PART 14

Unique Populations and Considerations

CHAPTER 91

Children in the Wilderness

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Once the realm of a few adventurous individuals, the wilderness today attracts an ever-broader range of explorers. This includes many in the pediatric age group, as parents seek to share the joys and lessons of wilderness travel with their children. In 2014, of the more than 45 million people participating in backpacking and camping, nearly 27% were younger than 18 years old.[75] Millions of children annually visit national parks and recreation areas.

Wilderness travel with children requires special preparation and places extra demands on parents. However, it also affords unique opportunities. Parents and children interact in a setting distant from the stresses of work and school. Isolated from the distractions of television and modern life, children experience new environments, interact with individuals of different cultural heritages, and participate in activities that enrich their lives. They learn to appreciate the beauty and delicate nature of the wilderness. These activities also bring families together as they learn to rely on one another for support and entertainment.

Physicians and other health care professionals can encourage and facilitate such undertakings by providing preventive health and treatment guidelines for families planning wilderness travel with children. This chapter focuses on how children differ from adults and how to prevent, recognize, and treat the medical problems children are likely to encounter in wilderness settings.

Wilderness travel may also involve travel to foreign countries. The number of families traveling outside the United States, particularly to developing countries, is on the rise, as is the number of families relocating abroad for prolonged periods. This chapter reviews risk avoidance techniques during travel, pediatric travel immunizations and prophylaxis, common pediatric medical problems seen during travel to and within developing countries, and specific issues that arise in children with chronic medical conditions.

WHAT MAKES CHILDREN DIFFERENT?

SIZE AND SHAPE

Children are distinct from adults in physical, physiologic, and psychological ways. The most obvious difference is size. During development, children may grow from the average 3-kg baby to a 60-kg adolescent, a 20-fold difference. Accordingly, medications and fluids must be calculated on an individual basis, based on the weight of the child. Table 91-1 lists average weights for age.

This variation in size also influences a child's risk of developing serious complications from envenomations. Many snakes, spiders, scorpions, and poisonous marine animals deliver the same dose of venom regardless of the victim size. Children often experience greater toxicity because of an increased dose of venom per kilogram of body weight.

Children have a larger surface area–to–body mass ratio than do adults. For example, a 3-kg infant has 2.5 times more body surface area per unit of weight than a 60-kg adult. The head, which is the part of the body most often left exposed, also takes up a larger proportion of the child's body (Figure 91-1). As a result, children experience greater exposure to environmental factors, such as cold, heat, and solar radiation. They are also more likely to suffer toxic effects from topical agents, such as medications.

MUSCULOSKELETAL SYSTEM

The musculoskeletal system in children differs from that in adults in several important ways. A child nearly doubles in height between birth and 2 years, and again between 2 and 18 years. In some respects, this rapid growth makes a child's bones much more flexible and forgiving. Because of the active osteogenic potential of the periosteum, nonunion or permanent angulation deformities at the metaphysis are unusual in children. For the same reason, fractures in the pediatric population heal quite rapidly. For example, a fractured femur typically heals in 3 weeks in a newborn, compared with 20 weeks in a 20-year-old. The strong, pliable periosteum also allows for greenstick and buckle fractures, which are not seen in the adult population. These fractures with their intact periosteum are quite stable, with little swelling or crepitus. If nondisplaced, they are often incorrectly dismissed as sprains.

Another key difference between the musculoskeletal systems of children and adults is that children have an open growth plate, or physis, at the ends of long bones. The physis connects the metaphysis to the epiphysis and consists of soft cartilaginous cells that have the consistency of rubber and act as shock absorbers (Figure 91-2). They protect the joint surfaces from suffering the grossly comminuted fractures seen in adults. However, because the growth plate is more vulnerable to injury than are the strong ligaments or capsular tissues that attach to the epiphysis, a true sprain in a child is rare. Any significant juxtaarticular tenderness in a child should be assumed to be a growth plate injury and immobilized accordingly. Such an injury is most common at the ankle (lateral malleolus), knee (distal femur), and wrist (distal radius). Physeal fractures have been classified into five Salter-Harris groups (see Figure 91-2). Salter-Harris I and II fractures generally heal without complications. Salter-Harris III and IV fractures often require open reduction of displacement to realign the joint and growth plates and to permit normal growth. A Salter-Harris V fracture has a poor prognosis; impaction and crushing of some or all of the growth plate may result in a bony bridge that inhibits further growth or causes unequal, angulated growth. Consequently, any significant injury, especially if it involves the growth plate, requires full evaluation in a medical facility.

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

Basic physiologic parameters change greatly during the transitions from infancy to childhood to adulthood. Recognizing these differences is important to avoid unnecessary and potentially harmful interventions in healthy children, and to intervene aggressively when abnormal vital signs are truly present. For example, a blood pressure of 70/35 mm Hg, pulse rate of 160 beats/min, and respiratory rate of 50 breaths/min are considered ominous vital signs for an adult. However, these vital signs are normal in a 2-month-old infant. Although blood pressure readings may not be available in a wilderness setting, it is possible to assess the general appearance, work of breathing, respiratory rate, pulse, peripheral circulation, and mental status of an ill child. These observations can accurately predict how sick a child is. In general, infants and children have higher respiratory and heart rates and lower blood pressures than do adults. The normal values for various age groups are presented in Table 91-2. It is important to note that children can often maintain a normal blood pressure in the face of significant fluid or blood losses (30% to

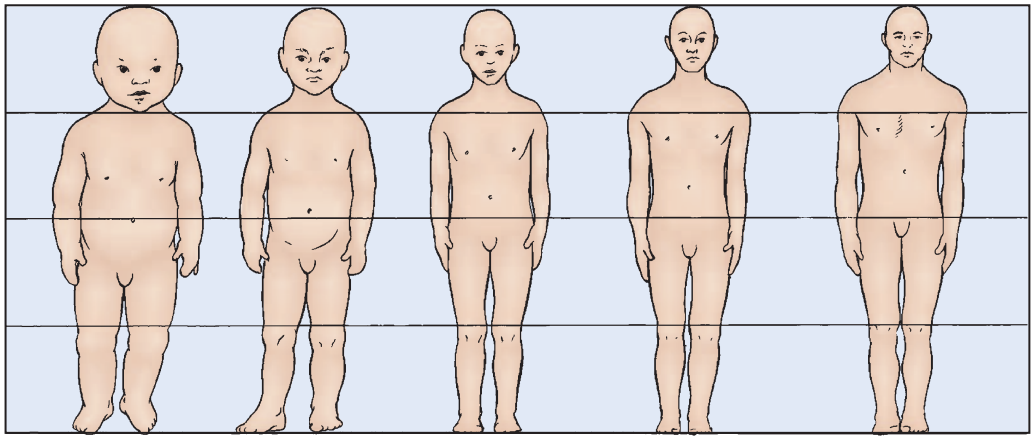

FIGURE 91-1 Body proportions.

TABLE 91-1 Average Weight for Age

Age	Weight	
yr	kg	lb
1	10	22
3	15	33
6	20	44
8	25	55
9	30	66
11	35	77
13	45	100

From U.S. Centers for Disease Control and Prevention National Center for Health Statistics: cdc.gov/nchs.

40% of total blood volume). Once the blood pressure drops, children can deteriorate very rapidly. Therefore, prompt and aggressive fluid resuscitation is essential when other signs of dehydration or volume loss (e.g., tachycardia, increased capillary refill time, cool extremities, poor urine output, decreased mental status) are present.

THERMOREGULATION

Because environmental extremes are often encountered when traveling in wilderness areas, it is important to recognize that thermoregulation is less efficient in children than in adults. A number of physiologic and morphologic differences make children more susceptible than adults to heat illness. During exercise, children generate more metabolic heat per unit of mass than do adults. Children also have a lower cardiac output at a given metabolic rate, resulting in a lower capacity to convey heat from the body core to the periphery. Because they have a larger surface area–to–body mass ratio, children also gain heat more rapidly from the environment than do adults when ambient temperature exceeds skin temperature. In hot environments, cooling from conduction, convection, and radiation ceases to be effective, leaving evaporation (sweating) as the only effective means of heat dissipation. Unfortunately, children have a lower capacity for evaporative cooling, likely because of decreased sweat volume, regional differences in sweat patterns, and a higher sweat point (the rectal temperature when sweating starts).[55] Finally, children acclimatize to hot environments at a slower rate than do adults.

