is important to remain hydrated before and during a search. Also, be sure to replace lost electrolytes by consuming sports drinks. Thirst is the body's signal that it needs hydration. When a searcher feels thirsty, they should drink water or a sports drink and eat regularly.

FOOT WEAR

Footwear is the most important gear to be concerned with. It consists of two (2) components: socks and boots. Starting with the socks, follow the three (3) W's rule of wicking, warmth and wet. The first layer should be a thin high-tech moisture-wicking fabric. Each foot can produce nearly a cup of sweat in one day of heavy activity. It is important to wick that moisture away to avoid blisters and body heat loss. The sock liner also allows any friction to rub between the socks instead of on the skin helping to prevent hot spots and blisters. Even in the summer the sock liner keeps feet cool and comfortable.

The warmth layer should be a heavier wool or synthetic sock. Make sure the sock fits the foot. One-size-fits-all or socks that are too large cause wrinkles and bunching, which lead to blisters. This layer also creates a padding layer to keep the feet comfortable after miles of hiking. Even in the summer use a summer weight wool or synthetic sock. Avoid cotton on the feet at all times during the year.

The wet layer is the boots themselves. Comfort and proper fit are very important when choosing a boot. Make sure the boot has good traction with a rugged sole.

COLD WEATHER CLOTHING

In cold temperatures, dress in layers. Strive to maintain a comfortable and slightly cool, but not chilled, temperature before any activity. If a person doesn't, then their body heats up as their activity increases and they begin to sweat causing their clothing to become wet and to lose some of its insulating properties, which ultimately makes them cold. Remove or add layers of clothing to maintain the slightly cool feeling as the temperature and activities alter heat levels.

The wicking base layer, the layer closest to the skin, should be made of a material such as wool or synthetic that allows moisture (sweat) to be wicked away from the skin. Cotton and similar materials absorb moisture and are slow to dry, keeping moisture next to the skin which can cause chilling and, even worse, hypothermia.

The warmth layer is the insulation layer and should again be wool or synthetic. Thickness equals warmth. Good examples are wool or fleece pants, sweaters, socks, beanie hats, and scarves. Wool retains 80% of its insulating factor when it is soaking wet. Wool can also absorb 30% of its weight in water and still feel dry.

The wind/wet outer layer performs two jobs. The first is to allow moisture wicked away from the skin by the previous layers to escape into the environment, and the second is to protect the insulation layer from the elements, such as wind and rain. The outer layer should be a waterproof and breathable Gore-Tex type of garment. A plastic rain coat should be avoided because it does not allow moisture to escape causing the inner layers to remain wet and lose their insulation qualities.

WARM WEATHER CLOTHING

While horrible for cold conditions, cotton is ideal for hot conditions. Wear light weight and light-colored breathable cotton clothing during hot desert conditions. Long sleeves and long pants help protect the skin from the sun and from desert plants. A wide brimmed hat is essential for summer months to help keep the sun off the face and neck. Radiation of heat from the head is one of the main ways the body loses heat. Make sure the summer hat is vented to allow heat to escape.

INJURIES

The common types of volunteer injuries are:

Back Injuries

These are very serious and have the potential to greatly impact the volunteer's life. Serious injury can disable a person permanently. Back injuries are the number one job-related injury. Fatigued

muscles are more susceptible to injury. Lighter backpacks reduce fatigue and the potential for back injury. Remember the proper techniques when lifting anything heavy or awkward.

Shoulder Injuries
These are experienced primarily in swift water rescue operations. The force of the water can easily overpower the strongest person. Attempting to struggle with this force causes injuries that results in serious loss of time from work, medical costs and potential permanent damage. Following the proper techniques in this environment greatly reduces this possibility.

Knee Injuries
These injuries are serious and costly. They are prevalent in swift water rescues but can occur from falls or loss of footing. Footwear should be appropriate for the conditions underfoot. Mounted personnel should be especially concerned if they dismount and are required to walk the mount down a steep hill.

Ankle Injuries
These are the most vulnerable part of the body to suffer injuries. This is due to the rough terrain and hazardous conditions that is encountered on searches and rescues. Proper footwear with ankle support and remaining vigilant is required.

POISON IVY, SUMAC, OAK
Rescuers should be aware of the possibility of Poison Ivy, Oak and Sumac. Poison Ivy and its relative plants grow abundantly all over. Some people are more susceptible than others to the rash resulting from contact with the plant. Most people experience only a localized itchy rash. Some, however, have a severe allergic reaction to any contact with the plant and should be wary of coming close to it. Regardless, whether allergic to the plant or not, it is best to stay away from any contact with any part of the plant. If someone does come into contact with the plant wash the plant's oil off with heavy soap as soon as possible. Washing with just water only spreads the oil around the skin.

SNAKES
The best advice when encountering a snake is to leave it alone. Be aware of pit vipers. And remember that rattlesnakes sometimes travel in pairs, so look behind before jumping back. If you or a fellow rescuer is bitten by a viper, you must evacuate immediately. There is no field treatment.

COLD RELATED PROBLEMS
Be aware that extreme cold weather conditions can create or increase the danger of weather-related injuries, illnesses, and accidents. Ice may make normally sure surfaces slippery and dangerous. Accumulated snow may collapse or become an avalanche. Winter storms can reduce visibility to near zero.

Cold related emergencies come in two basic categories. The first is generalized cold such as hypothermia which is an overall reduction in body temperature. The second is a local cold injury or damage to body tissue in local parts of the body, usually the extremities. Frostbite and frostnip are the most common.

SURVIVAL

The basic physiological requirements for a human to survive are air, water, food and shelter. It is commonly suggested that the average person can survive three minutes without air, three days without water and three weeks without food. The human body can do extraordinary things in its struggle to survive. Keep in mind the 3–3–3 rule when considering the possible survival of a search subject or if you yourself become trapped.

Depending on the time of year and your location a shelter may be the most important of the four basic physiological requirements to sustain life, with the exception for air. Whether in the desert summer or the alpine forest winter, shelter is the first thing needed in a survival situation.

Natural shelter

Nature often conveniently provides natural places of shelter such as a cave, rock outcropping, overhang, depression, tree or thicket. Be careful when using a cave. Do not enter a cave farther than the exit can be seen because it is easy to become disoriented and lost in deep caves or mines. Also consider that other wild life may already live in the convenient shelter nature provided. Trees and thickets can provide partial protection from wind and rain and they tend to keep radiated heat during night.

Bivouac shelter

A bivouac is a simple shelter that is easy to set up. The main purpose of the bivouac is to protect the body from heat exchange via conduction and convection. Use pine needles, leaves, grass, reeds and other soft plant materials to make a mat. Cover the body with black plastic trash bags, a reflective space blanket, or natural materials that you might use to make a mattress.

A-Frame shelter

An A-Frame shelter is a little more substantial and permanent than a bivouac shelter. There are many ways to make an A-Frame shelter. Use a space blanket or black trash bags taped together with duct tape to form a large tarp. Use a stick and a piece of parachute cord to form a central beam and drape the blanket over the top forming a tent like structure.

A Lean-To

A Lean-to is a simpler form of shelter. It is one side of a roof or wall to a structure that is open on the other. Typically, a lean-to is used to get out of the sun or wind. It can be used as an effective winter shelter if a camp fire is placed in front of the lean-to, so the heat is captured in the structure.

Fire

After securing shelter a camp fire needs to be made. The camp fire does many things in a survival situation. It not only provides warmth, but it also provides companionship, which has positive physiological effects and helps the survivalist remain calm and better able to reason through a course of action. Fire can also be used cook food, boil water, signal for help and keep predators away. Every pack should have equipment for making a fire.

Food
A Searcher may be expected to perform grueling tasks in some of the worst conditions. They will need regular replenishment of energy to help prevent exhaustion and fatigue. Searchers should be able to sustain themselves in the field for at least 24 hours. They should always carry enough food for that period and have extra food for another 24 hours in a base kit. When selecting food, consider that the body needs food high in energy. Dried foods such as jerky, dehydrated fruit and vegetables, granola bars, and energy bars are great sources of energy with the added benefits of being light weight and lasting a long time in a pack.

Water
The importance of water cannot be overstated. Searchers may run out. Don't let this happen. If it does there are some options to try to find water. Look for lines of green vegetation such as cottonwood trees, fan palms and willows. These plants require large amounts of water and if they are surviving, then water must be within reach. If water is not on the surface at these areas, then try digging at the base of large shade trees such as cottonwoods. Water may be just under the surface. Dry washes may have water still flowing beneath the surface. Find a place where the wash is forced to turn because of an area of granite rock. Finding vegetation growing at the base of the rock is a good sign. Try digging a hole a few feet into the sand and dirt on the outside edge of the curve. Water is forced nearer the surface as it is forced around the curve. Leave the hole for 15 to 30 minutes. If water does not begin to fill the bottom of the hole after that, then try a different spot. After finding a hole that fills with water place a bundle of grass or reeds at the bottom to help filter out the larger pieces of sediment before collecting the water. The base of large granite cliffs and rock formations may also have some water. As water flows down through the granite it may exit at the base of the rock or just under the surface.

STUDY QUESTIONS

1. What is the highest priority of search and rescue personnel?

2. List three common human errors that result in Searchers getting into trouble.

3. When does dehydration occur?

4. What is the main sign that a person needs hydration?

5. What are the three W's to follow when choosing socks for back country activity?

6. Why should you avoid wearing a plastic raincoat on a rescue?

7. What are the main advantages of wearing long sleeves and long pants in warm weather?

8. What is one way to reduce fatigue?

9. When are shoulder injuries most often experienced?

10. What should you do when encountering a snake?

11. What are the basic physiological requirements for a human to survive?

12. What is a benefit of a camp fire other than warmth?

13. For how many hours should a rescuer bring food?

2. Incident Command System

The Incident Command System (ICS) is the model tool for command, control and coordination of a response and provides a means to coordinate the efforts of individual agencies as they work toward the common goal of stabilizing the incident and protecting life, property, and the environment. ICS uses principles that have been proven to improve efficiency and effectiveness in a business setting and applies these principles to emergency response.

We live in a complex world in which responding to emergencies requires cooperation among several agencies. Given the current movement toward using an ICS structure for emergency response it is likely, therefore, that you will function in an ICS environment. In an emergency, including search and rescue, response operations are not "business as usual." ICS was developed in the 1970s in response to a series of major wildland fires in southern California. ICS uses a common organizational structure.

The ICS organization is built around five major components:

- Command
- Planning
- Operations
- Logistics
- Finance/Administration

These five major components are the foundation upon which the ICS organization develops. In small scale incidents, all the components may be managed by one person, the Incident Commander. Large-scale incidents usually require that each component, or section, is set up separately. The ICS organization has the capability to expand or contract to meet the needs of the incident but all incidents, regardless of size or complexity, will have an Incident Commander. A basic ICS operating guideline is that the Incident Commander is responsible for on-scene management until command authority is transferred to another person, who then becomes the Incident Commander.

INCIDENT COMMANDER

The command function is directed by the Incident Commander, who is the person in charge at the incident, and who must be fully qualified to manage the response. Major responsibilities for the Incident Commander include:

- Performing command activities
- Protecting life and property
- Controlling personnel and equipment resources
- Maintaining accountability for responder and public safety, as well as for task accomplishment
- Establishing command
- Ensuring responder safety
- Assessing incident priorities
- Determining operational objectives
- Developing and implementing the Incident Action Plan

- Developing an appropriate organizational structure
- Managing incident resources
- Coordinating overall emergency activities
- Coordinating the activities of outside agencies
- Authorizing the release of information to the media
- Keeping track of costs

An effective Incident Commander must be assertive, decisive, objective, calm and a quick thinker. To handle all the responsibilities of this role, the Incident Commander also needs to be adaptable, flexible and realistic about his or her limitations. The Incident Commander also needs to have the capability to delegate positions appropriately as needed for an incident. Initially, the Incident Commander will be the senior first-responder to arrive at the scene. As additional responders arrive, command will transfer based on who has primary authority for overall control of the incident.

- **Life** safety. The Incident Commander's first priority is always the life safety of the emergency responders and the public.

- **Incident stability**. The Incident Commander is responsible for determining the strategy that will minimize the effect that the incident may have on the surrounding area.

PLANNING SECTION
In smaller events, the Incident Commander is responsible for planning, but when the incident is of larger scale, the Incident Commander establishes the Planning Section. The Planning Section's function includes the collection, evaluation, dissemination and use of information about the development of the incident and status of resources.

OPERATIONS SECTION
The Operations Section is responsible for carrying out the response activities described in the Incident Action Plan. The Operations Section Chief coordinates activities and has primary responsibility for receiving and implementing the Incident Action Plan. The Operations Section Chief reports to the Incident Commander and determines the required resources and organizational structure within the Operations Section. The Operations Section Chief's main responsibilities are to:

- Direct and coordinate all operations, ensuring the safety of Operations Section personnel
- Assist the Incident Commander in developing response goals and objectives for the incident
- Implement the Incident Action Plan

LOGISTICS SECTION
The Logistics Section is responsible for providing facilities, services, and materials, including personnel to operate the requested equipment for the incident. This section takes on great significance in long-term or extended operations. It is important to note that the Logistics Section functions are geared to support the incident responders. For example, the Medical Unit in the Logistics Section provides care for the incident responders, not civilian patients.

FINANCE SECTION

Though sometimes overlooked, the Finance/Administration Section is critical for tracking incident costs and reimbursement accounting. Unless costs and financial operations are carefully recorded and justified, reimbursement of costs is difficult, if not impossible.

STUDY QUESTIONS

1. What is the goal of the Incident Command System?

2. What are the five major components that the ICS organization is built around?

3. What are five responsibilities of the Incident Commander?

4. What is the Incident Commander's first priority?

5. What are the primary responsibilities of the Logistics, Operations, and Planning sections or the ICS?

3. Lost Person Behavior

People have become lost in the back country for as long as people have been going there. However, the science of lost person behavior is very new. Some of the first data that was kept on lost victims was from the Swiss in 1783 when they used St. Bernard dogs to rescue people in the Alps. Father Lorenzo, from the Swiss monastery system, kept records only of fatalities. The data showed that about three or four people died each year as a result of either avalanche or hypothermia.

No new research was done until mid-1970's, when Bill Syrotuck developed eight (8) categories of Lost Person Behavior. That was very helpful and guided searches for several decades. The enormous leap forward in search and rescue came in 2008 when Robert Koester wrote a book called *Lost Person Behaviour*. This work has been proven to consistently assist search and rescue teams moving quickly in the right direction. However, despite its usefulness Koester is the first to acknowledge that people are unique and so his categories may not work perfectly every time. This work has been transformed into a smart phone app that is readily available and used frequently.

It is a myth that we panic when we become lost. Instead, most people experience shock, disbelief and embarrassment. Many people experience an irrational belief that no one is looking for them. When that happens, they respond to attraction efforts. Some even ignore a helicopter flying overhead. Hansel and Gretel may have benefited from leaving a trail of bread crumbs, but it's not a good sign when a lost person leaves a trail of clothing or equipment. Rather, it's an unfortunate indicator of either late stage hypothermia or exhaustion. Predicting the actions or behaviors of a missing person is often the biggest mystery in a search. These behaviors can be categorized by activity and cognitive capabilities.

LOST PERSON BEHAVIOR GROUPS

Children

- 1 to 3 years of age have poor navigational skills and tend to wander aimlessly when lost. They are difficult to detect because of their smaller size and tendency to seek natural shelters, often to lie down. They do not travel very far, and in 50% of cases in mountainous terrain, the children were found within 0.2 miles (0.3km) of where they were last seen.
- 4 to 6 years of age have more developed navigational skills and can travel further. The children in 50% of these cases were found 0.5 miles (0.8km) from where they were last seen. One challenge to consider is that they may not answer rescuers' calls because they've been taught to avoid strangers.
- Small children look for familiar spots rather than trails. They can't judge either direction or distance and tend to move randomly.
- 6-12 years of age have an improved sense of direction distance. They may also wander off for emotional reasons. They tend to go downhill more than uphill when lost and 75% are found within 2 miles of the point last seen.

Hunters

- Lost hunters are a concern because of the tendency to travel to remote and rugged areas. Their pursuit for game can lead them away from trails even in bad weather. For hunter, 89% are found within 3 miles of the PLS in flat terrain, and 58% within 3 miles in mountainous terrain.
- If lost after dark, the typical hunter will build a shelter and then proudly walk out of the woods, unassisted, at daybreak.

Miscellaneous

- Examples include berry pickers, nature photographers and rock hounds.
- They are often inadequately clothed or equipped. Their behavior can be difficult to predict since their decisions are based on their suspected or actual leads that serve their purpose.
- Rescuers try to put themselves in the lost person's shoes, asking questions such as, "Where do the best berries grow?"

Elderly

- Elderly subjects with severe dementia (including Alzheimer's) are much like very young children with respect to poor navigational skills. They tend to travel in the direction from which they departed until a physical barrier stops them. In the urban environment, 50% of all dementia subjects were found 0.7 miles (1.1km) from where they were last seen. None of the dementia subjects called out for help to searchers and 45% were found dead, which raises the urgency of implementing effective initial actions for subjects in this category.

Mental/Despondent

- Despondent people typically don't travel very far. If suicidal, they hide from search teams. Despondent people are often found at the interface between two types of terrain, such as a cliff edge, or along a shoreline.

Hikers

- When lost, hikers tend to go downhill more than any other group. They also travel further distances than other groups. Often they become lost when trail conditions become challenging to follow, or from the lack of recognizing terrain on the return.
- Hikers are very oriented to trails and, in 68% of cases, become lost because of decision points, including trail junctions, or obscured trail conditions. As well, 52% of hikers are found downhill from where they were last seen. This is the path of least resistance. However, a more recent phenomenon has been that hikers have moved uphill to obtain cell phone coverage.
- Hikers tend to become lost if the trail is obscured or if there are confusing trails that intersect. Rescuers should do a map and terrain analysis to determine where the confusing spots are so they can look there first.

GENERAL LOST PERSON BEHAVIORS

- Lost subjects will frequently follow travel aids, such as geographical paths of least resistance or trails.
- Fifty percent (50%) of searches resolve within three hours.

- Fifty-four percent (54%) of people are found within two miles of the point where they were last seen.
- Lost adults will usually stay on a trail. However, they may climb a hill to get a view of the area.
- They rarely travel in a straight line, and rarely reverse direction.
- Young people of ages 13-15 often become lost in groups of two or more. Youth in a group rarely travel very far from where they were last seen.

STUDY QUESTIONS

1. Why won't the lost person categories that were developed by Robert Koester work perfectly every time?

2. How are the behaviors of a lost person categorized?

3. What is a unique challenge related to searching for 4 – 6-year-old child?

4. What percentage of hikers are found downhill from where they were last seen?

4. Search Techniques

In discussing search techniques, it is important to know who we are searching for. Generally, we do not speak about a missing person as a 'victim' but as someone who has made a mistake in their backcountry travel plan. Search techniques are based on what can be learned about the lost persons behavior, determining the mistake made, and strategizing the best way to interject search tools with that information.

The first step in finding a missing person is to categorize the problem:

- **The Lost**
  These people often report by cell phone because they are lost, usually because they missed the trail or tried to take a short cut and they want to be found.

- **The Overdue**
  They are usually reported missing by family or friends. Most leave an itinerary or the reporting party gives a starting point for the search. They want to be found.

- **The Endangered**
  These are often elderly, or memory impaired. Lost children fall into this category too. These are subjects who are unable to care for themselves. They may not know or understand that they are the subject of a search.

- **The Suicidal**
  They are despondent and usually do not want to be found.

Second, a missing subject may be thought of as being in one of four (4) states during the search:

- **Mobile and responsive**
  Mobile means that the subject can move around, although they may not be moving at the present time. Responsive means that the subject has the ability and the willingness to signal the searchers in some way (voice, whistle, waving arms, mirror, etc.). An example of this is a healthy person who has merely lost the trail.

- **Mobile and unresponsive**
  Unresponsive means that the subject cannot or will not signal the searchers in any way. An example of this is a healthy child who has been taught not to talk to strangers.

- **Immobile and responsive**
  Immobile means that the subject cannot move around. They are stationary (standing still, not moving). An example of this is a person who has broken an ankle but is conscious and able to communicate.

- **Immobile and unresponsive**
  An example of this is a person who is unconscious or deceased.

Lost or overdue persons are the most common reasons to look for people. Up to 80% of all people lost or overdue are male. Hikers and hunters combined represent the largest portion of search subjects Many thousands of searches are conducted yearly by the National Park Service alone. It is unknown how many private searches are conducted. After a subject is reported

missing, the initial actions taken during the first 8 to 12 hours will normally locate the lost person. These initial actions include five (5) primary tasks that must be accomplished on any search. There are:

1. Investigation
2. Developing the search area
3. Containment
4. Attraction
5. Hasty search efforts

INVESTIGATION

Detailed personal information about the subject is essential as the search begins. Questions to ask include: How many victims are there? What is the physical description, outdoor experience and health concerns of the lost person? Is the subject mobile or immobile? Is the subject responsive or unresponsive? Do they have a cell phone? What are the weather conditions now and what will they be like in the next 8-10 hours? What is the terrain like? Do they have maps and are they experienced or inexperienced?

Comprehensive investigative efforts are immediately initiated from the onset of the search and will continue throughout the incident. Background information should be collected about the subject through sources such as interviews with family and friends, the internet and social media. This becomes the subject profile and guides the efforts of the search. As time elapses and data or clues are obtained regarding the subject, these scenarios can become more specific regarding subject intentions, background and the characteristics of the search area.

SEARCH AREA

The search usually begins at the initial planning point or the IPP. The IPP is very often the point a person was last seen (PLS). Planners usually define PLS as a person's last known point of travel, such as a parking lot or campground. The total search area is designated by a circle in which the likelihood of finding a person in the field is approximately 95 percent. The circle is not the final frontier of search but can be further defined based on terrain features, and it should be suitable for a specific exploration scenario. For example, the median distance from the IPP in temperate mountainous terrain at which missing hikers are found is 1.9 miles (3.1km).

A ***theoretical search area*** is the possible distance that a subject could have traveled from the IPP if the subject was able to travel in any direction unhindered by terrain. It is determined by an estimated rate of travel multiplied by the amount of time that the subject has had to travel. When plotted on a search area map, a theoretical search area is illustrated as a circle with the IPP at its center.

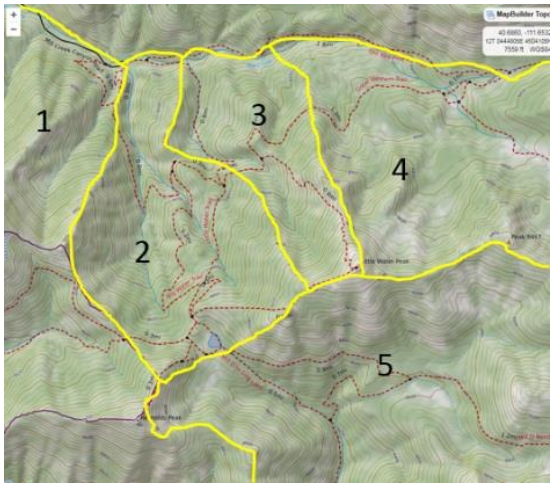
A ***statistical search area*** is based on data derived from previous incidents that reflects the distance other subjects have traveled from the IPP, given similar conditions. Statistics regarding lost person behavior are commonly used in establishing a search area and in determining high probability locations to be searched.

A ***subjective search area*** considers factors that exist for a specific incident and location. Factors may include terrain or even environmental conditions. history from previous searches, “gut feelings,” and physical or mental limitations of the subject.

A ***deductive reasoning search area*** is established by a method of systematically analyzing the circumstances surrounding the subject who is lost or missing. For example, realizing that a hiker is known to travel off trails will result in expanding the search area to include these areas. Knowing that a photographer had a specific destination for that day will help establish the search area in that general direction.

PROBABILITY OF AREA (POA) AND PROBABILITY OF DETECTION (POD)
Probability of area (POA) is the probability that the lost person is in a given area. The is estimated by having multiple people assign the percent chance they think the subject is in a number of predetermined areas.

In this example, the search area is divided into 5 zones, strategically divided by natural features such as ridges and drainage bottom. In all searches, an additional off map zone is included in the calculation. This zone (Zone 6 in this example) is often called "the rest of the world" and accounts for the chance the subject is not in the search area, either by traveling further than anticipated, or because they were never in the search area.
POA is calculated before the search occurs but can be completed repeatedly and subsequent attempts can include different individuals if needed. POA will help the Incident Commander determine how many resources to put in each zone.



	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Total (should be 100)
Searcher 1	12%	25%	5%	20%	37%	1%	100%
Searcher 2	5%	1%	1%	20%	73%	0%	100%
Searcher 3	10%	20%	10%	25%	35%	5%	100%
Searcher 4	8%	5%	15%	15%	7%	50%	100%
Searcher 5	20%	25%	5%	25%	23%	2%	100%
Average	**11%**	**15%**	**7%**	**21%**	**35%**	**12%**	

Probability of Detection (POD) is the probability that a searcher would have found the lost person in a given area. POD is estimated by the searcher. They will analyze the terrain they were in, the speed they traveled, and any other factor that impacted their search ability. POA for the zone searched is multiplied by the POD to determine the efficacy of search efforts.

Example: Searcher 1 spent his entire search efforts on the first day of the search in Zone 5. At the end of the day, during his debrief, he estimated that there was a 10% chance he would have been able to find the subject in that zone. 35(POA) X .1(POD) = 3.5%. His search efforts are summarized by saying there was a 3.5% chance that if the subject was in that zone, he would have found him. Since POD assesses the effectiveness of the entire search efforts, if 20 searchers were assigned to search Zone 5 and all 20 reported the same POD (which does not happen in reality) of 10%, the collective POD would be 20 X 3.5 = 70%. It can be assumed that 70% Zone 5 has been searched.

CONTAINMENT
Containing the search subject early will prevent the search area from expanding too fast. You must consider important factors such as past subject behavior, subject objectives, and other information obtained through the investigation. Containment teams stationed at strategic locations such as trailheads, roads, trail junctions, or lookout points serve to limit the subject's movement. Although these locations may be outside of the established search area, they typically lie along easily accessed areas and along natural borders adjacent to the search area.

Additional means of containment for a missing subject include the use of a lookout scanning from a promontory, roving patrols along a roadway, or track traps, which may be established in areas like a dry wash physically brushed smooth to highlight any subsequent foot travel later through the area. Investigation efforts also provide a means of "electronic containment" of a missing subject.

ATTRACTION
Attraction is a method used to help a lost person find a trail, trailhead or a strategic location like a meadow occupied by rescue resources. Attraction can include an emergency vehicle with its lights on at a trailhead, a rescuer stationed in one location that periodically blows a whistle, or notes left with high visibly flagging at key locations. Attraction is best applied as part of a search plan, but not as the primary search technique. Its priority in the search plan will vary based on the location, subject's behavior, and likelihood of success.

HASTY SEARCH
A hasty team search will usually consist of ten to twelve highly trained searchers. This team will be dropped into a virgin search area and will quickly spread out in pairs looking for clues or the lost person in obvious places. The goal of a hasty team is to move quickly through the search area, almost at a slow jog to check cliffs, wells, tangle hazards, caves, ditches, etc. where a person might be injured or might have stopped to rest. If a lost person is conscious, even if they are injured and unable to move, the hasty team should detect them as they pass through the area. The members of a hasty team are not directed to move along a certain path or in a given direction. They are usually given free reign over how they move through the territory. They might spend a few minutes checking an old barn but move at almost a run across an open field. The idea is to cover the ground. This is why it is so important to use trained searchers, because they are usually much more in tune with what clues to look for and how to quickly spot footprints, broken branches (tracking signs), etc.

The purpose of the hasty team is to bring a rapid end to a search. By putting a well-trained team into a high probability area, the search leaders are hoping to find the victim with a quick pass. If the person is truly just wandering around in the woods, then the hasty team will find them and bring the search to an end.

The expected probability of detection for a hasty team may vary somewhat based on the skill level of the team members and the ruggedness of the search area. However, for a well-trained team, search leaders might expect a probability of detection of 30-40% for a hasty team. Meaning, if the hasty team comes back empty, then there is a 30-40% chance that the victim isn't there. However, it may be a 70% chance that a conscious and uninjured victim isn't there.

The key considerations for a hasty team include moving quickly, searching all likely places while looking for clues and signs and communicating with other team members. In a hasty team search, it is very easy to get separated from the rest of your team, so communication is vital. They usually pair up hasty team members so they could support each other in the field. They don't have to stay side-by-side, but at least within sight of each other and in constant contact.

OTHER SEARCH CONSIDERATIONS

Night searching

Sometimes there is no choice but to search at night. This should be avoided unless the danger to the lost person is such that it is unavoidable.

Advantages of night searching:

- Some resources search well at night. For example, canines (dogs), night vision goggles and thermal-imaging devices.
- Because it is quieter at night than during the day, human voices and sounds carry farther.
- Light signals from the subject are more easily detected by searchers.
- The subject is usually immobile at night. There are two advantages to this. Subjects are more likely to hear Searcher sounds, and Searchers on trails can overtake them.
- Searchers can control the angle of light from flashlights to best illuminate tracks and cast shadows.

Disadvantages of night searching:

- Even with a full moon, visibility is not as good as in daylight.
- There is an increased risk to Searchers. Aside from a hazard like rugged terrain, deer and other prey move at night, which attracts predators such as mountain lions and bears.
- A missing person could be injured while attempting to move towards searchers.
- Clues can be missed or destroyed.

Long Term Searches

When hasty search efforts are unsuccessful, additional search efforts can be varied. Hasty search techniques can be continued in other high likelihood areas or redone in areas previously searched. Detailed search techniques can be employed, such as grid searches or tracking. Grid searches can search better than hasty searches but take a significant amount of resources that may not be feasible to acquire. Tracking requires an initial clue, like a footprint, and is particularly helpful to determine the direction a subject is traveling, but it can take a significant amount of time. Additional resources can be involved such as helicopters or airplanes, canine teams, untrained volunteers, or other specialized teams or individuals.

Many searches continue with search efforts every day for weeks before ceasing. At times, search efforts, especially for despondents, may cease after a relatively short amount of search time. Multi-day searches will more closely resemble the ICS structure as it requires greater planning. Investigation will continue throughout the entire search period to better understand the lost

subject, identify possible clues searches should be looking for, and possibly to adjust the search area.