Children are also at greater risk for hypothermia. Their larger surface area–to–body mass ratio causes them to cool more rapidly than adults in cold environments. Children also have less subcutaneous fat and, therefore, less body insulation. Infants, in particular, have an inefficient shivering mechanism. This makes them particularly vulnerable to cold environments because shivering is the primary means of generating extra heat when humans are

TABLE 91-2 Age-Specific Resting Heart Rate and Respiratory Rate*

Age	Heart Rate (beats/min)	Respiratory Rate (breaths/min)
0-5 mo	140 ± 40	40 ± 12
6-11 mo	135 ± 30	30 ± 10
1-2 yr	120 ± 30	25 ± 8
3-4 yr	110 ± 30	20 ± 6
5-7 yr	100 ± 20	16 ± 5
8-11 yr	90 ± 30	16 ± 4
12-15 yr	80 ± 20	16 ± 3

*Mean rate, ± 2 SD.

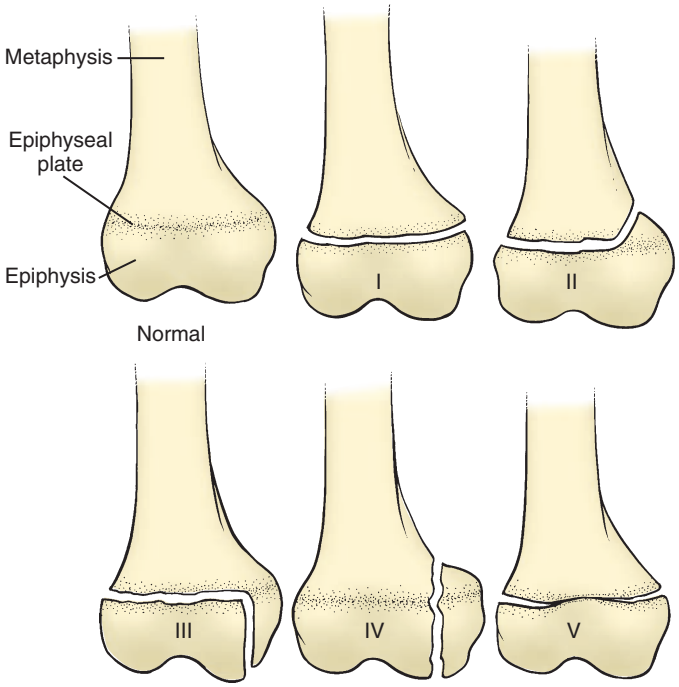

FIGURE 91-2 Salter-Harris classification of physeal fractures (I to V).

cold.[7] In general, humans are poorly adapted for cold environments and must rely on adaptive behavioral responses, such as seeking shelter and dressing appropriately, to maintain body heat. Infants and young children are not capable of these responses and must rely on caregivers to provide shelter and appropriate clothing.

IMMUNOLOGIC SYSTEM AND INFECTIONS

Children experience a greater number of infections than do adults. The average 1-year-old suffers six to eight infections per year, whereas the average adult has only three to four infections per year. Infections in children also tend to be more severe. The younger the child, the more likely it is that a given infection represents a first exposure to a pathogen. A first-exposure infection is more likely to cause fever and produce severe symptoms than is reexposure, in which the infection is attenuated by antibodies produced from the first exposure. Young children are also less likely to have cross-reacting antibodies from previous infections with antigenically related organisms. When present, cross-reacting antibodies serve to attenuate the immunologic response to an infection, thereby mitigating symptom severity.

Many common respiratory bacterial or viral infections tend to produce more severe symptoms in children because of anatomic differences. The pediatric bronchioles, eustachian tubes, and larynx are narrower, and are, therefore, more easily obstructed by edema and mucus. This obstruction worsens symptoms, prolongs clearance of infection, and increases the risk for secondary infection. Pertussis (whooping cough) is a classic example of the difference in severity of infection between children and adults. Nearly 20% of infants with pertussis have severe complications, such as apnea, pneumonia, seizures, or encephalopathy. In contrast, adult pertussis, although a common cause of chronic cough, is generally indistinguishable from a common cold.

TYPES OF TRAUMATIC INJURIES

Blunt trauma is the leading cause of disorders and death in children ages 1 to 18 years. Closed head injuries are responsible for 80% of pediatric trauma deaths.[58] Although pedestrian and motor vehicle accidents are the source of many of these injuries, falls and accidents leading to drowning are close behind. Children differ from adults in their susceptibility to injuries from blunt trauma, and the nature of their injuries differs as well. As a consequence of its smaller size and conical shape, the airway of a child is more prone to obstruction. Obstruction can also occur because of the child's relatively large tongue and floppy epiglottis or the presence of mucus. A child's rib cage is more pliable and hence provides less protection for the lungs; this makes rib fractures uncommon but increases the risk for pulmonary contusion. A child's mediastinum is more mobile, making it more likely that a simple pneumothorax will more rapidly progress to a tension pneumothorax, but less likely that a great vessel injury will occur. Similarly, the abdominal musculature in children is underdeveloped relative to that of adults, leaving the intraabdominal organs, specifically the liver and spleen, more vulnerable to injury. This greater pliability of bone makes pelvic fractures uncommon in children. Even when fractures occur, they rarely result in life-threatening bleeding or genitourinary injury.

The cranium of younger children is softer and hence less protective of the underlying brain. Fortunately, open fontanelles in infants provide a limited pressure buffer for children with intracranial hemorrhage or swelling. The relatively large head size, loose ligaments, poor cervical muscular support, and underdeveloped facets result in a different pattern of cervical spine injuries in children than is seen in adults. Although cervical spine injuries in children are uncommon, when they occur, they tend to be higher in the cervical spine and may involve injuries not visible with conventional radiography or computed tomographic (CT) scanning—thus the acronym SCIWORA, for spinal cord injury without radiographic abnormality. The term SCIWORA is somewhat of a misnomer, however, because although these injuries are not visible on radiograph or CT scan, the vast majority can be visualized with magnetic resonance imaging.

GENERAL CONSIDERATIONS AND EXPECTATIONS FOR CHILDREN IN WILDERNESS TRAVEL

Children of different ages have different needs and abilities. Expectations regarding distances of travel, pace, and safety issues vary depending on age (Table 91-3). This section explores key issues regarding wilderness travel with children of various ages and provides general expectations for each age group.

CHILDREN IN THE FIRST 2 YEARS OF LIFE

Travel Expectations

Because they are typically carried, children in their first 2 years can travel long distances, depending on the adult's hiking abilities. They do, however, place extra demands on their caregivers and require attention and care nearly all of their waking hours. Most children in this age group are content in front carriers (infants of < 6 months) or back carriers (older infants and toddlers weighing < 15 to 20 kg) and can easily travel for hours at a time. However, because of the increased risk of illness and limited communication skills, infants must be watched closely for signs of infection, hypothermia, hyperthermia, and altitude illness. Parents must be prepared to give prompt treatment

TABLE 91-3 Age-Specific Expectations for Wilderness Travel

Age	Expectation	Safety Issues
0-2 years	Distance traveled depends on how far an adult may go with child in carrier	Provide safe play area (e.g., tent floor, extra tarp laid out) for child; put bells on child's shoes; be aware that child may put things found outside in mouth
2-4 years	Child is at a difficult age; child can hike 1-2 miles on own and needs to stop every 15 minutes	Dress child in bright colors; give child a whistle to carry and teach child how to use it (three blows for "I'm lost")
5-7 years	Child can hike 1-3 hours/day and cover 3-4 miles over easy terrain; needs to rest every 30-45 minutes	Child carries a whistle; child can carry own pack with mini–first-aid kid, flashlight, garbage bag, and water
8-9 years	Child can hike a full day at an easy pace and cover 6-7 miles over variable terrain; if child is 1.2 m (> 4 feet) tall, can use framed pack	Same as for age 5-7 years, plus adult can teach child to use a map and find a route; preconditioning can be done by increasing maximal distances by < 10%/week; watch for overuse injuries; keep weight of pack at < 20% of child's body weight
10-12 years	Child can hike a full day at a moderate pace and cover 8-10 miles over variable terrain	Same as for age 8-9 years, plus child can expand role for route planning and can learn to use a compass
Teens	Teen can hike 8-12 miles or more at an adult pace; while growth spurt is occurring, there may be a decrease in teen's pace or distance hiked	Same as for age 10-12 years, plus teen can expand survival and wilderness first-aid knowledge

or evacuate to seek medical attention should signs of serious illness develop. Evacuation plans should be formulated before departure.

Entertainment in this age group is simple. A few small toys (attached to the carrier on a short string), the natural surroundings, and a little parental attention provide ample amusement. A toddler can spend hours examining rocks, leaves, and sticks and rarely tires of a parent's undivided attention. If a child is comforted by a pacifier, it can be attached to the child's shirt or carrier, with extras packed if replacements are needed.

Safety

As babies become more active with rolling, crawling, and then walking, they require constant attention. Bells attached to their shoes may function as an alerting device, ringing when they are on the move. These children often "graze," putting everything they come across into their mouths. When they are not being carried or directly observed, it is best to have a child-proofed area for them to play in, such as a tent floor or an extra tarp. Toxic ingestions are common in this age group, and parents should be vigilant to avoid unwanted objects or plants landing in the child's mouth. Toddlers are often attracted to and fearless of water. Children of this age should never be left unattended near even the smallest streams or ponds because they can drown in even a few inches of water.