CONCLUSION

As a search and rescue team member, it is important to remember why you are in the field. Your job is to find the lost person or to find clues related to the lost person. If your team is in the field and discovers a solid clue, then your team has assisted in the search by advancing the last known position (LKP). By connecting the various clues and positions, it will often draw a line directly to where the lost person will eventually be found.

It is important when you are in the field, regardless of what duty you are assigned, to always remember to watch for clues and report anything you find. Each piece of the mystery gives a clearer picture of what happened and how the person might be found.

STUDY QUESTIONS

1. What is the first step in locating a missing person?

2. Roughly how many searches are conducted yearly by the National Park Service alone?

3. Most lost persons are located within how many hours?

4. How is background information about a subject collected?

5. What is the median distance from the IPP in temperate mountainous terrain at which missing hikers are found?

6. How is a *statistical search area* determined?

7. How is the search tactic of attraction described in the text?

8. What is the purpose of the hasty search team?

5. Navigation

Most successful SAR operations can by summarized with the acronym **LAST: Locate, Access, Stabilize, Transport.** In order to locate and access a patient or patients, personnel must have a good working knowledge of backcountry terrain features and how to efficiently navigate in that terrain. Personnel must know where they are, where they need to go and how to get there efficiently. Along the way clues, hazards, or other items may be discovered and the coordinates of those locations need to be collected and transmitted to others. There are a variety of technologies available to aid in backcountry navigation. These include the use of a map and compass or the GPS system. Often both are effectively used together.

Location of the patient(s) can be as simple as receiving that location verbally from the patient or reporting party, or as complicated as a multi-day search. Once the location is known, SAR teams must access the patient as quickly and safely as possible. Many hours and even days have been lost to poorly navigating in the backcountry to the waiting patient(s).

If there is a choice between having a map, a compass, or a GPS as the only source of navigation information, choose the map. Good navigators often only occasionally use the compass and GPS but frequently look at the map. Maps come in a variety of different formats and sizes, each with its advantages and disadvantages. The bottom line is, never leave the Incident Command Post for an assignment in the field without a paper map of the area. GPS maps are a good tool, but if the GPS or mapping software fails, or if batteries fail, a paper map is essential as a backup and often easier to read for a larger comprehensive view than a map on a small GPS screen.

MAPS

Maps come in a variety of scales and are generally referred to as small-scale maps or large-scale maps. A small-scale map provides a large overview and covers many square miles. A large-scale map provides a more detailed view of an area and encompasses a smaller area. This seems counterintuitive but think about looking at a house on each of these types of maps. On a small-scale map the house appears very small and shows neighboring houses and structures, whereas on a large-scale map the house would appear larger and more detail can be seen.

There are several different map datums in use. It's important to know the map datums and to make sure that the datum of the GPS units in use on the incident match the map datum used on the incident. Simply stated, the map datum is a mathematical model of the size and shape of the earth. Not all map datums agree. Suppose one cartographer believed that the earth was a cube and devised a mathematical model based on that notion while another cartographer believed that the earth was a sphere and devised a mathematical model based on that notion. A particular point on the earth would have significantly different descriptions on each of those models. While that is an extreme example it does help to understand the issue. The same location on the Earth's surface in the same coordinate system has different coordinates under different datums.

COMPASS

There are several types of compasses available. The best compass for search and rescue use is the orienteering base plate compass with a declination adjustment feature. A term that is used

frequently when working with compasses is Azimuth. An azimuth is the angle of horizontal deviation, measured clockwise, of a bearing from a standard direction such as north or south.

The compass is a relatively simple instrument for finding direction. The compass works by aligning its magnetic compass needle with the magnetic force lines of the Earth's magnetic field at that location. The compass needle does not necessarily point to the magnetic north pole or to true north. To determine true north, it is necessary to apply a declination adjustment to the reading obtained. There are rules for doing this but using a declination adjustable compass is the preferred method for working with azimuths from map to field and vice versa. Once the declination is set for the area all the azimuths are true and match the map that also uses true geographic directions and not magnetic directions. This can serve to reduce navigation errors. The biggest contributor to compass error is the user. One degree of error equates to almost 100 feet of error over the course of one mile.

GLOBAL POSITIONING SYSTEM

The Global Positioning System (GPS) has become an essential tool for SAR and other emergency services. This system allows locations to be marked accurately on a map. It also allows users to input coordinates into a GPS receiver and navigate to those coordinates very accurately in all types of weather, in the dark, and in flat featureless terrain that makes navigating with other techniques difficult. GPS receivers can also track the movements of SAR teams, providing a variety of benefits. A team could use the track to safely return to base. The track can be downloaded to a map for further use in searches. Teams also used saved tracks to more efficiently navigate to future incidents.

GPS has become very prevalent outside of the emergency services as well. It is a relatively cheap but sophisticated technology that more members of the public are relying upon. Many GPS users do not receive any training about the technology and its limitations. The use of GPS without training or other navigation skills to back up the GPS has been a contributor to more than a few SAR missions around the country.

When a GPS receiver is turned on it begins searching for satellites. Once it has acquired signals from three satellites it displays a location. This location is commonly known as a 2-D location and when additional satellites are received the location becomes a 3-D location with horizontal location information as well as elevation information. Just like a map, GPS receivers use a datum, which must correspond to the maps being used. GPS coordinates can be given in several different formats. The format used is not as important as all parties using the same format. This is imperative for successfully navigating with the GPS.

ALTERNATIVE WILDERNESS NAVIGATION TECHNIQUES AND COMMON SENSE

Obviously, having a map and compass or GPS receiver (and the knowledge of how to use them) will be the most effective way to navigate to an incident in the backcountry. Sometimes, these tools are not available or even needed. Often a patient may be located at a known place on a known trail. SAR teams typically know most or all the trails in the area they serve and would simply hike that trail to the location, only needing to consult the map to confirm progress.

There are some alternative techniques that may help locate or navigate when a map or GPS is unavailable. Recognizing and identifying prominent landmarks can help. Knowing which way is north will help. The sun rises in the east and sets in the south. North slopes are typically greener than south facing ones, and moss usually grows on the north side of a tree trunk. Small streams run downhill to larger ones and eventually to bodies of water. Small trails typically follow the same pattern, becoming larger trails and then to roads, usually downhill or in the bottom of drainages or canyons. As SAR personnel are the ones doing the search and rescue, they shouldn't need alternative methods of navigation, but these alternative methods may be useful when gathering information verbally from patients or reporting parties.

In conclusion, SAR personnel cannot stabilize a patient until successfully locating and accessing the patient(s) involved in an incident. It is therefore essential they have a strong working knowledge of backcountry navigation techniques and experience using those techniques.

STUDY QUESTIONS

1. What do you always need to have before you leave the incident command post?

2. What is the map datum?

3. What is the biggest contributor to compass error?

4. How can you tell when the sun is at its highest point?

6. Patient Assessment

Once a patient has been accessed, rescuers should begin each rescue by surveying the scene. The scene survey consists of several parts, but the most important is safety for you, other rescuers and the patient(s). Placing a rescuer at undue risk can complicate the situation, if not create additional patients. Surveying the scene requires you to identify the number of patients, understand each patient's condition and note the presence of bystanders, equipment, and other clues that may be useful in determining the cause of the injury or illness.

1. SCENE SURVEY

- *Is* the scene safe for me to enter?
  If hazards are identified, take steps to mitigate them or wait until it becomes safe.
  Consider external hazards such as the following:
    - Physical dangers (rockfall, snow/ice/avalanche, trees, fires, wildlife, etc.)
    - Weather/environment (hot/cold temperatures, lightning, high altitude, etc.)
    - Other people (bikers on single track, climbers above you, hunters, etc.)

- *Will the scene remain safe? If not, what is my plan*?
    - Safe zones
    - Moving patients to a safe area

- *Is it safe for me to physically care for the patient(s)?*
  Gloves and barrier devices, such as a face mask, should be considered with every patient to prevent disease transmission through bleeding, vomiting, etc.

- *How many patients are there? Which one(s) need help first?*
    - The patient's equipment may provide information about the mechanism of injury (MOI).
    - Bystanders may have witnessed the patient's injury or may be able to assist with patient care.
    - Are there resources near the scene that may be useful in treating or evacuating the patient?

Approaching, Identifying, and Getting Permission to Treat the Patient(s)

- When approaching the patient, use caution so that you do not expose them to additional hazards such as rock or icefall. Consider marking the route to the scene if additional rescuers are to follow.
- Immediately identify yourself and request the patient's permission to treat. If the patient is unconscious or confused, then their consent to treatment is implied. Otherwise, the patient has the right to decline treatment.
- Ask the patient's name and say, "can you tell me what happened?" If the patient cannot answer these questions, they are either unconscious or have an altered level of responsiveness; start with the primary survey.

- This is an opportunity to determine the Level of Consciousness (LOC) of your patient. For this we use the AVPU (Alert, Verbal, Painful, Unresponsive) scale. Is the patient Alert and oriented, responsive only to Verbal stimulation (talking to them), responsive only to Painful stimulation, or Unresponsive to any stimulation? If the patient shows any signs of life such as movement, moaning, or talking, then you move on to the primary survey (below). For those patients who are completely unresponsive, the rescuer must quickly move forward with Basic Life Support (BLS) / CPR. This is extremely important if the situation involves a lightning strike, drowning or avalanche. These are wilderness situations where immediate CPR, which includes breathing for the patient may save a patient's life.

2. PRIMARY SURVEY: MARCH

The goal of the Primary Survey is to identify and treat conditions that pose an immediate threat to life. Approaching the patient using the acronym **M A R C H** allows the rescuer to address the life-threatening issues in order of importance. Anytime there is major bleeding you should always **stop the bleeding**. Preventing major hemorrhage is so important that it supersedes airway in the **MARCH** acronym for the primary assessment. We are not able to replace massive blood loss in the wilderness, so we must do our best to preserve blood volume and our patients. Airway does come early in the **MARCH** acronym, but massive hemorrhage is first. Therefore, we would stop the massive bleed before moving on to the airway. Evaluating the patient's pulse falls under the C for circulation in the **MARCH** acronym and would therefore not be the next best step.

Asking the patient if he takes any blood thinners will be part of your focused history, which comes after your primary assessment. You may be able to obtain this information during the primary assessment, but this should not distract from your assessment.

Because this portion of the assessment is searching for critical conditions, it is most applicable to patients who have an altered level of consciousness or have a significant injury. However, this survey should be utilized in *every* patient whom one treats in the wilderness. In those patients who are alert and appear well, this assessment may be brief. Problems found that are life threatening should be addressed immediately before continuing the survey

M - Massive Hemorrhage Management

- Massive hemorrhage must be rapidly managed because a patient can lose most of their blood volume in a matter of minutes with major arterial or venous bleeding.

- In the wilderness, you cannot replace this blood, and the patient may be required to be more active than the typical hospitalized patient.

- This step is applicable only for major bleeding and does not include injuries with only minor oozing that will be addressed later in the secondary survey. Generally, these types of injuries are rare in the wilderness but can have fatal consequences if not treated rapidly.

- Treatment usually consists of the placement of a tourniquet if it is an extremity injury. If one does not have a tourniquet or if the injury is not amenable to the use of a tourniquet (e.g. facial or torso wound), then a pressure dressing directly on the area of bleeding is the best option.

- The placement of the tourniquet does not mandate that the tourniquet stay in place until the patient reaches definitive medical care. The expectation is that that the rescuer will reassess the wound and the bleeding after the patient has been stabilized in the secondary survey and ongoing assessment stage. The use of tourniquets and their management is covered in depth in the wound management chapter.

A - Airway with Cervical Spine Stabilization

The "airway" is the continuous path from the patient's lips all the way down to their vocal cords at the base of their throat. Any blockage of this pathway can limit the flow of air into the lungs.

There are two issues in the assessment of the victim's airway:

1. *Is the airway currently open and is air flowing easily in and out*?

2. *Is the patient able to keep their airway open with good air flow without your help*? This is termed "maintaining their airway".

First, *Is the airway open*?

- If the awake patient is moving air but has noisy breathing, they will often put themselves in the best position that allows them to keep their airway open. Do not force them into a position that they do not want to go into. Generally, we like to place patients on their back, but you should not force a patient to this position if they cannot tolerate it.

- If the patient has a decreased level of consciousness, then roll them onto their back as a single unit, being careful not to twist or jerk the spine or neck. Once the patient is on their back, then attempt to open the airway using the head tilt-chin lift maneuver unless you think the patient was injured or involved in an accident.

- If you suspect that the patient has head or spinal injuries, use the jaw-thrust technique to minimize neck movement by placing one hand on each side of the patient's head and grasping the angles of the patient's lower jaw and lifting up and forward with both hands.

- If the patient has a decreased level of consciousness and is not moving air well with initial positioning, then inspect for and remove any foreign objects from their mouth. In patients of avalanches, snow burial, or major trauma, it is not unusual to see snow, teeth, dirt, and leaves in their mouths.

Second, *Is the patient able to maintain their airway*?

- There are potential airway issues, especially in trauma and allergic reactions, where the patient may develop worsening obstruction or blockage to their airway and have difficulty breathing. This is important when you consider how to evacuate the patient(s) and which patient should be evacuated first.

R - Respiration

- Respiration involves the evaluation of how well the patient is breathing and whether there is any potential for respiratory compromise in the future.

- If the patient does not start breathing after the airway has been opened, begin rescue breathing as described for basic CPR using current guidelines.
    - Each breath should be delivered over one second with enough air to see the chest rise.
    - If the breath does not go in, reposition the airway and try again

- If the patient is breathing, briefly assess the quality of the respirations. Does the patient appear to be working hard to breathe, are they breathing rapidly/slowly, is their breathing appropriate, etc. Be mindful of potential for flail chest and/or tension pneumothorax in trauma patients and consider needle thoracostomy if appropriate and able.

C – Circulation

- Any patient who is awake or showing any sign of life will have a heartbeat. This step is to assess the patient's cardiovascular status with a focus on the heart rate, pulse strength and to treat non-massive hemorrhage.

- You can assess the pulse at the pedal/tibial, radial, brachial, femoral or carotid arteries.

- Assess the quality of the pulse. Is it weak/thready, bounding, rapid, or irregular?

- Check for bleeding by performing a blood sweep. This is a rapid (5 - 10 seconds) full, head-to-toe check for blood, wet clothing, swelling or other signs of significant bleeding. Don't forget to look under bulky cloathing, coats, other layers. A blood sweep also affords the rescuer the opportunity to simultaneously note major deformities.

H - Hyperthermia and Hike vs Helicopter

- At this point in the primary survey, the rescuer has treated any immediate threats to the patient's life and has taken steps to mitigate those threats. Wilderness medicine presents an additional issue that one must consider: the environment and its potential to worsen the patient's medical course.

- Recognize that whatever the environment, the patient has likely been exposed to it for a longer period and has not been compensating as well as the rescuers.

- A patient in a cold/hot environment will likely be colder/hotter than the rescuer.

- Steps should be taken to limit the patient's exposure to the environment.

- Hypothermia in trauma can lead to the cascade of acidosis and coagulopathy with increased mortality.

- Think about the evacuation plan (hike vs. helicopter).