Food and Drink

Nourishment in the first 2 years is fairly simple. Infants in their first 4 to 6 months require only breast milk or formula. As long as the mother remains healthy, breastfeeding is the safest and most convenient way to feed an infant. However, if the mother is not nursing or not available, formula may be used. Formula is most conveniently carried in a powdered form and mixed as needed. The water for formula may be boiled or otherwise disinfected once a day and stored in individual bottles with airtight lids. The powder for the formula is added just before feeding. Any unused, reconstituted formula should be discarded after 2 to 3 hours at room temperature.

Baby cereals can be carried conveniently in a dry form to be mixed with formula or breast milk. Dry cereals mixed with breast milk or formula have a higher nutritional value than ready-to-feed cereals in jars. Jars of commercial pureed foods may be carried, but the empty jars must be packed out. Squeeze tubes of infant food are more convenient for all but the shortest ventures. Once a jar or tube of baby food has been opened, it should be used for only that meal. Without refrigeration, opened containers of baby food spoil quickly. Some families prefer to bring a hand grinder and make their own pureed foods.

By age 9 to 12 months, many babies are eating finger foods. Parents should be cautioned to avoid any firm round foods on which a baby may choke, such as peanuts, candies, whole grapes, or hot dogs. Up to 1 year of age, honey should be avoided because of an increased risk of botulism. Parents may also want to avoid citrus fruits, which may cause rashes around the mouth and in the diaper area. Any new food should be tested at home prior to travel to be certain the baby will accept it when away from home.

All water for drinking must be disinfected by boiling, halogenation, ultraviolet light, and/or the use of small-pore/chemical filters, depending on the water source. Chronic iodine poisoning and neonatal goiter have been associated with prolonged ingestion of large amounts of iodine, although small amounts ingested for short-duration water disinfection appear safe. It is worth noting that infants and small children often reject the taste of iodinated water. Iodine must be kept out of reach of small children; severe acute toxicity can occur with an ingestion of just 2 to 4 g. Because of toxicity issues and iodine's limited efficacy against *Cryptosporidium,* boiling, filtering, or ultraviolet (UV) light is the preferred form of water disinfection for infants and small children.

Diapers

Most children under the age of 2 years are in diapers, either disposable or cloth. Soiled diapers in a wilderness environment require special care. Thin paper diaper liners may be purchased to help collect the stool. The stool and liner should be buried in a trench at least 15 cm (6 inches) deep and 60 m (197 feet) from any water source. If disposable diapers are used, they should be packed out after the stool has been removed and buried. The used disposable diaper should be placed in a double bag for packing out. To reduce weight, urine-soaked diapers may be set out in the sun to dry. Avoid superabsorbent diapers, because they often are left on babies much longer than they should be and can lead to serious diaper rash. Also, these diapers cannot be dried out as easily and, consequently, add significant weight for the rest of the trip.

On longer trips, some families prefer to use cloth diapers, which may be washed out and reused. Cloth diapers must be changed more frequently, because they are not as absorbent. Washing cloth diapers is labor intensive, time consuming, and requires an abundant supply of water. A washbasin is needed, and the diapers must be washed in hot soapy water. The diapers should be rinsed at least twice to remove irritating soap residue, and the wastewater dumped where it will not pollute, at least 60 m (197 feet) from any water source.

Equipment

Because infants and young children are not capable of extended hikes, they are typically transported in carriers. Most front carriers work well from infancy until an age when babies can sit fairly well, typically 6 to 9 months (Figure 91-3). It is important that a front carrier extend up high enough in the back to completely support a young baby's head. Once a child is sitting well, back carriers are more comfortable (Figure 91-4). Back carriers function on the same principle as framed backpacks, redistributing the weight off the shoulders and onto the hips. Many back carriers are able to stand alone and can double as a highchair. Children must be strapped into back carriers, because it is easy for a child to be catapulted out of a carrier if the adult bends over or falls.

Sleeping bags are available for infants and toddlers, but should not be used for babies under the age of 1 year to avoid entanglement and possible suffocation. In a warm climate, a sleep sack is a safer alternative for nighttime; in a colder environment, an insulated snowsuit with hood or hat should suffice (Figure 91-5). Avoid placing diaper-clad infants into a sleeping bag with an adult; apart from safety concerns, accidents or a leaky diaper can create very unpleasant sleeping conditions. Children, including young infants, also need their own sleeping pads. Such pads protect them from hard, rough ground under the tent and insulate them from the cold ground.

Shoes for young children should protect their feet and allow for full range of movement. The best shoes for toddlers are lightweight and flexible. They need shoes that stay on well, because children can flip their shoes off while in a carrier. Velcro-strapped shoes stay on well and are easy to put on and take off. Because children often lose shoes, an extra pair should be included.

CHILDREN 2 TO 4 YEARS OF AGE

Travel Expectations

Children 2 to 4 years old are the most challenging to take into the wilderness. Two-year-olds become easily frustrated and throw temper tantrums, often as a result of the collision between adult restrictions and their desires for independence and control. By 2 years of age, children are becoming too heavy to carry for prolonged periods, but they are still incapable of hiking long distances on their own. They are just gaining bladder and bowel control, and accidents are frequent. Despite these difficulties, wilderness trips with this age group can be successful with appropriate planning, preparation, and adjustment of expectations.

A key ingredient to successful wilderness trips with small children is to keep things slow, simple, and flexible. This is the age of independence and assertion. The children need to be given some control and allowed to set a pace. Adults should encourage young children to express their natural curiosity and

FIGURE 91-3 Infants in front carriers. *(Courtesy Judith R. Klein, MD.)*

enthusiasm for the outdoors by letting them stop to explore their surroundings. Parents can enjoy rediscovering nature through the eyes of their children by exploring rocks and tide pools and observing a caterpillar's crawl. Parents should expect to stop at least every 10 to 15 minutes while hiking. If a diversion or a stimulus is needed to get the children hiking again, parents can begin a story or favorite song and continue it while hiking. An alternative for those willing to carry a small electronic device and headphones is an audiobook. Recorded stories are an extremely effective distraction for children in this age group, particularly if the terrain is less interesting or the day longer than expected (Figure 91-6). Overall, with patience and plenty of time, parents can expect children in this age group to travel 1 to 2 miles (1.6 to 3.2 km) under their own power over easy terrain.

Safety

Unfortunately, 2- to 4-year-olds are notorious for exploring the environment either by wandering off or by trying to become a backcountry gourmet. Young children must be watched closely and cautioned to keep wild mushrooms, plants, berries, and other inedible or toxic items out of their mouths. Children should be kept within sight at all times because their desire to explore often defies good judgment and exceeds their physical abilities. Although attacks are rare, mountain lions may view small children as easy prey and can strike quickly. Parents should, therefore, discourage their children from wandering ahead unaccompanied. Toddlers should also be encouraged to step only where they can see (i.e., on top of logs rather than over them) to avoid any unsuspecting reptile or large insect.

When selecting a campsite, dangerous features such as steep drop-offs and fast, deep water should be avoided. Children should be dressed in brightly colored clothing, so they are more easily located if they become lost. As children get older, they may carry a whistle to call for help when they are lost. The standard distress signal is three blows to indicate "I'm lost" or "I need help"; the response is two blows to indicate "help is coming." Parents should teach children to stay put once they discover they are lost and wait to let help come to them. If children panic and start running when they realize they are lost, they increase the chance not only of getting injured but also of traveling farther from the family. The concept of "hug a tree" will be described later in the chapter.

FIGURE 91-4 Toddler in back carrier. *(Courtesy Judith R. Klein, MD.)*

FIGURE 91-5 Infant and toddler sleeping options. *(Courtesy Judith R. Klein, MD.)*

Food

The diet of 2- to 4-year-olds is usually quite simple but very individual. They tend to have strong preferences and dislikes. Unfortunately, many children at this age do not care for the convenient "all-in-one-pot" cooking common around campfires. Foods should be tested at home first to be sure they are acceptable to the child. Nutritious snacks, such as raisins, granola bars, bagels, nut butters, string cheese, and fruit bars, can be packed. These snacks may become a child's meal. Small children should not be given items on which they may choke, such as peanuts, grapes, hard candies, or hot dogs. At least one adult member should be trained in basic cardiopulmonary resuscitation (CPR) and know how to assist a choking child.

Toileting

Most children become toilet trained by the end of their third year. However, accidents are common and parents need to be prepared with extra dry clothing that is readily accessible. Children should be taught correct toileting procedure for the wilderness environment. Stools should be deposited at least 60 m (197 feet) from a water source, buried in a hole approximately 15 cm (6 inches) deep, and completely covered. Many families carry a special trowel for this purpose. Some groups staying in one location for more than a day dig a specific toileting trench, 30 to 45 cm deep, to be used multiple times. They then add enough dirt after each use to cover all waste. Children need help learning to squat over the trench and to bury their stools.

It may be years before children gain reliable nighttime bladder control. Cotton and down sleeping bags should be avoided because they lose their insulating abilities and take a long time to dry. Fortunately, many synthetic bags are available, with fills such as Primaloft and Climashield, which maintain warmth and loft when wet. Once again, children at this age should sleep in their own sleeping bags to avoid sharing nighttime accidents with parents or caregivers.

CHILDREN OF SCHOOL AGE (5 YEARS AND UP)

Travel Expectations

Once children enter kindergarten, their abilities and attention span increase dramatically. This enables them to participate more actively in many outdoor activities. Children are hungry for knowledge and readily absorb information about nature and outdoor activities. They enjoy being included in initial planning, as well as in field activities, such as setting up camp, cooking, purifying water, and cleaning up. School-age children can understand maps and often enjoy following their progress from one point to another. This is an ideal age to explain to them the rules of survival in, living in, and traveling through wilderness areas. The examples and rules parents set for appropriate behavior in the wilderness at this age become lessons engraved for a lifetime.

When parents are planning hiking trips, it is important that they have appropriate expectations for children's evolving abilities (see Table 91-3). Children enrolled in organized sports activities are likely to have greater endurance in the wilderness. A child's hiking ability can be estimated by walks around the neighborhood or in a local park. If this practice becomes a

FIGURE 91-6 Use of headphones and audiobooks during treks and travel. *(Courtesy Judith R. Klein, MD.)*

routine, children become preconditioned, increase their endurance, and learn to pace themselves. More importantly, parents can learn what to expect and can test methods for motivating their children. It is better to underestimate than to overestimate a child's ability. Parents should also remember that children, like adults, have good and bad days, so allowances should be made.

Safety

School-age children can learn to become more self-sufficient and in tune with their surroundings. They can be taught to recognize landmarks in their environment, so they are less likely to become lost. Such landmarks can be pointed out, and children should be encouraged to view their surroundings from different angles so that they can find their way back if they stray off. Children should periodically turn around so they can see where they came from, as well as where they are going. As children advance in school years, they can learn survival skills, such as how to maintain warmth, build shelters, secure food and water, and use a signal mirror, map, and compass. As with the previous age group, they should carry a whistle and know how to use it appropriately.

Equipment

Children like to feel important, capable, and independent. These feelings are enhanced if they are allowed to carry some of their own gear. Even 5-year-olds like to carry their own soft backpacks. Items they can carry in the packs include snacks, a favorite small toy, extra clothing, sunscreen, a flashlight or headlamp, a small trash bag (excellent to wear for warmth or rain protection), and a whistle. As a child grows, the contents of his or her backpack should reflect his or her increasing independence, with more self-care and survival items. In addition to the preceding items, children may wish to carry their own water bottle, mini–first-aid kit (adhesive bandages, wipes, personal medication), insect repellent, and other survival items (e.g., pocket knife, flint and steel) as they learn to use them. The maximal weight of these packs should be 20% of the child's body weight until he or she has had significant backcountry experience and can comfortably carry more. Once children reach 4 feet (1.2 m) in height, they can be fitted for a framed backpack. Internal-frame backpacks tend to be more comfortable than external-frame packs. When a backpack is properly fitted, the waistband should rest at the hips and the shoulder strap should be adjusted so that the weight is carried on the hips, not on the shoulders (Figure 91-7). With a framed pack, children can carry even more of their own gear. However, the total weight should be gradually increased to allow the child to become comfortable with heavier loads and should not exceed 30% of the child's body weight.

ENVIRONMENTAL ILLNESSES

DEHYDRATION

Children are at greater risk of dehydration than are adults. Because the surface area–to–body mass ratio of a child is greater than that of an adolescent or adult, insensible fluid losses through the skin account for a larger percentage of total fluid losses as the size of the child decreases. In addition, the sodium concentration of children's sweat is generally less than that of adults, leading to a greater relative free water loss. Infants are unable to report thirst, an important marker of fluid deficit, thereby increasing their risk of dehydration. Even once they become verbal, children are often preoccupied and fail to report or meet their need for fluids, even when water is freely available.

Symptoms

As little as a 2% decrease in body weight through free water loss results in mildly increased heart rate, elevated body temperature, and decreased plasma volume. Water losses of 4% to 5% of body

FIGURE 91-7 Backpack fit for a child. *(Courtesy Judith R. Klein, MD.)*

weight reduce muscular work capacity by 20% to 30%.[55] Symptoms of dehydration include weakness, fatigue, nausea, vomiting, and, ultimately, lethargy. In a young child, the first sign may be irritability and loss of appetite. Dehydration also predisposes a child to other environmental hazards, such as hypothermia, hyperthermia, and acute mountain sickness (AMS).

Treatment

It is the caregiver's responsibility to provide fluids and coax the child to drink frequently. For short (<2-hour) periods of activity, water is as efficacious a rehydration solution as are carbohydrate-electrolyte drinks.[55] That being said, a small amount of juice or other sweetener diluted in a larger volume of water may enhance the fluid intake of a child. Avoid undiluted juices or heavily sweetened drinks because they can worsen dehydration; the high carbohydrate load in these drinks promotes osmotic diuresis. A child eating a normal diet does not require electrolyte replacement unless sweating is prolonged or excessive. By closely monitoring a child's urine output, fluid deficits can be recognized and promptly managed. A child with decreased urine output or dark, concentrated urine needs extra fluids.

HYPOTHERMIA

Children cool more rapidly than do adults because they have a relatively large surface area and often lack the knowledge and judgment to initiate behaviors that maintain warmth in a cold environment (see Chapter 7). In addition, they have a more difficult time maintaining body temperature in cold climates, predominantly because they do not shiver as effectively.[7] As a result, parents participating in cold weather recreation with children should be able to recognize, treat, and, preferably, prevent hypothermia and frostbite.

Hypothermia is defined as core body temperature below 35° C (95° F). At this temperature, the body no longer generates enough heat to maintain body functions. The condition is considered mild when core temperature is 33° to 35° C (91° to 95° F); moderate at temperatures between 28° and 32° C (82° and 90° F); and severe when it is less than 28° C (82° F). The signs and symptoms of hypothermia are listed in Table 91-4, although these may be quite variable. The most important clue to significant hypothermia is altered mental status. An infant may become lethargic and difficult to arouse. An older child may be shivering, stumbling, or appear confused. These signs merit prompt treatment for hypothermia. Of note, the presence or absence of shivering is not a reliable marker of the severity of hypothermia. Physicians should also caution parents that hypothermia can develop at moderate ambient temperatures if adverse climatic conditions are compounded by illness, fatigue, dehydration, inadequate nutrition, or wet clothing.

TABLE 91-4 Signs and Symptoms of Hypothermia*

Rectal Temperature		Signs and Symptoms
Mild	33°-35° C (91°-95° F)	Sensation of cold, shivering, increased heart rate, progressive incoordination in hand movements, development of poor judgment
Moderate	28°-32° C (82°-90° F)	Loss of shivering, difficulty walking or following commands, inappropriate (for the outside temperature) undressing, increasing confusion, decreased arrhythmia threshold
Severe	<28° C (<82° F)	Rigid muscles, progressive loss of reflexes and voluntary motion, hypotension, bradycardia, hypoventilation, dilated pupils, increasing risk of fatal arrhythmias, looks as if death is imminent

*Data from adult subjects.

FIGURE 91-8 Layering of clothing for cold environments. *(Courtesy Judith R. Klein, MD.)*

Prevention

When preparing for cold weather activities, children should dress in layers to allow clothing to be added or subtracted as necessary (Figure 91-8). This avoids excessive perspiration while maintaining warmth. An inner, wicking layer should be followed by a middle, insulating layer and, finally, by an outer, protective layer.

Because children generally avail themselves of any opportunity to get wet, clothing that maintains low thermal conductance when moist is particularly important. Conductive heat loss may increase 5-fold in wet clothing and up to 25-fold if the child is completely immersed in water. Traditional wool retains warmth when wet because of its unique ability to suspend water vapor within the fibers; however, it is heavier than synthetics and takes much longer to dry. Cotton has a high thermal conductance that increases greatly when wet and is, therefore, a poor choice for wilderness activities in cold weather. Synthetic materials (polypropylene, Capilene, Thermax, CoolMax) wick moisture away from the skin and dry quickly, making them ideal for an inner layer. Finely woven merino wool also provides these same advantages as a wicking layer. The middle, insulating layer may incorporate wool, polyester pile or fleece, down, or similar materials. Finally, windproof and water-resistant outer garments (e.g., Gore-Tex) decrease heat loss from convection and keep children dry. Hats and mittens are also essential; the uncovered head of a child dissipates up to 70% of total body heat production at an ambient temperature of 5° C (41° F).[7]

Treatment

For the hypothermic child, field rewarming begins with limiting further exposure to the cold environment. Find immediate shelter for the child. Wet clothing should be removed, and the child's head and neck should be protected from further heat loss. Place the child together with a normothermic person in a sleeping bag insulated from the ground to provide external warmth. Hot water bottles, insulated to prevent burns, may also be placed at the axillae, neck, and groin. If the child is alert, oral hydration with warm fluids containing glucose repletes glycogen and corrects

dehydration, which frequently accompanies hypothermia. Signs of severe hypothermia (e.g., severe lethargy or confusion, diminished pulses) dictate immediate evacuation as conditions permit. Rescuers should handle the victim gently to prevent precipitating arrhythmias.