1. The life-threatening injuries have been identified at this point.

2. What types of resources will you need and how can you get them to you to help your patients?

3. This is also a point to consider sending someone to go get help depending on the situation. This can be helpful because that individual can relay more valuable information beyond the initial "someone's unconscious."

4. If you are going to send somebody ahead to get help, you should send two people to help ensure that help is reached and that something does not occur to that single person sent out.

- As a general rule, and especially when dealing with possible injuries to the spinal column, perform first aid on the patient where he or she lies. However, there are special circumstances under which there is potential for more severe injury or death if the patient is not moved.

- At the end of your primary survey, it is also the time to decide if this patient needs an immediate evacuation ("load and go") or if it's suitable to "stay and play" and to manage their issues at the current location.

Primary Survey in Conscious Patients

- When the patient is conscious, the rescuer may be able to substitute portions of the complete primary survey with questions. *For example*:
    - A talking patient has, for the time being, intact airway, breathing and circulation. The rescuer should still assess the quality of the breathing and pulse.
    - Asking a patient about what happened and if they are bleeding may eliminate the need for a blood spinal immobilization.

3. SECONDARY SURVEY

The goal of the secondary survey is to identify and treat any remaining injuries and illnesses. These conditions may become a problem if left unnoticed or if they require advanced medical attention. This portion of the patient assessment is comprised of two key elements:

- An abbreviated medical history
- A physical exam including vital signs

The order in which these components are performed depends on the issue. For example, a fallen rock climber should have the physical exam portion of the secondary survey performed first to identify any other traumatic injuries, whereas an abbreviated history from a camper who has developed abdominal pain may be more useful.

Abbreviated Medical History

- Most of the patient's history is obtained immediately by asking "what happened?" However, a few other key questions must be answered to ensure the patient's problems are treated properly.

- The mnemonic SAMPLE will help you to remember the essential points of a patient history.

- For critical patients, you may be the only person who can gets to talk to the patient while they are still conscious. Therefore, if an initially unconscious patient regains consciousness, immediately obtain a history.

- In patients with an altered level of consciousness, other clues may be needed to obtain the history.

- The mnemonic **AEIOUTIPS** can be helpful in unresponsive patients. A few examples of clues:
    - Medical alert tags can be found in the form of necklaces, bracelets, anklets, tattoos, etc.
    - List of medications or medical problems may be found in a wallet.
    - Medications or devices such as a glucometer (blood sugar meter) or epinephrine auto-injector may be found in a patient's bag/tent/pocket/etc.
    - Bystanders or family members may be familiar with a patient's past or present medical history.

- Cell phones may be employed to contact family members.

- To assist you in characterizing a patient's pain, use the acronym COLDERR. Notice that this is most helpful in patients with pain from medical problems rather than traumatic injuries.

Potential Sources of Major Bleeding

- These are potential areas of internal bleeding that are not obvious when just looking at the patient.

- These are all areas to consider when evaluating a trauma patient and are picked up mostly on the physical examination portion of the secondary survey.

- We use the **CARTS** mnemonic to help remember these potential areas for significant bleeding.

CHEST	The chest is a common source of bleeding, particularly in high-energy trauma. Look for shortness of breath, pain with breathing, and coughing up blood. Examine for chest tenderness, crepitance over the ribs and sternum, flail chest and crackling noises of the chest consistent with air under the skin.
ABDOMEN/PELVIS	Assume abdominal and/or pelvis bleeding in every trauma patient until proven otherwise. Look for bruising over the abdomen and pelvis. Palpate for abdominal and pelvic tenderness on compression.
RENAL	Usually the bleeding is from the kidneys. Look for blood in the urine if you have a prolonged time with the patient. Examine for tenderness of the spine and chest and the lowest level of the ribs.
THIGH	This may occur if there is a femur fracture. Look for deformity, swelling and bruising of the thigh. Palpate for tenderness and crepitance of the thigh.
SKIN/STREET	This is the most obvious place for a rescuer to detect blood. A common error in the wilderness setting is the failure to remove clothing or to roll the patient to look for bleeding. Also, ensure that you survey the area immediately surrounding the patient for a large amount of blood on the ground that may have come from the patient. Specifically, an arterial injury that bleeds significantly may be in spasm at the time you are evaluating the patient and not be an obvious source of bleeding.

4. ONGOING SURVEY

- A unique aspect of wilderness life support is that the rescuer may care for a patient for several hours to days. For this reason, it is important to continue the patient assessment over a longer period. The ongoing survey very much depends on the patient's condition, and as such, changes often.

- Initial vitals obtained during the secondary survey should be compared to vitals taken throughout the evacuation or management period. Changes in vitals help alert the rescuer to an improving or deteriorating patient.

- As changes occur, such as the patient's condition, level of responsiveness or the environment, go back to the beginning of the patient assessment.

- Use your knowledge of the mechanism of injury/illness to try and anticipate problems rather than merely being reactive to acute changes. This can be particularly challenging in a wilderness or other austere setting but trying to think ahead can greatly assist evacuation and other planning.

- If the rescuer has the time and appropriate materials, he or she should try to document the important details. When this is handed off to medical professionals later, they will have a better understanding of the patient's history.

STUDY QUESTIONS

1. What can be used to prevent disease transmission through bleeding, vomiting, etc.?

2. What does the acronym AVPU stand for?

3. What is the goal of the Primary Survey?

4. What does the acronym M A R C H stand for?

7. Technical Ropework in Rescue

Familiarity with crucial equipment is essential to mountain rescue, and no piece of equipment is more crucial than the rope. Nevertheless, you might well ask why a medical practitioner should be familiar with ropework, as critical as it might be. There are many reasons. First, a good understanding of how to use this tool will enhance your abilities, safety, and confidence in the backcountry. In addition, since you may be the sole trained rescuer in an unforeseen emergency, you may not be able to rely on others for their rope skills when needed. And, thirdly, even if you are operating with a team whose members have greater technical rope skills than you, it is vital that you be familiar with the basics of ropework and related tools, in the same way that each member of a resuscitation team should be trained in ACLS. The physician may be running the code; but each paramedic and nurse on the team needs to be fully trained in the practices of cardiac life support to ensure an effective and coordinated resuscitation effort. Just as a high-performance resuscitation team can maximize a patient's chance for survival, a high-performance rescue team, with each member trained in the basic tools of extrication and ropework, can help ensure an effective and safe rescue operation.

TECHNICAL RESCUE

The four steps in Search and Rescue are represented by the L.A.S.T. mnemonic: Locate, Access, Stabilize, Transport. Frequently, accessing and transporting a patient will require the use of high-performance ropes, hardware, technical systems, and specialized patient transport equipment. Rope rescue probably began when the first person tied a rope around their waist and either climbed up to or were lowered down to someone injured in technical terrain. Contemporary systems are considerably more complex, efficient, and safer than a twisted rope and a strong heave. But, in the end, the goal is the same: Get the patient to definitive care safely, quickly and without further injury.

The tools and methods discussed here are needed in what is termed 'technical' conditions. The word technical is used in outdoor recreation, hiking, climbing and rescue to describe a landscape that is difficult to navigate because of steepness, obstacles, unstable terrain, or other challenges. In rescue operations, the steepness of the terrain is assigned to one of four categories, Flat, low angle, steep angle, and high angle (see table). The method used for rescue, the required equipment, and number of needed rescuers can vary greatly depending on the character and slope of the terrain, of course. And while ropes are generally used only in high angle conditions by recreational climbers, in rescue, given the vulnerability of the patient, higher level of safety required, increased equipment burden, and other factors, ropes are frequently indicated at much lower slopes.

Category	**Slope**
Flat	0-15°
Low Angle	16-40°
Steep Angle	41-60°
High Angle	> 60°

Rope rescue can be as simple as a safety line attached to a compromised patient when covering tricky terrain, or as complicated as lowering and raising a patient and rescuer over a rock overhang. The techniques and equipment required for the range of possible situations and conditions is vast and cannot be fully covered here. And the gear and techniques used are continually evolving, trending toward options that are lighter, stronger, and less prone to human error. Our present goal is simply to review basic rope rescue equipment and practices. Developing technical rope rescue skills will take a great deal more time, effort, and hands-on training. It cannot be mastered from a text or the internet.

Belaying

Commonly, in mountaineering and climbing, belaying is the use of ropes, harnesses and friction devices (all to be discussed below) to secure or lower a person down steep or unstable ground or to provide a safety tether or backup as someone climbs technical terrain. The climber that is 'on belay' is secured to the end of a rope which is run through an anchor above, called a 'top rope'. The belayer can be above or below the climber and maintains a low slack safety rope, paying out rope through a device that provides friction resistance for braking action. The belayer typically does not pull a climber up or lower a climber down. Rather, in a rescue, the belay is a safety operation, meant as a back-up to safely stop a fall. It can operate in conjunction with a main line used by the descending rescuers to lower or raise a patient. So, a belay in a rescue system is typically slightly different from a belay commonly employed and understood by rock or ice climbers. When needed, a rope may simply be tied to a basket stretcher, or litter, and held in hand as a backup as rescuers carry or wheel a patient down a trail, sometimes called a walking belay. Or an anchored rescuer may pay out rope which is attached to an ambulatory patient's harness as the patient moves through steep or technical terrain. So, unlike rock climbing, belaying in rescue is usually indicated in lower angle or lower consequence terrain. It is a safety line in low angle terrain, and the last line of safety in higher angled terrain.

Rappelling, also called Abseiling, is similarly a controlled descent down steep, unstable or technical terrain. The terms rappel and belay are often used interchangeably or without clear distinction among climbers. However, commonly the term rappelling is used when a climber controls their own descent down a rope that remains static and is anchored above. The friction brake is attached to the rappeler with a harness, and the rappeler regulates their decline by slipping rope through the device. One or two ropes can be used, with two ropes adding security and friction for a slower descent, greater safety, or a heavier load. Rope rescue now commonly utilizes a double rope technique (DRT) for improved safety. While most commonly employed for high angle terrain in rescue, rappelling down lower angle terrain can improve safety for the rescuers and patient and can permit hands free rescue activities and patient care on loose or unstable ground. Bold mountaineers have rappelled by wrapping the rope around their body without a friction device or harness, a practice called *Dülfersitz* or body abseil. This is absolutely not recommended in rescue activities; however, in rescue a rope may be used as a safety handhold when crossing tricky but non-technical terrain, particularly with a compromised patient. And a safety rope may be indicated for a patient with diminished mobility or balance even at low angles.

Lowering or Raising Systems

Because of the increased stability, control and safety required in rescue work, ascending or descending high angle topography typically requires much more than a rope, harness and friction brake. Accessing or transporting a patient frequently requires the lowering or raising of equipment, rescuers, or patients, at times straight up or down. When operating in vertical or near vertical topography a lowering or raising system may be required to transport patients and rescuers safely. These systems can be very complex, vary by terrain and conditions, and require highly-trained operators. A typical lowering or raising system might consists of the following components: anchors, ropes, descent control devices, raising or hauling systems, edge protection to protect ropes from abrasion, multiple devices called directionals, which can be bolts, cams or pulleys that holds a rope line in position through irregular terrain and obstacles, and of course a team of competent rescuers experienced in assembling and operating high angle rope rescue system. We will introduce some of these tools below.

SAFETY

For those involved in technical rope rescue, safety is paramount. Personal protective equipment (PPE) must be worn by both rescuers and patients. Life-safety gear must be inspected regularly, its use logged diligently and replaced when necessary. Although safety is the responsibility of everyone involved in a rescue operation, assigning one individual as safety officer may be required. At a minimum, one set of fresh eyes must inspect the gear used, knots tied, or systems built before rescuers or patients enter a potentially hazardous situation.

PPE includes but is not limited to helmets, eye protection, gloves and harnesses. If a helicopter is involved, ear protection should be added. Many SAR teams require rescuers to wear full harnesses. Patients should also have PPE appropriate to the rescue. Personal gear may also include a personal anchor system (PAS), anchor materials, ascenders, descenders and assorted carabiners, all to be discussed below. Team gear will include litters, ropes, anchor materials, descent control devices, raising systems, edge protection, high directionals, and sometimes much more, including packs or bags to carry everything.

Helmets are a particularly vital component of a rescuer’s PPE. Head protection should obviously be worn during any technical ropework. However helmets may also be worn during off-trail carry-outs to protect the wearer against branches, falling rocks, debris, or other hazards. An acceptable helmet should allow adequate air circulation, so the wearer is not tempted to remove it on hot days; and it should be suspended above the skull to provide shock absorption. A three- or four-point chinstrap is also essential to ensure the helmet does not shift during a fall. So, a construction-style hardhat is not acceptable.

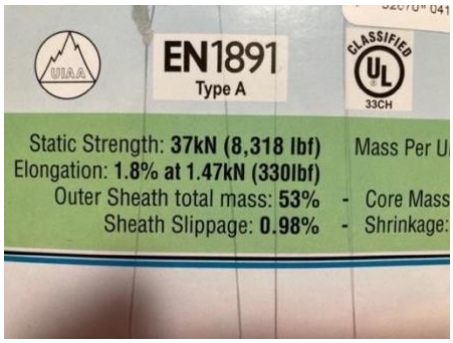
ROPES

As mentioned, ropes enable efficient and safe movement over technical terrain that might otherwise be dangerous or impassible. They help move, secure and protect equipment. And

perhaps most importantly, they are vital to the safe extrication (removal from an immediate hazard) and evacuation (transport to definitive care) of the nonambulatory sick and injured.

There are numerous types of ropes, with many varying characteristics. Some ropes are twisted from natural grass fiber and others are cutting-edge technology, made of sophisticated long-chain synthetic polyamides. It is important that you are aware of the variations in rope performance so you can properly select and use the proper rope for a given need. However, it should be said that in an emergency the best rope is the one you have. And so, in an emergent rescue situation, you may find yourself needing to use the wrong rope for the right job. In that case as well, you should have some sense of the potential weaknesses and threats posed by an improper rope so you can be prepared.

Ropes can vary by strength and size, of course. But they can also vary by stiffness, abrasion resistance, water repellency, floatation, flexibility, stretch and other factors. Often, these characteristics present tradeoffs. For example, a flexible rope can be easy to handle and easy to pack; but because of its low friction it will be unsuitable for belaying and rappelling.
Nylon rope offers high strength, and when stretched it readily returns to its original shape, making it good at absorbing shock loads. Polyester is nearly as strong as nylon, and it offers very good abrasion resistance; but it stretches less readily, and so does not absorb shocks well.
Polyester ropes are very common in mountaineering, boating and rescue work, and are durable and strong. They can be marketed under various trade names, including Dacron, Fortrel, ACE, and others; but these are all variations on polyethylene terephthalate (PET), the same stuff water bottles are made from. Polypropylene and polyethylene are used for common utility ropes. Not as strong as polyester, they stretch easily, are more susceptible to abrasion, and degrade with sun exposure. These are the typical ropes you might find at a big-box home store; and they are not a good choice for backcountry use.



The National Fire Protection Association has established standards for safety ropes used in rescue. The standards define 300 pounds as the regular load requirement for one-person, and 600 pounds defines a rescue load, or two persons, rescuer and victim. The NFPA recommends a safety factor of 15:1; so a rope used for a single person should provide a breaking strength of at least 4500 pounds of force, and rope used for rescue load for two should be rated at 9000 pounds of force. The UIAA (*Union Internationale des Associations d'Alpinisme* or International Mountaineering and Climbing Federation) sets baseline standards for mountaineering ropes; look for their mountain seal on a rope's label before you buy (image above).

In mountaineering and backcountry rescue, kernmantle ropes are the standard. The rope is made of an interior kern, a fiber core that provides strength, firmness and rigidity, and a braided exterior sheath, called the mantle, that holds the rope together and provides abrasion resistance, durability, and friction characteristics. Rescue ropes can by nylon; or they

might combine a polyester sheath and nylon core, offering abrasion resistance and reliable strength. Other variations in design might offer improved abrasion resistance, stiffness, weight, or chemical resistance. Some ropes might have a stronger continuous bond between the sheath and core, offering improved resistance to damage and reliability when the sheath is abraded. Aramid fiber, commercially called Kevlar, can be used to increase strength or abrasion resistance in some ropes, though this has drawbacks.

There are new ropes on the horizon that may become more common in mountaineering and backcountry rescue. For example, ultra-high molecular weight polyethylene (UHMWPE) is an extremely tough polymer now used in ropes. It offers high abrasion resistance and very high strength with extremely low stretch. In fact, it is stronger than steel wire rope of equal size and is flexible and floats on water. However, like other advanced synthetic ropes, it does not easily hold a knot (called knotability), making it problematic for most rescue applications. Nevertheless, it is starting to find use in mountain rescue for winch lines, lifting slings and other high demand applications.

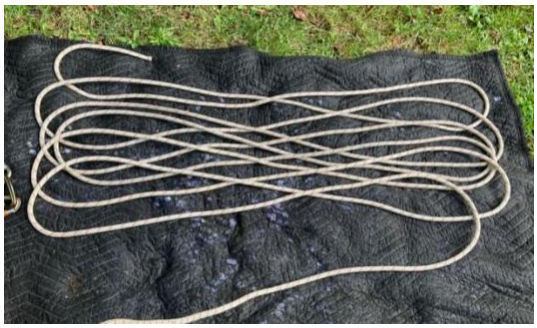
There are a few other ropes you may run across. It is worth quickly mentioning a small version of the kernmantle called paracord. As the name implies, this rope was initially designed for parachutes; however, it offers exceptional versatility in backcountry and rescue work. The so-called '550' cord offers 550 pounds of tensile strength with a diameter slightly above 1/4 inch. It is easily packed. It is useful in lashing together makeshift stretchers, splints or shelters. And, notably, the internal strands can be pulled out, offering multiple fine but tough threads that have many uses. Little wonder this cordage has been used in U.S. military survival training for decades. On the other end of the spectrum, you may also run across twisted rope, called laid rope. Despite its antiquated look, twisted rope can be reliable and strong. It is typically made of three major strands coiled in the same direction, with the fibers in each strand coiled in the opposite direction. In this way, the rope can be made ‘balanced', that is to say it will hang straight and not kink. These ropes are now largely absent from mountaineering work, but still used in some marine applications and utility work, so you may find yourself using one in a pinch. Laid ropes are no longer used for belaying, rappelling, or mountaineering. But they will provide suitable lashing and support in an emergency. Remember, the best rope for the job is the one you've got.

Other variations can include straps and webbing. Webbing, sometimes called flat rope, is closely woven, durable flat strips of fabric used for lashing. It works well for applications that are subject to abrasion or required to lie flat, such as anchors, or when avoiding concentrated pressure and injuries that might be caused by the use of ropes, such as with belts, harnesses, patient packaging, or slings. Because it can change directions more sharply and not lose as much strength as a rope when doing so, webbing is commonly used to connect to carabineers (below). Tubular webbing is common, and basically like the mantle of a rope without the inner kern (red and orange in image). It has good knotability and versatility. Flat webbing is typically stronger,

thicker and stiffer than tubular webbing. It makes durable rigging, lashing and belts. Both can be made into useful climbing devices such as slings and harnesses.

Modern mountaineering ropes are precisely manufactured to provide specific performance characteristics. The amount a rope stretches, for example, is carefully designed into the rope. A rope that stretches more under load, called a dynamic rope, is favored by rock climbers as a safety line. The ability for a dynamic rope to absorb some of the force when a climber falls reduces the likelihood of deceleration injuries or musculoskeletal trauma at the harness points when a fallen climber comes to an abrupt stop. In search and rescue, static ropes are common. Since the ropes stretch very little, they provide firm and reliable support for tension lines and safety ropes. In rescue, the greater the rope elongation, the greater the distance and uncertainty when working close to anchors, obstacles, or patients; and that can mean greater danger.

Care for ropes is important. Just like medical equipment, a rope must be carefully maintained to ensure that it is ready when needed. Twisting a rope can damage its strength and make it difficult to use. So, care must be taken to never willfully twist a rope. This means the common method of spooling a rope around your forearm is absolutely out. This practice will twist and mangle a rope terribly. Instead, you can coil a rope by looping it over your shoulders or perhaps over a knee, alternating hands as you lay the coils so you do not twist or kink the rope. Coiling in a left and right overlapping figure eight can also be done on a tarp. Either way, you end up with alternating loops that allow the rope to lay flat and untwisted. A diamond design on the mantle of some ropes, called a tracer, is there to allow the user to readily identify any unwanted twist. A rope can be carefully prepared for use in the field by running the entire length through your hands and laying it untwisted and loosely coiled on a tarp or other protective surface, a practice called flaking or stacking. Similarly, take great care to never step on a rope. This can grind soil and stone into the fibers, damaging a rope's strength even if it appears unharmed. Remember, your life or the life of your patient may depend on the reliable strength of that rope.



While ropes can be coiled for easy transport while in use, ropes should be stored (clean and dry) in rope bags when not in use. Begin by tying off one end of the rope outside the bag to keep it accessible. Feed the remaining rope loosely and without knots into the bag. Shake the bag to allow the rope to settle rather than forcibly stuffing it; and tie off the other end outside the bag. Select a bag that is large enough to allow an easy fit. Take care when removing a rope from a bag or releasing a coiled rope, as you can easily end up with a tangled mess.

Here are a few rope care guidelines:

- Never step on a rope.
- Keep ropes clean. Wash and dry them if soiled while in use.
- Ropes should be stored protected from sunlight.
- Carefully coil a rope without twisting.
- When storing a rope remove knots and place in a rope bag.

- Inspect ropes for damage before and after each use.
- Label ropes with age, type, diameter, length and special characteristics.

KNOTS, BENDS AND HITCHES

The rope you rely on is only as good as the knots used to secure it. And, just as in suturing, different knots are needed to provide reliable performance in different circumstances. Again, a detailed description of belaying and rappelling techniques and equipment, technical rope work, and related skills is well beyond the scope of this text and better learned in practice. Do not attempt technical rope rescue skills unless and until you receive practical, competent training from a qualified instructor. However, basic knot tying is a skill that anyone in the backcountry, and particularly search and rescue personnel, should master. Each member of a rescue team should be familiar with the knots below and their uses. Ideally, you should be able to tie each of these blindfolded. It's true, you're unlikely to be blindfolded in a rescue. However, you are very likely to have to tie off a rope, strap, or webbing in low light, around an obstacle, or when reaching above your head, behind a stretcher, or in another difficult circumstance. As in sutures, the knot, not the line, is the most common cause of failure. So, the more familiar you are with the use and tying of each of these knots the better.
There are multiple online sources that explain and demonstrate the tying of knots and hitches. So, here we will simply and quickly review the use of key knots in SAR and backcountry emergency care; these include:

- Overhand
- Square Knot
- Surgeon's Knot
- Half Hitch
- Anchor Hitch
- Clove hitch
- Bowline
- Alpine butterfly
- Figure eight
- Double overhand (fisherman)
- Sheet bend
- Water knot
- Munter (Italian) hitch
- Prusik
- Truckers Hitch
- Simple Anchor

Overhand Knot

The overhand knot is a staple and the basis of many other knots. It's simply a single wrap of a rope, as you would do when tying your shoe. A double overhand knot is preferable in rescue work. Simply add a second throw to the knot before securing. A simple overhand knot such as this is a common and useful way to create loops in webbing.

Square Knot (Reef Knot)

The basic square knot is a quick and useful way to fasten two low-tension lines together or tie a rope to an object. When tight, it can have respectable reliability and strength. However, it should

be distinguished from the granny knot which comes apart easily. The square knot relies on the reversal of two overhand knots, so a right overhand followed by a left overhand. Two overhand knots in the same direction makes a granny, and that's not good. Can you see the difference in the images?

Surgeon's Knot

A surgeon's knot should be familiar to many medical practitioners. It's composed of a double overhand knot followed by a singly overhand in the opposite direction. The advantages are the same as in suturing. It is resistant to slipping. And, most notably, the initial double throw will keep the lines from slipping if further adjustments need to be made before the knot is secured. For example, when applying a splint, it can be useful to secure the splint in place initially with multiple caveats using double overhand knots. This allows you to adjust each for proper position and tensions, and then lock them down by adding the opposing overhand to form a surgeon's knot when ready. A similar practice can be used when securing a patient to a makeshift stretcher.

Half Hitch

A half hitch is a simple way to tie a rope to an object. It is simply an overhand knot. Alone, this is not a reliable anchor. A double half hitch allows for improved reliability (left image below).

Anchor Hitch

An anchor bend, or anchor hitch (right image), can offer a more secure attachment of a rope. Historically used to secure a ship's anchor, the knot is a good choice to secure a line firmly to a litter, tool, canoe, or other object.

Clove Hitch

When securing a middle section of rope to an object, a clove hitch is a good choice. Since they can withstand tension from either direction, clove hitches are commonly used in mountaineering to provide running anchors as you move across a rock face.

Mooring Hitch

A mooring hitch offers a quick and easily removable hitch. A quick tug on the free end and the rope is released. It's a useful hitch to know for general backcountry travel; and it is particularly useful when a cord may need to be easily, or perhaps urgently, removed. Securing a hypothermic wrap, for example, when access may be needed to reassess the patient's status or address an emergency calls for a knot that is easily and quickly removed such as this.

Bowline

A bowline is a well-known standard in knot tying. It is very secure and excellent for rescue use. When correctly tied, the end should emerge on the inside of the loop (upper image). If extra security is needed, a locking bowline can be used; just add half hitches on the working end after the knot is set. A bowline used in rescue can be better secured with a so-called Yosemite finish, when the end is turned back up through the initial bight to add extra security to the knot (lower image, left loose).

Alpine Butterfly

An alpine butterfly, or butterfly noose, is one of the few knots that can be easily and quickly tied in the middle of a rope. It allows for a handhold or fixed connection point mid-line. It is a common knot in climbing and can be used to make a connection, isolate a damaged line, create a hand or foothold, and many other functions.

Figure Eight

A figure eight is a great standard of knot tying and indispensable in mountaineering and rock climbing. It is a stopper knot, so it can be used to stop a rope from slipping through a retaining device or hole. It can also be used to make a secure loop, called a figure eight loop or figure eight on a bight (image). This is the standard knot used to secure a tension line to carabiners and then to a harness or litter. It's fast and easy to tie, and highly reliable. Because the knot resembles an eight, it is easily identified and inspected, just check for the presence of three parallel lines at three points in the knot.

Double Overhand Bend (Fisherman's Knot)

A fisherman's knot can be used to secure two similar ropes together. It is simply two opposing double overhand knots. The end of each line should come out of the knot parallel to the main line. Look for this to be sure the knot is correct and secure.

Sheet Bend

A sheet bend, sometimes called a slippery bend, can be used to connect two ropes that are not similar sizes or stiffness. It can allow a heavy line to be drawn through terrain or obstacles by a smaller line that can be more easily drawn or thrown. The bend can also be tied with a bight on the smaller line, defining a quick release version called a sheet bend on a bight. (A 'bight' is a U-shaped bend in rope, as opposed to a 'loop', which forms a circle and crosses the rope back over itself.)

Water Knot

When tying webbing together, a variation of the double overhand can be used called a water knot (or more precisely a water bend since it connects two ends). When strapping a patient to a stretcher, configuring a harness from webbing, or making a loop of webbing while climbing, this knot can be useful. An easy method is to tie a loose overhand knot in one section, then feed the second webbing through that knot in the opposite direction. A double fisherman's can also be used to connect webbing, as long as it does not need to be easily untied.

Munter Hitch

A Munter hitch, also known as an Italian hitch, allows a basic D ring or carabiner to be used as a belaying or rappelling device. The hitch is a simple double wrap that produces friction, and so allows for the controlled descent of a load. Friction is produced in both directions and increases with tension. So, it is a forgiving and uncomplicated alternative for an emergency belay. A belaying device is preferable if available, as it produces less wear on the rope. Be sure to have

the working end come out away from the carabiner gate. Otherwise, the rope movement may inadvertently open the gate.


Nope!


Yes!

Prusik Knot

This knot is invaluable to climbers and rescuers. This simple friction hitch is easily moved up and down a rope when slack and pushed at the barrel; but it brakes with friction when pulled parallel to the main rope. Various manufactured loops of rope are sold as prusik cord; and a climber may carry several. They are easy to place and can function as a sling or emergency hold. A pair can be used to ascend a rope. Ascending devices with locking cams can be used for this purpose (see below). But, in a pinch, prusiks alone work and do not damage the main rope. A Prusik is made of two or three loops of a simple hitch (called a girth hitch or a lark's foot). A two wrap Prusik can be used for a single person; however three wraps should be used for a rescue load.

Trucker's Hitch

A trucker's hitch can be used to add tension to a line by use of mechanical advantage. The principle is the same as for a block and tackle mechanism. The tension is shared between two points of movement, so the pulling or lifting force on the line can be doubled. Begin with a slippery half hitch or butterfly loop tied a few feet from the point of anchor (that is to say, the thing you want to pull on). To reduce friction loss, a carabiner should be attached to the loop or hitch. This provides one point of movement. (The more stretch in the rope, the more distance you will need from the anchor point, as elongation will quickly move your knot toward the anchor point preventing further tightening.) Feed the rope though the anchor point and pull back through the loop. As you pull on the rope, your force is shared by two points, the anchor point and the loop, and this means your pulling force is doubled on the main line. Secure the line with a hitch when set. This hitch can be used anytime a taut line is required.

Simple Anchor (Wrap 3/Pull 2)

While not technically a knot, establishing a reliable anchor is a key skill that should be mastered by a rescuer. A secure single point anchor in the backcountry can be obtained with webbing wrapped three times around a solid natural anchor such as a tree or large boulder. Wrap the webbing three times loosely around the tree then connect the two ends with a water knot facing the direction of pull. A carabiner can then be attached to the two winds that are not knotted, leaving the knot against the tree and experiencing relatively little strain. More complex multi-point anchoring systems that require multiple lines are often necessary, but beyond our current scope.

BACKCOUNTRY RESCUE HARDWARE

Emergency medical rescuers should be familiar with the basic climbing hardware they may need to use in an extrication or transport. There are, of course, many more tools used by skilled climbers, mountaineers, and rescue professionals; but, again, instruction on advanced climbing gear is beyond our present scope. Here is some of the basic hardware with which any rescuer should be familiar:

Carabiners

Carabiners are specialized mechanical shackles or links that can make secure, easy, and removable connections between harnesses, ropes, tools, anchors, or virtually any component of mountaineering. They are widely used in a range of outdoor activities, from caving to ballooning, as well as technical rescue. And in all cases, they should only be loaded along the long axis. Carabiners are not designed to maintain a lateral load across the gate, or to be loaded in multiple directions. Common carabiners, sold as keychains or strapping devices, are not appropriate for backcountry or rescue activities. Mountaineering carabiners are precisely engineered, rated for specific loads, and certified by the UIAA. Use only these quality devices in rescue work.