FROSTBITE

Localized cold injury can result in frostbite (see Chapter 9). Predisposing factors include wet skin, constricting garments that hinder blood circulation, fatigue, dehydration, contact with cold surfaces, and wind. If the skin temperature drops below 10° C (50° F), cutaneous sensation is generally abolished and injury may go unnoticed. Skin cooled to −4° C (24° F) freezes.

Frostbite has traditionally been divided into degrees of injury, much like burns. Determination of the depth of injury should occur 24 to 48 hours after rewarming; prior to this, frostbitten skin generally appears hard and feels numb. Skin with superficial frostbite is typically swollen, pink or erythematous, painful, somewhat warm, and often blistered. Sites with deep frostbite are cooler, not edematous, pale, anesthetic, and do not have blisters or bullae. In children, frostbite that extends into bone may affect the growth plate and result in skeletal deformities.[7] Verbal children will frequently report cold hands and feet, but adults should be vigilant about checking extremities and noses and ears of nonverbal children, particularly those poorly visible in back carriers. A mirror, frequently used, can assist in this regard. Reports of small children developing frostbite and hypothermia while being carried on the backs of adults engaged in outdoor winter pursuits are not infrequent.

Treatment

All wet and constricting clothing should be removed and hypothermia treated aggressively. Rapid rewarming, the primary treatment for frostbite, should be initiated as soon as possible. This is best accomplished by immersion of the frostbitten area in water warmed to 40° C (104° F). This temperature maximizes the rewarming speed while preventing thermal burn injuries. Thawing usually takes 30 to 45 minutes and is complete when the skin is soft and pliable. Field rewarming is indicated unless evacuation is imminent and rapid; however, great care should be taken to avoid refreezing. Refreezing causes far more damage than delayed thawing, because of formation of ice crystals in connective tissue. Vigorous rubbing should be avoided because it is ineffective and potentially harmful to skin. After thawing, proper wound care is essential. Frostbitten sites should be kept clean, ruptured bullae debrided, and the area dressed in a bulky dressing. Oral ibuprofen and topical *Aloe vera* facilitate healing. Evacuation to a medical facility skilled in the management of frostbite is essential.

HYPERTHERMIA

Families participating in wilderness activities in hot climates must take special precautions to avoid heat illnesses (see Chapters 12 and 13). Children do not tolerate the demands of exercise in the heat as well as do adults. They generate more heat per kilogram and are less able to disperse heat from the core to the periphery. Parents planning wilderness ventures with children in hot climates can follow some simple guidelines for avoiding heat illness. The most obvious guideline entails reducing the duration and intensity of activities under conditions of high climatic heat stress. Likelihood of heat illness depends on relative humidity, wind velocity, and radiant heat, as well as standard dry-bulb thermometer temperature. Figure 91-9 gives a rough guide for activity levels based on temperature and relative humidity.

Prevention

Children should be fully hydrated before prolonged exercise and actively encouraged to drink fluids at regular intervals.[55] Infants and neonates are most vulnerable to heat illness. Under high climatic heat stress, infants fed undiluted cow's milk or formula may develop marked salt retention and dehydration. They should be given extra water or dilute feedings. The lower osmolar load of breast milk appears to protect against heat illness and hypernatremia.

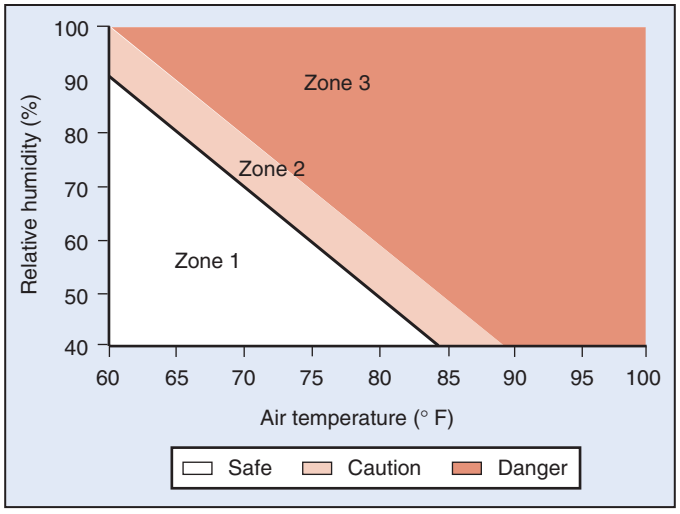

FIGURE 91-9 Activity levels based on temperature and relative humidity.

Because their mechanism of evaporative heat loss (sweating) is immature relative to that of an adult, children should be encouraged to engage in activities in the shade to maximize other means of dissipating heat, such as radiation (skin-to-air gradient). Also, because sweat evaporated from clothing contributes less to cooling than does sweat evaporated from skin, children should be changed out of sweat-soaked clothing and wear dry, lightweight, loose-fitting clothing. As exemplified by cultures that inhabit the desert (e.g., Bedouins of Saudi Arabia), full-coverage, lightweight, and light-colored clothing items provide the most protection from heat. Finally, children acclimatize to heat more slowly than do adults, often taking 10 to 14 days to fully adapt. Intensity and duration of exercise should gradually be increased over this period.

Symptoms and Treatment

Early signs and symptoms of heat illness include flushing, tachycardia, weakness and lethargy, mild confusion, headache, and nausea. Vomiting often occurs in children. Sweating may be present or absent and should not be relied upon as a clinical indicator of the severity of hyperthermia. If heat illness develops, children should be removed from obvious sources of heat, including direct sunlight, and have their clothing removed. Convective cooling can be increased in the field by vigorous fanning after spraying or sprinkling the victim with water. Ice packs or cold compresses placed on the groin, axillae, and scalp will aid cooling. Cool-water immersion is probably the most effective means of rapid field cooling if the child's head position can be controlled. If the child is alert, dehydration should be corrected with oral fluids. Progression of symptoms or failure to respond to treatment mandates immediate evacuation.

SUN DAMAGE

Hazards of overexposure to sunlight include sunburn, photoaging, skin cancer, and phototoxic and photoallergic reactions (see Chapter 16). Climatic changes, such as global warming and ozone degradation, have increased these hazards.[10] Preventing ultraviolet damage to skin should begin in childhood, because 50% to 80% of a person's lifetime sun exposure occurs before 18 years of age.[9,30] Adolescence is the period when children are most at risk. In one study, 83% of children 12 to 18 years old reported at least one sunburn per summer; 36% reported three or more sunburns per summer.[30] Recent evidence suggests that the risk of developing malignant melanoma increases significantly with the number of sunburns in childhood.[23] This risk is even higher

if a child is light-skinned with a propensity to burn rather than tan. Tolerance to sun exposure is determined by the amount of melanin in skin and ability of skin to produce melanin in response to sunlight. In general, children have lower melanin levels and thinner skin than do adults and are at greater risk for sun damage.

The ultraviolet (UV) wavelengths UVA and UVB are principally responsible for the harmful effects of solar radiation. UVB is primarily responsible for suntan and sunburn and also promotes development of skin cancer and skin aging. UVB increases 4% for every 300-m gain in elevation above sea level. Therefore, a backpacker at 3000 m will have a 40% increase in UVB exposure. UVA, which is 10 to 100 times more abundant than UVB, is only 0.001 as potent at inducing sunburn. It is also less affected than is UVB by changes in season or solar zenith angle. UVA is primarily responsible for photosensitivity reactions and solar urticaria. It also contributes to skin cancer and skin aging. A number of drugs often used in adolescence, such as tetracycline, vitamin A derivatives (Retin-A, Accutane), and nonsteroidal anti-inflammatory drugs, increase the risk of photosensitivity reactions and the need for UVA protection. Consequently, it is important to use sunscreens that protect against both UVA and UVB.

The harmful effects of UV radiation from the sun can be reduced if parents are educated regarding the dangers of sun exposure and encouraged to use sun-protective clothing and sunscreens early in their children's lives. One study demonstrated a 60% reduction in childhood sunburns with good parental role-modeling and sunscreen vigilance.[61] Regular use of sunscreen with a sun protection factor (SPF) of at least 15 for the first 18 years of life reduces a person's lifetime risk of developing non-melanoma skin cancer by 78%.[54]

Prevention

The most effective means of preventing sun damage is using protective clothing and avoiding excessive sun exposure. Midday hours (10 AM to 4 PM), particularly around highly reflective surfaces (e.g., water, sand, snow), at high altitude and at the equator are the most dangerous in terms of quantity of UV exposure. Shady areas should be used for activities during these times. Hats with wide brims and neck drapes help to protect the face and neck from sun exposure (Figure 91-10). Clothing made from tightly woven fabrics is more protective than clothing made from loosely woven fabric. For example, loosely woven fabrics, such as those used in most T-shirts, have an SPF of only 5. Most clothing loses more of its sun protective effect when wet. Several manufacturers are marketing high-SPF (25 to 50) protective clothing (coolibar.com; sunprotectiveclothing.com). This specialized clothing is cool and lightweight, dries quickly, and can maintain its full SPF capabilities when wet (see Figure 91-10). Caution is advised on overcast days, because 80% of the sun's rays still reach the earth even when the sun is not visible.[54] In addition,

FIGURE 91-10 Options for appropriate sun wear: protective clothing, wide-brimmed hat, and sunglasses. *(Courtesy Judith R. Klein, MD.)*

because clouds filter out heat from infrared rays, children feel more comfortable and tend to stay out longer, thereby increasing their overall UV exposure.

Proper eye protection is often overlooked in infants and young children. Excessive UV light, particularly during snow and water activities, can result in UV keratitis (see Chapter 48) with even brief exposures. Properly fitting sunglasses that transmit less than 10% of UV rays should be part of a child's outdoor activity armamentarium (see Figure 91-10). Side shields and polarizing lenses are particularly important in snow conditions.

Sunscreens

Sunscreens formulated with a variety of different agents to prevent UV damage to the skin include physical blocks, chemical blocks, and antioxidants. Physical blocks, such as zinc oxide and titanium dioxide, reflect UV light and do not penetrate the skin. Chemical blocks prevent UV light from entering the skin, and are themselves absorbed into the epithelium. Chemical blocks have ingredients that block UVB or UVA, or both. Agents that block UVB include PABA, cinnamates, salicylates, and anthranilates; those that block less potent UVA rays include avobenzone and the anthranilates. Benzophenones, oxybenzone, and the physical blocking agents protect against both UVA and UVB.[54] Antioxidants present in sunscreens include vitamins C and E, resveratrol, and pomegranate. These agents help to repair skin damage. Sunscreens that combine protective ingredients with antioxidants are the most effective. The sun protection factor (SPF) is a measure of a sunscreen's effectiveness. It is measured in terms of the minimal dose (in length of time) of UV radiation required to cause skin erythema. Sunscreens with SPF 30 or higher provide a superior degree of photoprotection and almost completely prevent cellular changes seen with sunburn.[54]

Overall, there is little difference between child and adult sunscreens except for price. Parents should select sunscreens based on ingredients. Physical blocks are preferred for children because they are difficult to wash or rub off and do not degrade in the sun. Therefore, they do not need to be reapplied as frequently as do chemical sunscreens. In addition, they are much less likely than chemical sunscreens to be absorbed through skin because of their larger particle size. Several studies have suggested that certain chemical sun filters (notably benzophenones, cinnamates, camphor and parabens) may act as endocrine disrupters when absorbed through the skin of developing children, in particular affecting reproductive hormones.[43] This emerging body of evidence provides yet another reason to choose physical sunblocks for children during sensitive periods of development.

Apply a thick coat of sunscreen at least half an hour before outdoor activity. Sunscreens must be applied in adequate quantity to provide the SPF indicated on the bottle.[69] Select a sunscreen with a SPF of at least 15, but preferably greater than 30. Waterproof sunscreens are preferred if children are anywhere near water, because these products maintain efficacy for up to 80 minutes of water immersion. Sunscreens should be reapplied at least every 2 hours (or more frequently) during prolonged water immersion or excessive sweating. Cream and lotion sunscreens provide coverage superior to spray-on formulations because they can be applied evenly and in the quantities required to provide effective sun protection. Attention should be focused on applying ample sunscreen to vulnerable areas, such as the nose, shoulders, and dorsum of the feet. Infants younger than age 6 months should be outfitted with hats and protective clothing and should be placed in the shade (Figure 91-11). Sunscreens in this age group should be limited to small areas of skin only, because infant skin is thin and chemically sensitive.

Treatment

When sunburn occurs, the mainstays of treatment are cool compresses, topical antipruritics, and nonsteroidal antiinflammatory drugs. Topical *Aloe vera* cream or gel often provides a soothing effect for an uncomfortable child. Further sun exposure should be avoided while the skin is healing. As always, prevention is superior to any treatment.

FIGURE 91-11 Infant wearing clothing with full sun protection. *(Courtesy Judith R. Klein, MD.)*

DROWNING

According to the Centers for Disease Control and Prevention (CDC), drowning (see Chapter 69) is the second leading cause of injury-related death in children ages 1 to 14 years in the United States.[85] Worldwide, drowning is the leading cause of death among boys ages 5 to 14 years.[85] Those most at risk are unsupervised toddlers and male teenagers, in particular, those with inadequate swimming skills and poor judgment. Complications and deaths result from asphyxiation, hypothermia, and/or trauma.

If a child is pulled from the water after a submersion event, cervical spine precautions should be maintained unless the event is witnessed and no trauma has occurred. All children who have experienced a period of near drowning should be observed for symptoms, have vital signs taken, and have their lungs auscultated. Respiratory distress, vital sign abnormalities, and rales on physical examination are indications for transport to a medical facility.[77] If the child is apneic or pulseless, CPR should be initiated immediately, with emphasis on effective ventilation, because this condition is the primary cause of cardiopulmonary arrest. Five rescue breaths should be given prior to initiating chest compressions because initial ventilation may be difficult due to water in the alveoli. The child should be transported to an emergency care facility as quickly as possible. All wet clothing should be removed and rewarming initiated.

Prognostic assessments based on the initial appearance of the child should not be made in the field, particularly in the setting of cold water immersion. Reduction of brain temperatures by 10°C (50°F) during drowning decreases adenosine triphosphate consumption by 50%, doubling the time that the brain can survive intact during a period of apnea.[77] Survival with good neurologic outcome has been documented in children with prolonged (> 40 minutes) submersion in cold water. The exception to this would be a drowning event in a remote wilderness area, where transport and evacuation times may be extremely long. That being said, emphasis in the field should be on rapid rescue and immediate CPR.

Prevention

Preventive measures are critical to reduce the number of drowning and near-drowning incidents. Most importantly, children should be taught to swim at an early age and learn to "read" the water and make appropriate judgments regarding water safety. They should be taught to swim with a buddy, particularly in moving and deep water. Young children should always be supervised by an adult skilled in CPR and water rescue. Use of a

personal flotation device (PFD) is highly encouraged until the child is a strong swimmer capable of treading water for prolonged periods. Air- or foam-filled toys, such as rings or noodles, or floats placed on the arms should not be used in place of PFDs. Cold water, rapidly moving current, water hazards, and large waves should be approached with extreme caution and only by strong swimmers.

HIGH-ALTITUDE ILLNESS

High-altitude illness (see Chapter 1) can be viewed as a continuum from acute mountain sickness (AMS) to life-threatening conditions such as high-altitude pulmonary edema (HAPE) and high-altitude cerebral edema (HACE). AMS usually develops within 24 hours of ascent. The incidence and severity of AMS depend on individual susceptibility, as well as rate of ascent and altitude attained. In one study, 37% of children who ascended rapidly to 3500 m developed AMS.[11] Studies have shown mixed results in terms of the relative incidence of AMS in children versus adults, but children may more susceptible to hypobaric hypoxia than are adults.[56]

Symptoms

Children need to be queried frequently for the onset of symptoms because they are less likely to speak up and report symptoms than are adults. The cardinal symptoms of AMS are throbbing headache, anorexia, and malaise. Children are particularly prone to nausea and vomiting. Other symptoms include dizziness and fragmented sleep. Infants may display nonspecific findings, such as irritability, poor feeding, and sleep disturbance. As AMS worsens, headaches become more severe, and nausea and anorexia progress to vomiting. Dyspnea at rest and confusion and ataxia mark development of the life-threatening conditions HAPE and HACE, respectively.

Prevention

The safest and most effective method of preventing high-altitude illness is to allow for acclimatization via graded ascent. No precise, scientifically proved guidelines exist, given the markedly variable individual susceptibility to altitude illness. However, general recommendations for children (and adults) without altitude experience are listed in Box 91-1. After day trips to higher altitude, children should return to lower altitude to sleep in order to aid acclimatization. The sleeping altitude is particularly important with regard to development of symptoms. A high-carbohydrate diet and plenty of fluids can also help reduce the risk of high-altitude illness.