Carabiners come in multiple shapes and sizes. Conventional clips are shaped in a symmetrical oval. Others are laterally asymmetric, defining a so-called D ring or offset D. The advantage of this shape is that it more readily aligns the major load with the longitudinal axis of the long side, ensuring greater strength. An offset D carabiner has a more exaggerated asymmetry that allows for a larger gate opening. A carabiner can also take a pear shape, called a pear carabiner or an HMS (*Halbmastwurf sicherung* or half clove hitch). These offer a larger curve on one side that can be used as a friction brake for belaying with a Munter hitch. A large version of this is used in urban rescue work, called a ladder hook (or firefighter hook, rescue hook). It is large enough to

connect to fire escapes, rescue ladders, or railings, and makes a reliable and simple rappelling device.

Carabiners can also be sorted by the type of gate they use. Non-locking carabiners have a spring-loaded gate that allows easy and fast connections. They are frequently used to attach lines or webbing to fixed objects such as litters or tools. Locking carabiners provide the ability to fix the gate in a closed position. This has great advantages for connections with ropes that slide, twist, or move in ways that could press against a gate and release the link. Typically, locking carabiners use a sleeve over the gate that prevents inadvertent opening. Some sleeves are spring loaded with a quarter turn mechanism, a twist lock, so they turn and lock automatically whenever they are attached. Others must be screwed into a locked position deliberately, called a screw lock. A newer alternative utilizes small, embedded magnets that pull a steel insert into a locked position. These may be somewhat easier to operate one-handed.

Belay Devices

Belay and rappel devices use friction to allow a controlled descent on a slope. As previously mentioned, one common rappel device is basically a large pear carabiner. A proper rope coil or hitch can provide a friction brake that will allow a controlled descent. Similarly, running the line through multiple carabiners can also work. There are many different ways to configure carabineers for rappelling (images below). However, they all share a common characteristic, running a stiff rope through an indirect path to create resistance that will allow for a controlled descent.
This technique has been used for decades by the military and rescue personnel. However, it requires good familiarity with your equipment and technique, as differing configurations of carabiners will allow slower or much faster descents, and the wrong carabiner configuration can cause a gate to open mid-rappel with catastrophic results.

A commonly available belay device is a tube-based device, commonly called an ATC (which stands for, you guessed it, Air Traffic Controller). A bight (or two) is threaded through a tight 'tube', creating a constrained friction pathway. V shaped friction groves are often added to a side to allow improved braking. These are lightweight and suitable for rappelling and belaying, so they are generally popular with climbers.

A figure eight device, or super 8, uses the same friction brake principle, but is simpler and easier to use. The rope runs around a simple loop, creating enough friction to allow a control descent. With no gate or break in the loop, this device offers improved certainty, particularly for an inexperience climber. A super 8 is typically best for short rappels with a single person. However, a heartier version, called a rescue 8, is stronger, with added 'ears' to facilitate lock off for hands free work, and typically more rope routing options.

The 8 is one of many plate belay devices, that is to say, a device machined from a single solid metal plate. Many offer a reliable and flexible function in a simple device. A simple plate may essentially be two connected rings with two center slots (image below). Ropes can be threaded in multiple ways to provide the desired level of friction. They are popular with alpinists and some rescue squads because they can easily work in multiple rappel and belay configurations as well as 'guide mode', configured to lock automatically in case of a fall.

In rescue operations, any belay mechanism must provide default braking action if the operating rescuer is distracted or disabled. This is often called the 'whistle test', meaning that if a hypothetical whistle were blow and all rescuers suddenly just stopped, the patient would remain safe. The intent is to protect against any possible unanticipated complication. If a rescuer slips, is caught by a rockslide, a bee sting, a falling branch, syncope, or any unforeseen distraction, the patient remains safe, and the rescue is uncompromised.

Descent Control Devices

Given the special requirements and challenges of technical rescues, often more specialized devices are required. These more robust friction brakes, commonly called descent control devices (DCD), have been designed to handle the high loads associated with technical rescues. As an example, the Conterra SCARAB incorporates a sturdy center cross bar, and offers a durable and reliable descent for single or twin ropework (left image below). It offers easy braking and tie off, an essential feature for rescue work. Alternatively, open frame racks, such as the CMC Rescue Rack (right image below), uses multiple cross bars to provide controlled application of friction and reliable braking for hefty loads. Since the rope is not subject to tight friction turns, the rack also produces less rope wear, and friction can be adjusted while under load by adding or removing bars. The capacity to change the friction while the device is under load is a key advantage of the rappel rack. This capacity can be essential when rappelling

rescuers take a trapped victim on their rigging, called a pick off. Load on the rope doubles in that instance.

Variations on these DCDs and many other alternatives exist, each with its own advantages. Such devices are essential to the safe and precise controlled descent of heavy litters and equipment. However, these devices are heftier than a simple super 8 or ATC, so they are not commonly used by climbers. And they can easily be improperly used and so are appropriate only for experience and trained operators.

Mechanical DCDs can incorporate an inertia reel and cam mechanism that will automatically lock the decent in case of a fall. Importantly, this allows panic-proof decent of an inexperienced, sick or injured patient. While relatively heavy, and not always popular with climbers, their reliability, flexibility, and robustness have clear benefits for rescue work. There are many devices available, all with their own merits. As an example, the CMC Rescue Clutch or the Multi-Purpose Device (MPD) offer multiple capacities in one piece of hardware (top images). The MPD can serve as a high-efficiency pulley, DCD and a belay device with a 'parking brake' (orange center knob) and a release handle (orange lever). Alternatively, the Petzl I'D is a self-braking descender with anti-panic function and easy rope installation (left lower image). And the Wild Country Revo Belay Device is a lightweight device that promises fool-proof loading and panic-proof braking (right lower image).

Image: CMC

Image: USMC Mountain Warfare School

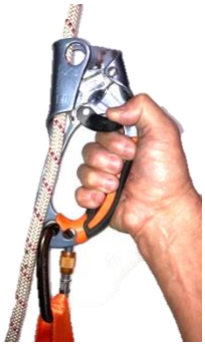
Specialized Hardware

An array of additional specialized hardware can be helpful in backcountry rescue operations. While most of it cannot be covered here, a few are worth mentioning. First is pulleys (center image). While slip connections are frequently made with carabiners alone in climbing, there are times when a lower friction pulley is preferable. These lightweight devices can allow a low friction redirection of a rope around obstacles; or it can be used to gain mechanical advantage, as is often necessary in complex extrications. Some include a rope clamp that allows the device to be lock in place, or a ratcheting mode that allows movement only in one direction. This can facilitate the lifting of loads, extrication through tight or complex spaces, as well as self-rescue.

A related device is an ascender. This cam device can allow one-way slip on a rope with a directional cam lock. This can allow connection to a safety rope when covering steep terrain; it can enable self-belay, or even allow a rescuer's short ascension up a vertical rope when coupled with a second ascender or a Prusik cord. The use of two ascenders for safety is recommended for steep or high angles or when falls are likely. Handled lanyard ascenders (left image below) are common in climbing as they offer increased freedom of movement, while chest ascenders that connect directly to a harness are more frequently used in rescue as they provide improved stability and rope glide.

Anchors are also key components of a technical rope rescue. Besides natural anchors such as trees and rocks, common artificial anchors include nuts and cams. Both of these devices are

designed to be jammed into craigs, seams and cracks to create a secure hold (right image below). Pitons, on the other hand, are metal spikes driven into the rockface to produce an anchor point.



HARNESSES AND SLINGS

Technical rope rescue clearly relies on a secure and safe connection with the rescuer and the rescued, and this is provided with a harness. Many years ago a climbing harness was just a thick leather belt. Current climbing harnesses come in many forms. But all generally include a wide secure belt with a reliable buckling mechanism, a strong hitching point, and leg straps to distribute pressure and stop the harness from riding up the torso. These are lightweight, easy to use and secure. So they are universally used in climbing. Seat harnesses are identified as Class 2 harnesses. Those designed specifically for victim rescue differ slightly from typical climbing gear in that they prioritize comfort and are not designed to absorb high shock from a long fall. Typically, they have wide padded back straps and double back buckles. A chest harness can be added to a seat rescue harness to distributed compression and shock force more evenly.

Alternatively, a full body harness, or Class 3 harness, integrates straps over the shoulders, defining a much more substantial harness, thus distributing support and fall arrest forces over five areas: thighs, pelvis, waist, chest, and shoulders. Both rescuers and the rescued can use a full rescue harness, as they offer greater strength, durability, and certainty in conditions where hazards are common and the possibility of a fall is high. They also allow far greater flexibility of use, as they typically have multiple anchor points, allowing the wearer to quickly reconfigure, from lowering themselves to lowering another person or attaching to an anchor or equipment. And they generally offer good mobility. The additional strapping ensures that the harness cannot come off inadvertently and the rescued are less likely to hang sideways if they panic or lose consciousness. They also provide a greater sense of security for an anxious victim than a seat harness. Because the patient is held more upright, a full harness can be useful when pulling a victim up through a narrow opening, such as a cave, crevasse, or hole. it is worth noting that similar systems are often used as fall arrest devices in industry, called five-point harnesses. However industrial safety harnesses commonly employ a connection point at the back, to keep the line out of the way while working. A rescue harness will have the primary connection points in the front so a rescuer and victim can face the climbing surface or each other. A more extensive version of the rescue harness, called an LSP, offers a padded full body harness with integrated

half-back immobilizer and head support. Keep in mind that ideally a rescue harness should be able to be fitted easily on an injured patient and in a confined space, without requiring that the wearer step into the harness.

STUDY QUESTIONS

1. The four steps in Search and Rescue are represented by the L.A.S.T. mnemonic, which stands for what?

2. In rescue operations terrain that is difficult to navigate because of steepness, obstacles, unstable terrain, or other challenges is usually referred to as what?

3. High angle terrain is typically identified as having a slope greater than?

4. The use of ropes, harnesses, and friction to enable one person to provide a safety tether or backup as someone climbs or descends technical terrain is called?

5. The most common material used for mountaineering rope is

6. You need to secure a tarp that is protecting an unstable patient from wind. However, you want to be able to release the tarp if fast access or movement of the patient becomes necessary very quickly. What would be a ‘good knot?

7. You need to use a basic D ring as a belaying device to lower equipment down a rock face. Which hitch would work best?

8. You need to run a taught rope across a river to provide a secure safety line for injured hikers with compromised mobility. Which knot or hitch would best allow you to ensure a taught line?

9. Which knot would best be used to connect two similar ropes semi-permanently under a high tension use?

10. You need to rappel down a 40-foot (10 meter) sheer face to access an injured climber. Which rope would be your best choice?

8. Rescue Patient Packaging and Transport

Sick and injured patients who cannot safely ambulate are typically transported in stretchers designed for use in wilderness settings. However, when professional rescue is not available or will take too long, a group self-evacuation may be indicated; and this may require the fabrication of an improvised stretcher with whatever materials are available. This chapter will review the basic characteristics of commercial patient packaging and transport options, the improvised possibilities necessary for emergent self-evacuation, as well as some of the key concerns and priorities in patient packaging for both possibilities.

Regardless of the mechanism used, when a patient is transported, key concerns should be addressed. The first priority, of course, is that a patient be well protected and secure. Avoiding additional injury is always primary. To this end, ensuring that a patient is fastened longitudinally as well as laterally is important when moving over technical or steep landscapes. Commercially made litters typically have purpose-built straps for securing the patient, and pads to assist with comfort, protection and immobilization. However, frequently additional padding and securing straps, typically called lashing, are required. At the same time, the need to preserve quick access to the patient for ongoing assessment or emergency care must be considered. And, of course, padding for patient comfort, security, warmth, cervical spine precautions and any required immobilization must be provided, as well as protection from environmental conditions.

Whether using a commercial litter of a makeshift alternative, the choice of transport method, as well as any modifications and adjustments to that method, should be made to accommodate the nature of the patient's injuries, and with several key factors in mind:

- Assure cervical spine protection as needed and address any requirement to immobilize injuries to the axial skeleton and pelvis as a fundamental feature of the packaging and transport plan.
- Seemingly small insults, such as an over-cinched strap or a point pressure, can lead to significant injury over time, and this can seriously degrade a patient's emotional as well as physical condition. So, careful padding and vigilant placement of lashing is important.
- Consider the patient's psychological state. Allowing a patient to see what’s happening and allowing some patient movement, if not contraindicated, can be helpful.
- Identify how to accommodate dressings, splints, or other injuries, particularly immobilized penetrations, femur fractures, and injured extremities, before moving the patient to the stretcher.
- Similarly, consider proper positioning of the patient before the move. Head elevation or an elevated upper body may be indicated for head injuries, pulmonary edema or dyspnea. Consider the rescue position for a patient at risk of vomiting or compromised airway, or modified side position for a patient with a unilateral lung injury. Also consider the potential use of the shock position with slightly bent knees for hypotensive patients. And be mindful of the possibility of vomiting and urination, and the need for drinking.

Patient packaging and the rigging requirements of a litter will vary significantly depending on the category of terrain being faced. However, it is advisable to rig the stretcher securely even in

modest terrain, ensuring an ability to shift, turn, or even flip a litter without injury to the patient, so a stumble or accidental drop by a bearer will not cause significant injury to the patient.

If high angle terrain or a helicopter lift requires suspension of the litter, maintaining a horizontal litter is generally preferable. Keeping the patient close to parallel with level ground will help maintain patient comfort in a supine position. It reduces the risk of injury due to pressure from the lashing and can allow better patient care mid-rescue if needed. It also generally improves control of the litter as well as the rescuers' ability to maneuver a basket stretcher without patient injury.

As mentioned, avoiding the infliction of additional injuries is a top priority. So, protection from debris is essential. Utilize a face shield, a helmet and eye protection whenever available. In an improvised rescue without these items, protective cover can be fashioned from available clothing and gear. Protection from the elements, both hot and cold, including shielding from direct sun, must be addressed. Be sure the patient will be able to drink, if not contraindicated, particularly in hot or dry climates. And ensure rapid access to the patient for reassessment and emergency airway management.

Lastly, as a general concern, it is important to not underestimate the human effort required to evacuate a litter. Ideally, at least four to six rescuers should be available, even for short transports over level terrain. Steep terrain may also require belay while the litter is carried. So, as the terrain gets steeper and more technical, or the transport gets longer, more rescuers will be needed both to ensure a safe and stable movement of the litter across obstacles and to address stretcher bearers' fatigue. On smooth grass, snow or ice, a litter may be skidded or dragged at times; but the normal practice will be to carry the litter. And the litter may need to be passed from rescuer to rescuer across rocks and other obstacles. On high angle technical terrain or over longer distances, more rescuers will be needed to ensure support, provide belay, clear a path, care for the patient, and rotate litter bearers. Keep in mind that a two-rope system with a main line and a belay line is always preferred when ropes are indicated.