Acetazolamide has been convincingly shown to reduce the incidence of AMS in adults.[24] Pretreatment with this agent mimics the acclimatized state by inducing hyperchloremic metabolic acidosis, allowing for inducing published studies of its efficacy in children, but clinical experience suggests that it is beneficial. The primary indication for acetazolamide prophylaxis in children is a history of recurrent AMS despite graded ascent.[56] Acetazolamide is given at 5 mg/kg/day, in two divided doses, up to a maximum daily dosage of 250 mg. It should be started 24 hours before ascent and continued for 3 to 5 days while at maximal altitude. It can be discontinued once descent has begun. Side effects include nausea, mild somnolence, and paresthesias that can be particularly bothersome in children. Ibuprofen as a prophylactic agent for AMS has also been examined in several studies in adults only. The presumed mechanism of action of ibuprofen is modulation of the inflammatory cascade that leads to AMS. Taken on the day of initial ascent until peak altitude is reached, ibuprofen at 600 mg three times a day (10 mg/kg/dose in children) has been shown to reduce the incidence of AMS relative to both placebo and acetazolamide.[48,62] Dexamethasone prevents or reduces symptoms of AMS in adults, but its use is discouraged in prevention of AMS in children, because it masks early symptoms of AMS and thereby encourages continued ascent. Ginkgo biloba has also been studied as an herbal alternative to acetazolamide for prevention of AMS; its efficacy is uncertain because of variability in commercially available formulations.[45] Salmeterol, an inhaled long-acting β-agonist, has been studied as a prophylactic agent against HAPE in adults, but has not been evaluated in children.

BOX 91-1 Preventing High-Altitude Illness

Avoid abrupt increases of more than 500 m in sleeping altitude per night above 2500 m.
Spend 2 or 3 nights at 2500 to 3000 m before ascending further.
Climb high; sleep low.
Drink sufficient fluids.
Eat high-carbohydrate foods.
Avoid artificial sleep aids (e.g., diphenhydramine).
Consider using prophylactic acetazolamide.

Treatment

Treatment of mild AMS requires prompt recognition of symptoms, cessation of ascent, and allowing time for acclimatization. Proceeding to higher altitude in the presence of symptoms is strongly contraindicated and may lead to the life-threatening conditions HAPE and HACE. Symptomatic therapy includes rest, acetaminophen for headache, and adequate hydration. Ondansetron (Zofran) may be used to relieve nausea and vomiting. Dystonia in response to phenothiazines, such as promethazine, occurs disproportionately in young children, so these agents should be avoided. Ondansetron is given orally at 0.1 to 0.15 mg/kg up to 4 mg every 4 hours. If symptoms resolve, the child may continue to ascend slowly. However, if symptoms progress or fail to improve, descent is mandatory. Although descent should proceed as far as necessary for improvement, 500 to 1000 m is often sufficient. If immediate descent is not possible, oxygen should be administered. Studies examining dexamethasone and acetazolamide for treatment of AMS suggest that both are effective.[24] Dexamethasone should be reserved for patients with moderate to severe AMS or HACE. Symptoms of HACE or HAPE demand immediate descent and possible evacuation to a medical facility.

BITES AND STINGS

Bites and stings occur commonly in the pediatric age group. In 2012, the American Association of Poison Control Centers reported that more than 20,000, or roughly one-third, of reported bites and stings occurred in individuals under the age of 20 years.[57] Remarkably, no fatalities were reported in this age group. This emphasizes the need for appropriate triage to determine which children require aggressive therapy so that potentially harmful field interventions can be avoided.

Dangerous interactions between children and surrounding fauna can be limited by judicious use of protective clothing, sturdy footwear, appropriate chemical barriers, and education. These principles apply to snakes, bees, wasps, yellow jackets, mosquitoes, and ticks.

Snakebites

Of the 8000 venomous snakebites that are estimated to occur in the United States each year, about 20% occur in people under the age of 20 years.[57] Deaths from domestic snakebites are uncommon, with none reported in children in the 2012 Annual Report of the American Association of Poison Control Centers. More than two-thirds of bites in children are on the lower extremities; these are predominantly in younger children walking or running over rocks and in brush. Most snakebites can be prevented. Children should be instructed not to handle snakes, not to reach blindly into crevices, and to avoid turning over rocks and fallen limbs. A useful adage is that hands and feet should never go where the eyes cannot see. When walking through endemic areas, hikers should stay on trails and wear long, loose pants and boots that extend above the ankle (see Figure 91-10). Campsites should be on open ground, away from wood piles or rock piles.

If a bite occurs, the child should back well away from the snake and be calmed. Agitation and movement of the bitten

extremity might promote venom circulation. The wound should be cleansed rapidly and any constricting items of clothing or jewelry removed. The bitten extremity should be immobilized and positioned at the level of the heart. No incision over the bite should be made. Mechanical suction (e.g., Sawyer extractor) is ineffective at removing snakebite venom and can worsen tissue ischemia in the 99% of endemic snakebites that are inflicted by members of the crotalid family (rattlesnakes, cottonmouths, copperheads).[2] Advanced techniques for potentially limiting venom spread, particularly with exotic snake envenomations, are discussed in detail in Chapters 35 and 36. All victims of potentially poisonous snakebites should be transported to a medical facility for prompt evaluation, local wound care, and possible antivenom administration. Crotalidae Polyvalent Immune Fab antivenom (CroFab, BTG International) has been shown to be safe and effective in children, particularly if administered early.[31]

HYMENOPTERA STINGS

Hymenoptera (bees, wasps, hornets, and ants) stings are the most common cause of envenomations in children (see Chapter 41). Although Hymenoptera venom possesses intrinsic toxicity, the amount delivered is small and multiple stings are necessary for significant human morbidity. However, the venom components are potent antigens capable of producing anaphylaxis mediated by immunoglobulin E in sensitized individuals. Although children appear less susceptible to systemic reactions than are adults, physicians should educate parents in the management of Hymenoptera stings, particularly if a child has previously had a severe reaction.

Hymenoptera stings usually produce local pain, swelling, and erythema. If a stinger is embedded, it should be removed as quickly as possibly by whatever means available, because the speed of removal of the stinger is far more important than the method of extraction.[84] Within 20 seconds, 90% of the contents of the venom sac are discharged into the victim, and 100% within 1 minute.[12] Applying ice or cool compresses reduces pain and swelling. Elevation and immobilization are indicated for large local reactions on extremities. In older children, oral antihistamines may provide additional symptomatic relief.

Early signs of a systemic reaction include generalized pruritus, urticaria, angioedema, bronchospasm, and laryngeal edema. Presence of these signs or symptoms mandates immediate medical evaluation. Aqueous epinephrine (1:1000) is the drug of choice for systemic sting reactions and should be administered in the field if available (0.01 mg/kg intramuscularly up to 0.3 mg). Epinephrine is easily delivered in the field with an EpiPen or EpiPen Jr. These contain a spring-loaded automatic injector that delivers 0.3 mg (EpiPen) or 0.15 mg (EpiPen Jr) of epinephrine IM when triggered by pressing the device against the thigh. The EpiPen Jr. is appropriate for children up to 15 kg, and the regular EpiPen is appropriate for larger children and adults. Carrying two EpiPens is recommended because transport times to definitive medical care are often longer than the effective half-life of a single dose. In addition, in a dire situation, an extra dose of epinephrine can be accessed from an EpiPen by cutting away the autoinjector mechanism and using the syringe and needle directly. Because up to one-half of all patients with anaphylactic reactions have no forewarning, epinephrine belongs in all wilderness medical kits.