RESCUE LITTER (BASKET STRETCHER OR STOKES LITTER)

By far the most common commercial rescue stretcher used for search and rescue is the basket litter, and with good reason. Commonly called a Stokes litter, or simply a Stokes, the design was introduced by Rear Admiral Charles Stokes in the early 20th century for use in the tight confines of hospital ships. The basket design offers good durability as well as protection for the patient, helping to prevent injury during complex extrications and transport over technical terrain. With a ridged tubular metal frame, the Stokes allows easy connection with ropes and carabiners, straightforward securing of a patient for high angle rescues, and ready suspension with specialized bridals. And with new materials and metals, the modern Stokes is much lighter and easier to maneuver than older steel litters.

Image: CMC

Image: Harken Safety and Rescue

Once only available as a basic steel litter, Stokes are now available in multiple configurations. New materials include plastic, steel, aluminum, carbon fiber or even lightweight titanium (right image above). In addition, stokes are available in various dimensions, and with an array of accessories. A stokes can be fitted with skis for snow transport. Floats can be attached to the sides for water rescue. A snowmobile tow bar may be used. Various sorts of ridged polymer shields can be attached to the head end of the litter to ensure patient protection from brush, falling rocks, debris and inclement weather (left image above.). Design options include articulating lift points, modular disassembly, foldability, and integrated padding and contour support.

Image: Harken Safety and Rescue

A litter can also be attached to what is called a litter wheel, or mule wheel. Some units have two or more tires, but a mule is typically a large singular wheel beneath the stokes that allows easier transport on narrow trails (image above). An alternative provides a wide, knobby all-terrain tire that functions well on snow or soft, muddy ground.

A litter handle system can be utilized as well. These extended arms allow rescuers to change handle positions based on the height of the rescuers and varying terrain. This enables the litter to more easily be kept level on inclines and reduces fatigue and chance of injury for rescuers.

The rigid structure of the Stokes allows it to be readily used for aerial hoisting. Specialized bridals can allow both horizontal and vertical lifting. A horizontal bridle provides four or six adjustable straps and a center rigging plate or tri-link to suspend a basket litter from a single point. Each webbing leg provides a carabiner connection point for easy and fast connection and release. A rescuer can be attached above the bridle with a prusik. Alternatively, a bridal for vertical lifts provides two or three webbing point attachments at the head of the litter.

Image: René Kieselmann

Stokes Patient Packaging

The ridged structure and multiple connection points of a stokes makes packaging a patient relatively easy and fast. Numerous straps are typically provided with the litter and multiple additional anchor points around the perimeter readily allow for further lashing. To some degree, packaging requirements depend on whether the stokes will be maintained horizontal or potentially placed at a high angle or vertical. However, as a general rule, it is much better to err on the side of caution and over secure a litter rather than take the risk of a patient fall.

In general, patient packaging in a stokes can be thought of as having two layers, external and internal. These will be discussed in greater detail below. However, in simple terms, internal lashing is aimed at stopping patient slide toward the head or foot of the litter. And external lashing is aimed at preventing the patient from rolling or falling out the side of the stretcher. External lashing is at least begun with the standard straps provided with the litter. This is typically three or more straps across the chest, pelvis, and legs. At a minimum, these straps should be securely connected whenever a patient is moved even a very short distance over level ground. When a patient is carried over potentially hazardous or technical terrain or over longer distanced, additional lashing is indicated. The internal lashing, aimed at preventing longitudinal slipping, is not always necessary. However it must be provided for a vertical lift, and it should also be provided when covering technical terrain, when suspended, when tipping or high angles are possible, when major obstacles are present or expected, or when bearer fatigue is a concern.

There are many methods of packaging a patient in a stokes. To some degree it is a matter of training and preference; and of course, the nature of the patient's injury, weather conditions,

terrain, and other factors may shape packaging methods. Nevertheless, it is useful to review a typical low-angle patient lashing method:

As mentioned, internal lashing should provide bidirectional anchoring of the patient along the longitudinal axis. Often, a full body harness is a preferred tool for securing the patient. However, a simple system of harnessing may be quickly and easily arranged with webbing. This is composed of a shoulder harness to prohibit slide toward the head of the litter and a pelvic harness to arrest slide toward the foot of the litter, assembled in three basic steps:

1. Use a 15-20 foot section of webbing to lay an 18 inch loop of webbing where the patient's head will be, and lay the remaining webbing on either side of the stokes. This will provide the shoulder harness. Similarly, lay webbing at the level of the greater trochanter. And draw an eight-inch bight at the center, later to be drawn between the patient's legs (images below).

2. Lay the patient on the litter over the webbing. Pull the upper loop over the patient's head. Pass each side of the upper webbing under the patient's arms and connect to the loop at the midclavicular line even with the sternum using an overhand knot. Likewise, draw the two ends of the lower webbing around the outer hips and secure to the bight with an overhand knot at both sides, fashioning a pelvic harness. Do not over tighten the straps.

3. Draw the hip webbing upward and secure at the first litter rib superior to the shoulders. Correspondingly, secure the shoulder webbing to the first rib inferior to the patient's hips and secure with a clove hitch.

If desired, foot slings may be easily added by strapping webbing around and under the patient's feet and attaching on either side at an attachment point at or above the knees.

Once inner lashing is complete, outer lashing can be used to add security to the default lateral straps typically attached to a stokes. First, secure all the litter straps as the manufacturer directs. Then thread webbing laterally across ribs at the patient's shins. Criss-cross the webbing upward through subsequent rib anchor points at the level of the patient's thighs,

umbilicus, and sternum. Remove any slack and secure with a hitch (image below). Additional padding, strapping or tape across the forehead may also be required to ensure cervical spine immobilization.

As mentioned, there are a variety of ways to provide both layers of lashing. If a mountaineering or rescue harness is available this can simplify the packaging process. Anchoring with a full harness (Class 3) is ideal and can be accomplished with webbing attached to the harness and anchored to the litter similarly to the above. Or a seat harness (Class 2) can be used, with additional anchoring at the shoulders. In any case, ensure minimal patient movement in the event the stretcher becomes inverted or vertical with secure clove hitches and minimal slack. Keep in mind that overtightening can cause pressure injuries and should be carefully monitored. Be certain to always keep webbing on the inside of the stokes and not over the outside rail, since webbing on the rail is very likely to be compromised by abrasion. Alternatively, as mentioned, multiple commercial patient packaging systems are available and can provide reliable and safe patient protection.

ALTERNATIVE PATIENT TRANSPORT EQUIPMENT

There are an increasing number of alternatives to the basket litter. Each was developed with a particular need in mind, from cave rescue to HazMat evacuation. However, rescue squads are increasingly recognizing the more general utility of these new options. For example, several of these newer stretchers are lighter and packable and so may be appropriate for an expedition that would not want to carry a rigid litter for possible self-evacuation. They may also provide a more easily carried alternative for a fast-moving ground team in rugged terrain. Medical rescuers should be familiar with the basic operation and relative merits of these new alternatives to the ridged basket litter.

Flexible Plastic Litters

Tough, durable polyethylene plastics have allowed for flexible litters that can be made semi-rigid for extrication and transport by curving the sides inward. These litters are basically a large sheet of thick, tough plastic with binding straps, hand holds and grommet attachment points. The plastic sheet can be rolled up tightly for easy carrying and weighs about 30 pounds. And, when evacuating patients, the lateral straps lock the litter into a semi-rigid, curved structure. When locked in place, the litter can be stable enough for helicopter suspension, technical rescue,

vertical lifts, and high angles. With a cross section significantly smaller than a stokes, a flexible litter is preferred for vertical lifting in tight spaces. The wrapped high sides can offer a patient a feeling of security and provides protection during difficult extrications. However, patient comfort requires greater attention in a flexible litter as the sides can cinch in toward the patient and the back support maintains a modest curve. You are, after all, rolling the patient in a piece of hard plastic.

An early developer of a leading plastic litter named their product a Sked, combining skid and sled, since the device is tough enough to be dragged over rough surfaces with minimal damage or slid across ice easily. As a result, this system is also useful for fast evacuation from a hazardous site, as loading a patient and fast dragging can be done by a single rescuer.

Images: Skedco

Packaging a patient in a flexible plastic litter is straightforward but presents some important differences from a basket litter. First, of course, the stretcher should be unrolled, and will frequently require a firm 'reverse roll' to allow it to lay flat. Then open the straps and put the patient in place and centered. Centering requires a bit more attention than in a Stokes where poor patient position is more obvious. Once the lateral straps are connected, the stretcher becomes firm. Do not tighten these too tight, as tightly curved sides can cause patient discomfort and interfere with the placement of a bridle or harness connection. Some rescuers use a backboard even if not indicated for spinal injury, as this can reduce side intrusion on the patient and provide additional protection when sliding over rough surfaces. To provide longitudinal anchoring, the

foot and head of the Sked are curled up and secured, providing a barrier to patient movement. Bulk padding under the feet can help address any awkward upward push on the toes. Similarly, a helmet is particularly desirable with these litters, as the upper curve can push against the patient's head. Outer lashing is then completed with a single run of rope through the grommets from head to toe. This can be done more tightly if required for narrow passages but should not tightly press against the patient unnecessarily.

There are now multiple manufacturers of similar systems, each with their particular attributes. The maker of the Traverse Rescue Stretcher, for example, wraps the ridged plastic structure in a tough outer fabric shell. This allows for more integrated straps, harness and padding for full restraint of patient movement and easier packaging. Similarly, the maker of the Rite Rescue System incorporates a fixed inner harness system and color coordinated anchor points that allow patient packaging in a matter of minutes. While this system is designed specifically for firefighter rescue, the ease of deployment of such systems may make similar products more common in future backcountry rescue.

Vacuum Stretcher (Vacuum Spine Board, VSB)

The vacuum stretcher is a relatively new device that offers a combination of lightweight packability and durability with reliable MSK and cervical-spine immobilization. The basic product is a thin mattress composed of a tough and thick polymer outer shell and a fill of loose polystyrene beads that are contained in multiple independent chambers so they remain evenly dispersed. When not deployed, the mattress is floppy and foldable, as the beads are free to circulate. It can be folded or rolled into a bag and, while a bit bulky, weighs only about 20 pounds including the pump.

Deploying the device is straightforward. Lay the patient out on the loose mattress. The beads will mold themselves to the patient's contours. Pushing the sides of the mattress toward the patient can help mould it for a contoured fit. The air is then pumped out of the mattress through a valve, and the valve is sealed. As a result of the relative pressure difference between the inside and outside of the mattress, the outer shell is pushed in by ambient atmospheric pressure. This squeezes the inner beads together, locking them in place, and creating a rigid supportive mattress that is fitted to the patient's contours. Securing straps and multiple reinforced loop handles on either side allow the device to be used as a rigid litter.

A vacuum mattress offers valuable adaptability for a backcountry rescue team. It enables easy and safe cervical-spine precautions, supports femur traction splinting, facilitates immobilization of any body area, and is compatible with supine, lateral decubitus, rescue position, or most

positions of comfort. So, it can replace the problematic backboard and head blocks, as well as a litter, and offers greater flexibility than a typical Stokes. Testing demonstrates that vacuum mattress cervical immobilization success is similar to a rigid backboard; though the vacuum mattress can offer reduced patient pain and agitation when compared to the conventional backboard. The mattress is Xray translucent and MRI compatible, so the patient can be taken from the backcountry to the radiology department without releasing the immobilization. Initial reluctance by wilderness rescuers to adopt these devices is waning as vacuum mattresses have become more durable, reliable, and lighter.

HELICOPTER LIFT

On uncommon occasions, in high angle terrain, dense tree cover, or over water, landing is not a safe option; and a short helicopter lift is required, often called a short-haul rescue. As noted, this can be accomplished with a basket litter, certain flexible plastic litters as well as some vacuum mattresses. Specialized bridles can be used with each to enable a direct lift. Alternatively, some rescue nets can allow any litter to be placed in a deep, loose net for safe retrieval

In fact, there are many ways to lift victims by helicopter without landing. Rescue harnesses can be used in tight situations, as previously mentioned. For modestly-injured persons, padded rescue rings that fit under the arms and across the back, called rescue strops, are used to allow fast and easy attachment. These can be fitted with additional straps under the legs to provide improved security and position options for the victim. Several rescue slings and seats are also available for helicopter lifts, commonly called screamer suits. While these slings vary, they are typically triangular or rectangular heavy fabric with security straps. They ideally place the victim in a reclined, deep-seated position so they have low possibility of falling out. However, they generally do not easily accommodate cervical-spine precautions or splints.


Image: ROK Armed Forces

A helicopter rescue basket or basket litter can provide a more protected and secure helicopter ascent. Early devices, such as the so-called Sproule Net (think of a large half circle butterfly net) were designed to scoop an unconscious victim out of the water. More recently, larger baskets have emerged that allow up to five people to be lifted out of danger, a great benefit when evacuating people from an encroaching fire or sinking boat. However, the more common rescue basket is a simple rigid, high sided basket with overhead suspension. It is durable, easy to use, and can handle one or two seated persons. The use is intuitive; and with attached floats, they are excellent for water rescue, when an uninjured victim can climb or be placed into a floating basket. Some rescue nets offer improved versatility. For example, the Billy Pugh rescue net is adjustable, and can provide an easily entered deep seated position for a responsive victim; or it

can be laid flat to accommodate a stretcher or backboard without removing the patient or releasing immobilization (right image).

Rescue Bags offer performance similar to a net or basket, but with enhanced patient protection in a more expedient and lighter package. In simple terms, this system is a durable, reinforced canvas enclosure that can accommodate a litter, backboard, or vacuum mattress. Notable advantages over an open stokes include patient protection from wind, rain and debris, as well as integrated webbing, connection points and bridals, and room for an oxygen bottle, mattress, and other equipment in a single package. A semi-rigid head box preserves patient comfort (smaller fully ridged systems are available for pediatric patients). Operationally, because it can be folded, a rescue bag requires less room in a helicopter, and can offer improved penetration and less risk of entanglement through tight canopies. When combined with drag stabilizers, a rescue bag can also help address a significant challenge in air rescue: spin of the litter due to the helicopter's propwash that can at times become severe and induce patient nausea.

Image: Air Rescue Extraction System (ARES)

IMPROVISED PATIENT PACKAGING AND MOVEMENT

Frequently, in wilderness medicine, creativity and improvisation are necessary. A commercial rescue device is almost always preferable for patient moves and should be used when available. However, the responders in a rescue scenario may not always be fully equipped, and in a partial or complete self-evacuation little or no rescue equipment may be available. So, when no commercial system is available, a patient may need to be moved with whatever innovative methods and materials are available. When covering a longer distance, for evacuation to a road, landing zone, or trail, the fabrication of an improvised stretcher is necessary (see below). However, for a short distance, or urgent escape from a dangerous or unstable situation, an emergency carry or drag may be required. Similarly, even in a low-urgency situation, you may need to move a sick or injured person a relatively short distance, with whatever method you have that makes movement possible and adequately protects the patient. This might include using a backpack as a makeshift stretcher to get back to a trail, perhaps a rope sling for a short carry down a path, or another quick improvisation. The options below can be used to provide relatively safe, stable, and effective moves urgently when the patient faces an immediate threat, or less-urgently, when professional rescue is delayed or not an option.

QUICK CARRIES

When the urgent move of a nonambulatory patient must occur due to an encroaching hazard, and proper equipment is not available, a sick or injured person can be moved with a drag or carry. These techniques are intended for urgent situations. Maintaining needed cervical immobilization, bleeding control, and general care to not aggravate existing injuries or cause further harm should be considerations when deliberating a drag or carry; however, when large rocks are rolling your way, the greater immediate danger may require a fast and rough move. These techniques are typically not adequate for movement greater than 30 meters or so. They are meant to move a nonambulatory patient when:

- There is an encroaching hazard that required immediate relocation.
- The victim cannot move under their own power.
- The immediate threat seems to exceed the possibility that grave injuries will be worsened by a move.
- The safety of the rescuer will not be seriously jeopardized by the move.

The ability to perform a carry is similarly defined by multiple factors, including:

- Scene conditions and safety
- The strength and fitness of the rescuers
- The number of rescuers
- The size and condition of the patient
- The nature of the injury
- The nature of the terrain and distance

Blanket Drag

When a sheet, blanket, tarp, or tent is available and the terrain is relatively smooth and flat, a blanket drag may be a good option (right image). It has the advantage of allowing the patient to remain lying down; and pulling along the longitudinal axis is less likely to aggravate a MSK injury. Tie a quick knot at the patient's feet and wrap the sides of the blanket over the patient so they are less likely to slide off during the drag. A smaller rescuer attempting to move a larger patient may choose to remain kneeling to avoid back injury and provide greater pulling force. If a blanket, tarp, or sleeping pad is not available, a patient can be dragged by their shoulders or clothes in the same manner, or less preferably, by their ankles if necessary.

Fireman's Drag and Fireman’s Carry

A fireman’s drag, also called a neck drag, may be necessary to allow a quick and rough move of a patient out of immediate danger. If a patient cannot cooperate by linking hands around the rescuer's neck, the patient's hands can be quickly tied together with webbing, caveat, a belt, or other available material. Movement will be slower than a blanket drag, as the rescuer is crawling. However, the strength required is low and no blanket is required.

A classic fireman's carry, on the other hand, requires hoisting a patient over the rescuer’s shoulder and holding the patent’s leg and arm with one hand to allow a free hand to the rescuer and a standing posture. This allows for a faster patient move over rough terrain and through obstacles. However, there are several disadvantages that should be considered prior to attempting this maneuver: This carry requires considerable strength and familiarity with the technique. In additionally, MSK injuries can be aggravated, particularly if the maneuver is poorly executed or the patient or rescuer falls. The fireman's carry also presents risk for the rescuer, most notably back injury. If an immediate move through obstacles is needed, and the rescuer has sufficient capacity, this maneuver can save lives. However, if other options are viable, they should be considered first.

Wheelbarrow Carry

A wheelbarrow carry is a more certain and stable method of moving a patient when multiple rescuers are available, and the patient is able to cooperate and has no shoulder injury. The patient places an arm over the shoulders of a rescuer on either side. The patient is then lifted to their feet (if unable to stand), and a third rescuer lifts the patient's legs over their shoulders. Like the fireman's carry, this maneuver allows faster movement over rough terrain. However, it requires less strength from the rescuers, it can provide somewhat improved stability for the patient, and it can allow for longer transport distances before rescuer exhaustion. With multiple rescuers taking turns, this method is very effective and stable, and can be used to move a victim a considerable distance without having to fabricate a litter.

Pole carry (Stick Carry, Ice Ax Carry, etc)

The pole carry maneuver requires two rescuers with backpacks and a long shaft that can be suspended between the two packs to create a seat. The shaft could be ski poles, hiking poles, or straight tree branches. Simply place the poles at the base of the shoulder strap or crest of the hip

straps on the packs of two side-by-side rescuers. To ensure that whatever shafts are used have adequate combined strength, place an uninjured person on the seat first and bounce a bit. Then, rescuers can squat slightly while maintaining a straight back and allow the injured person to get in position, placing an arm over each rescuer's shoulder for stability. This maneuver can allow for longer transports, depending on the fitness of the rescuers and size of the patient of course.

Backpack Carry

There are many ways to fabricate a sling that can allow a patient to be carried like a backpack. One simple method that may be viable for a smaller patient is to open or cut leg holes and access slots in a large backpack and carry the patient as in a large child carrier on the rescuer's back (ideally patient facing forward). Alternatively, webbing can be used to fashion a sling that fits over the shoulders of a rescuer, and around the legs, hips, or waist of the patient. Multiple wraps should be used if possible, to better distribute the load on the rescuer's shoulders and patient's thighs. Similarly, a large, coiled rope can make an excellent sling, called a rope seat. Simply coil a large rope into a ring of about 6-foot diameter (adjust for patient size). Tie the rope ring at the middle to create a figure 8 of the coil. The patient can then be helped to step into the rope with the middle of the 8 between their legs and each leg through a rope loop. These loops can then be used as shoulder straps by a rescuer to carry the patient. If two rescuers are available, each can place one rope loop over a shoulder, and the patient can sit between the two as in the pole carry.

IMPROVISED STRETCHERS

There are two broad types of improvised stretchers: either a fabricated open stretcher or a so-called cocoon wrap. An open stretcher is most practical with a modestly injury patient, such as a broken foot or mild trauma, that prohibits walking but does not require axial skeleton immobilization. Alternatively, a cocoon wrap is a more secure alternative that can provide acceptable immobilization and support for axial-skeletal or pelvic injuries. A wrap also provides superior patient stability when traversing technical terrain. However, for a modest MSK injury in an awake and alert patient, a full wrap may not be necessary and may increase patient discomfort and anxiety. When unsure which to choose, a cocoon wrap is the safer alternative and should be used unless it is clearly not necessary.

Canvas Litter (Pole-less Litter, Quick Litter, Soft Stretcher)

While not strictly an improvised device, a variation on the simple stretcher is commercially available as a packable, flexible, and light tool for urgent and quick moves. Originally used for in-hospital patient moves, the canvas litter is basically a reinforced canvas sheet, with multiple loop handholds and perhaps security straps (right image). These are principally designed for use by first responders to allow for the fast movement of victims away from a shooter or hazmat incident. However, because these can be easily packed with other medical supplies, they can also serve as an emergency wilderness litter for backcountry groups and expeditions. While rudimentary, this device can provide a ready means for emergency transport on gentle terrain. For example, packing a canvas litter might be ideal for a Scout troop, where an injury would be likely to be a small patient with a twisted ankle that needs to be transported a short distance over

a well-groomed trail. Obviously, these litters offer little support for the patient, make cervical spine precautions difficult (but not impossible), and provide little protection from hazards during transport. However, they will facilitate short moves of the sick or injured away from danger; and they typically weigh about a pound. So, they can be worth adding to a group medical kit.

A similar soft stretcher can be easily fabricated from typical backcountry materials, if a commercial device was not packed. Simply tie webbing with a hitch at four, six, or eight locations around a blanket, tarp or tent footprint. Ideally, stuff a sock, T-shirt or hat into the section of blanket before you tie it off so the hitch will not slip off (image).

Improvised Stretcher

In its simplest form, a stretcher has only two essential components: two poles and a bed suspended between them. There are many ways to assemble a similar device with backcountry materials. The poles may be tree branches, skis, bundled trekking poles, or any other adequate-length item with acceptable strength. And the bed can be made of duct tape, rope, clothing, a tarp, or a combination of the these. It may be preferable to include two supporting cross members at the head and the foot. This will ensure that the stretcher poles are not drawn together by the patient's weight and can make carrying easier. Cross members can be attached with duct tape, paracord, or strips of clothing.

An improvised stretcher can be adjusted to suit the patient and the injury. Typically, the length should be at least the distance from the patient's feet to their hands when arms are extended above their head. The width should be about six inches more than the widest part of the patient (shoulders or hips). Do not make the stretcher unnecessarily wide, as this will make securing the patient more difficult and it may inhibit movement through tight brush or narrow trails.

There are countless models and ideas for improvised stretchers. Some are reasonable, others less so. There is no single best option. Instead, the technique chosen will depend greatly on the materials available. Some of the more workable alternatives are listed below. However, these are not exhaustive of all possibilities, and they are not mutually exclusive; a workable stretcher may combine elements of several models. So, these examples are meant to simply spark creative thinking. The best materials for an improvised stretcher are the materials you have.

Common improvised litters may include the following:

Tarp stretcher: Suspending a tarp between two poles by folding over the two sides or rolling the tarp around the poles. The tarp will hold relatively well with friction; however, duct tape or webbing can help reduce slipping.

Clothing (jacket) stretcher: Place the poles through the arm holes of 3-4 jackets, T shirts, sweaters, or other clothing of proper size. Make sure zippers are zipped and buttons are secured. Sleeves can be inverted into the coat to allow a closer fit of multiple garments. Apply tension by subsequently fixing cross members. Ensure adequate strength if necessary by bunching the shirts or sweaters at the ends so several may be used. Two or three T shirts will likely not provide reliable strength for a larger patient. A wider sleeping bag can be used similarly to clothing to create a bed between two poles. If two sleeping bags can be zipped together, do so to make a wider bed.

Rope stretcher: Wrap a rope in alternating directions around two polls. Space the poles a bit wide since they will be pulled together when the rope is made taut. It is easiest to initially thread the rope into place loosely with the cross members already secured then tighten, rather than attempting to maintain a taut line while wrapping the rope. Double wrapping the rope periodically or securing regular hitches will help maintain even tautness.

Duct Tape Stretcher. Duct tape is exceptionally useful for securing cross members or reinforcing the bed. You are unlikely to have enough duct tape in the backcountry to complete a full stretcher bed. However, a stable frame can be fabricated with tape; then cordage, webbing, clothing or tarps can be used to complete the bed.

Creativity is key. Again, these ideas are not exclusive; and a hybrid may offer the best option. For example, a clothing or sleeping bag stretcher can be reinforced with duct tape at the ends to take pressure off the zippers. Remember to evaluate your stretcher carefully and ensure it provides a safe and comfortable bed for your patient. Whenever possible, after the fabrication of the improvised litter is complete, test it with an uninjured volunteer to be sure it is stable, adequately strong, and reasonably comfortable. Make needed adjustments before moving to the injured patient. Remember to consider cervical spine precautions both when moving the patient to the stretcher and during transport. A backpack can be used as a short backboard for moving or positioning a patient. And a sleeping pad or jacket can make an adequate cervical collar.

Several additions can improve an improvised stretcher when time and supplies allow. For improved lateral stability, consider diagonal crisscrossed tape or cord under the bed to help address skewing of the poles. Securing the patient to the stretcher may rely on backpack straps,

belts, cravats, clothing or other available materials. Insulation should be used to ensure patient comfort, protect from injury, provide needed support, and shield from the elements. Blankets, towels, clothing, sleeping bags can be carefully packed around the patient, using straps and tape to provide security.

Adding carry loops for stretcher bearers can make a big difference. It is difficult and fatiguing to carry a stretcher using the extended poles as handles. Secure webbing at four, six or, eight locations around the stretcher to simplify carrying, facilitate handoffs over obstacles, and to allow easier rotation of bearers. Connection points for rope belay may also be necessary, depending on terrain and conditions. And further modification to the basic design may be needed to allow a stretcher to be dragged, slid on ice, secured to backpacks, or whatever else may be required. The basic rule is simple: Be creative and use what you have to make what you need.

Rescue Wrap (Cocoon wrap)

As discussed, when a patient requires axial skeletal or pelvic stabilization, a wrap should be favored over an open stretcher. While the greater patient mobility offered by an open stretcher can be an asset for a moderately inured and alert nonambulatory patient, for a patient with significant injury, possible cervical injury, or compromised mentation, a wrap is strongly preferred. In general, the wrap provides stability, improved patient protection, and easier transport, particularly over technical terrain or narrow trails. It is notable that the use of a wrap to provide a full body splint is not novel to wilderness medicine. For example, the Neil Robertson stretcher (image) was designed in the early twentieth century to facilitate patient moves in tight spaces. The classic design is a multi-leafed cotton canvas wrap reinforced with multiple short wood shafts at the back, neck, and legs. This is very similar to a rescue wrap and is still widely used in maritime rescue. It is clear that enveloping a patient in a full body splint can offer good security and immobilization for transport.

Like a splint, wrap should be designed or modified to suit patient injuries. The wrap can be made lighter in warm climates or if hyperthermia is suspected. Extra insulation can be used if hypothermia is suspected or feared during transport. Supporting members can be adjusted for position and size as indicated. Hand loops can be added. Poles can be used to carry the patient across flat or low angle terrain, and easily removed when cumbersome.

The basic method of a cocoon wrap is straightforward:

1. String a rope in a zig-zag pattern on the ground. Keep about six inches between each lateral run. This will be the outer tie of the cocoon. The width should be a bit larger than the circumference of the patient, typically around 3 or more feet. The width may be smaller inferiorly, since the legs have a smaller diameter; but too wide is better than too narrow.
2. Lay a tarp, tent footprint, or other protective sheet over the ropes. This will provide protection from water and debris, and generally help hold the wrap together.

3. If spinal immobilization is indicated, use stiff items to provide a supportive bed. These can be walking sticks, canoe oars, perhaps skis with the bindings facing outward, an empty backpack, a collection of straight branches, bamboo shoots, or a combination of similar items.
4. Lay a protective padded layer over the supportive items. Sleeping pads are ideal. Clothing, a tent or bivvy bag, or other items can be made to work. Be sure to avoid protrusions as they can cause painful injuries to the patient over time.
5. Lay the patient in the bed. Ensure cervical support if indicated, as well as accommodations for injuries or splints. In cold weather or when hypothermia is a concern, wrap the patient in insulative layers. Sleeping bags are ideal.
6. Wrap the tarp over the patient, forming a secure but not too restrictive 'burrito'.
7. Use the rope to lace up and secure the wrap. Begin at the feet with a hitch then lace each subsequent bight, alternating right and left, until complete. Secure with a hitch at the top.
8. Consider attaching webbing loops to the ropes to facilitate carry, or one or more poles through the top of the rope to allow portage. However, watch for possible pressure injuries throughout the transport.

Like any medical treatment, patient packaging must be adjusted to suit the patient's condition. Whichever method is used, stretcher or wrap, several factors should be considered as the device is fabricated and the transport plan is set:

- Ensuring support for any indicated immobilization, and generally stability and support for the entire body, is a primary concern.
- Consider the need to accommodate injuries, such as penetrating objects, tourniquets, and splints. This may require a modification of the wrap technique.
- Seemingly minor discomforts can build to significant injuries during a rough transport. So, ensuring patient comfort by avoiding protruding features and possibly allowing a slight bend at the knees is important.
- Protection from further injury with an even, flat bed and adequate padding is essential (sleeping pads are excellent). A hastily assembled bed is more likely to shift during transport.
- Consider the need for quick access to the patient for reassessment or emergencies. So wrap hitches should be secure, but capable of fast removal.
- Recognize environmental conditions. Provide protection from rain or cold, and avoid excess insulation in hot weather.
- Plan for contingencies such as vomiting or compromised airway, urination, and patient hydration.
- Consider the patient's mental state. Ensuring the patient can see around them and accommodating some mobility or even handholds to allow the patient appropriate security for modest movement, when not contraindicated, can help greatly.