Mosquito Bites

Mosquitoes not only present a high nuisance potential but also serve as vectors of disease (see Chapter 39). A number of steps can be taken to avoid mosquito bites (Box 91-2). A proper wardrobe that provides an excellent physical barrier is the first defense. This should include ankle-high footwear, pants cinched at the ankles or tucked into socks, a long-sleeved shirt, and a full-brimmed hat. Mosquito head netting draped over a child's hat will protect the face and neck. Mosquito netting, especially in the sleeping area, has been found to reduce the mosquito attack rate by 97%.[15]

Repellents containing DEET (*N,N*-diethyl-*m*-toluamide) are effective against mosquitoes, ticks, black flies, and many other arthropods. DEET works by providing a vapor barrier that presents the insect with an offensive odor and a bad taste. DEET has an extensive safety record; over 50 years, there have been only 43 case reports of toxicity.[42] These rare toxic effects are more common with high concentrations and include dermatitis with erythema, bullae, and skin necrosis, and, even more rarely, meningoencephalitis. A large study based on data from the American Association of Poison Control Centers refuted the commonly held belief that children are more susceptible to DEET toxicity. The study demonstrated that children actually have less severe outcomes after DEET exposures than do adults.[8,42] Although products containing 100% DEET are commercially available, long-acting formulations of less than 30% to 35% DEET appear equally effective in protecting against mosquitoes, with much less potential for toxicity.[60,80] Although available data do not permit precise safety guidelines, infants younger than 6 months should avoid DEET, but those older than 6 months can use products with up to 30% to 35% DEET. The repellent effect can last up to 8 hours, but heavy perspiration or swimming should prompt reapplication every 6 to 8 hours. Dawn and dusk are particularly risky times; outdoor activities should be limited at these times if possible. Parents should not allow children under 8 years old to apply DEET to themselves, because of the risk of DEET exposure to the eyes or mouth in this age group. Repellent should not be applied over lacerations, wounds, or irritated skin because of increased risk of absorption. DEET products can be applied over other creams to maximize the repellent effect. Combination sunscreen and repellent products should be avoided, because the instructions for use of the two ingredients are different (e.g., sunscreen requires more frequent application) and because sunscreens may increase skin absorption of DEET. In addition, some studies have shown that DEET can degrade sun-filtering chemicals, thereby decreasing the SPF of the sunscreen.[42] Parents should also be cautioned to keep DEET out of reach of small children, because ingestion may be fatal.

Picaridin (e.g., Natrapel) is an alternative to DEET. Commonly used in Europe and Australia, it is odorless, minimally toxic, and considered by the World Health Organization (WHO) and the U.S. Environmental Protection Agency to be an effective insect repellent. Although picaridin does not have the lengthy record of efficacy and safety of DEET, concentrations of up to 20% are considered effective against a broad array of biting insects for up to 8 to 10 hours. Picaridin is not recommended for children under 2 years of age. Botanical products have increasingly been marketed as safer, more "natural" alternatives to chemical repellents. These include oil of lemon eucalyptus, lavender oil, soybean oil, and geraniol oil. In various studies, oil of lemon eucalyptus has been shown to be as effective against mosquitos, biting flies, and gnats as low-concentration (7% to 15%) DEET products.[42] It is not particularly effective against ticks. Where data are available, the other oils appear to be even less effective.[80] Although natural products may be acceptable in areas where mosquitoes do not carry disease, in U.S. areas with persistently active West Nile virus disease and tick-borne diseases, and certainly in much of the tropical developing world where malaria and dengue fever are endemic, these products are inadequate. Also, the above oils have been associated with aspiration pneumonitis when

BOX 91-2 Mosquito Avoidance

- Wear hat, long-sleeved shirt, and pants. Tuck pants into socks.
- Minimize outdoor activities at dusk.
- Use mosquito netting to cover the heads of children and the sleeping area.
- Soak or spray clothing, netting, and screens with permethrin (Permanone or Duranon).
- Use insect repellents with picaridin or < 35% DEET on exposed skin only, avoiding children's hands.
- Apply repellents over any other creams such as sunscreen to minimize absorption and maximize the repellent effect.
- Keep repellents out of reach of small children.

DEET, *N,N*-diethyl-*m*-toluamide.

accidentally ingested by young children. They are not recommended for children under 3 years of age.

The pesticide permethrin, available as a 0.5% spray or soaking liquid (Permanone, Duranon Tick Repellent), is safe and effective against arthropods, especially ticks. Unlike DEET, permethrin requires direct contact with insects in order to repel, so should not be applied to skin. Permethrin should be applied to clothing, bed sheets, and netting for maximum efficacy. Permethrins as a class have low toxicity in mammals. The combination of DEET applied to exposed skin and permethrin treatment of clothing is particularly effective in protecting against mosquito and tick bites. This combination can reduce mosquito bites by up to 99% for up to 8 hours.[52] The protective effect of mosquito netting is also greatly enhanced when it is impregnated with permethrin. These effects are longer lasting with permethrin soaks (up to 20 washings) than with permethrin spraying (5 washes) of clothing and netting. Alternatively, clothing, bed nets, and bed sheets are available that are made of fabric already treated with permethrin and effective for 25 washings (buzzoffoutdoorwear.com).

West Nile virus (WNV) disease continues to be a concern across the United States, with over 30,000 cases and 1500 deaths reported from 48 states by 2010.[87] During 2012, another major outbreak occurred with nearly 6000 new cases. Infection is uncommon in children; they represent only 5% of known WNV cases. WNV disease is a zoonotic disease transmitted from animal hosts to humans via infected *Culex* mosquitoes. Most infected individuals are asymptomatic, but 20% develop a mild nonspecific febrile illness and 20% to 25% develop a maculopapular rash lasting less than a week. Overall, 9% of reported cases had neurologic involvement, mostly in adults. Protection against bites during the active daytime hours of the *Culex* mosquito is the only means of prevention of WNV-related disease in humans.

Tick Bites

Like mosquitoes, ticks serve as vectors for disease, most notably Lyme disease (see Chapter 42). Lyme disease is rare on the Pacific coast but endemic in the northeastern United States, where up to 30% to 50% of *Ixodid* ticks are carriers.[27] As global temperatures rise, the northern range of the *Ixodid* tick is expanding, so we are likely to see more cases extending into Canada. The number of cases in the United States each year has leveled off at nearly 35,000 cases reported to the CDC in 2013.[66] Children between the ages of 5 and 9 years have the highest incidence of Lyme disease, likely because of extended outdoor play.[89] Transmission of the Lyme spirochete, *Borrelia burgdorferi,* typically requires 48 to 72 hours or more of tick contact. Therefore, tick checks should be conducted regularly while traveling through wilderness areas. If a tick is found embedded in skin, it should be grasped with forceps close to the skin surface and gentle traction applied. Using alcohol or an open flame for removal is strongly discouraged, because these techniques do not tend to work and can induce tick salivation or regurgitation into the wound.

After tick removal, parents should observe the child for appearance of a large erythematous or targetoid annular lesion at the bite site within 7 to 10 days, but occasionally as long as 30 days. This rash, erythema migrans, either painful or pruritic, is characteristic of early localized Lyme disease. If neglected, the rash spreads and fever, neurologic symptoms, and arthritis may develop. Treatment for early-stage Lyme disease in children 8 years of age or younger is amoxicillin 40 mg/kg/day (for a maximum dose of 1500 mg) divided into three doses for 14 to 21 days; for children older than 8 years of age, doxycycline is given at 2 mg/kg (for a maximum dose of 100 mg) twice a day for 14 to 21 days. A vaccine against Lyme disease is no longer commercially available. Some infectious disease experts have advocated antibiotic prophylaxis for individuals over 8 years of age if tick exposure exceeds 36 hours and if the prevalence of the spirochete in ticks in the area is more than 20%.[89] Prophylaxis, if given, is doxycycline 4 mg/kg in a single dose, up to a maximum of 200 mg. As with mosquitoes, clothing and chemical barriers, such as DEET and permethrin, are the first lines of defense against ticks and the diseases they carry. Children should be dressed in light-colored clothing for outdoor play so ticks are more visible during tick checks.

LOST CHILDREN AND SURVIVAL

It is common, but preventable, for children to become lost in the wilderness. Children should be taught to recognize landmarks and to turn around and look backward periodically to familiarize themselves with the terrain. Those who are capable of reading a compass and topographic map should carry these items at all times. Young children should wear brightly colored clothing to facilitate a search should they become lost. They should carry a whistle around their necks and be taught the universal signal for help: three blasts in a row. It should be emphasized to the child that the whistle is intended for emergency use only. Portable two-way radios can also be used for emergency communication if a child is lost. Depending on the model, the range can extend 2 to 5 miles, but mountains and ridges can cause interference. As soon as they are able to carry a backpack, children should be equipped with survival items. A flashlight, bottle of water, extra food, and a few brightly colored garbage bags can make all the difference for a child forced to spend several hours or a night out in the wilderness. Also, every child should carry a piece of paper with his or her parents' names, address, and phone number on it. Older children who venture out without their parents should always tell an adult where they are going, with whom, and when they expect to return.

A few programs, such as Hug-a-Tree (gpsar.org/hugatree.html), instruct children in the basics of survival when lost. The title of the program is intended to remind children of three important tenets of survival when lost: stay in one place to facilitate any search, take advantage of the natural shelter provided by a tree, and feel the security and calming effects of a large natural protector. By hugging a tree and not wandering around, children can work on making signals out of rocks or branches, thereby indicating their location. Children should be taught to make themselves look big and noisy (coats or arms in the air, blow a whistle) or to lay down with arms out if they hear a helicopter. Children should learn to avoid getting wet (e.g., wear a garbage bag if it is raining and avoid rivers or lakes), to wear a hat, and to stuff pine needles or dry grass into their clothes to insulate themselves if they become chilled. Children can practice making temporary shelters out of logs, branches, and leaves and thereby experience the warmth and protection provided by these natural features. They should avoid lying directly on the ground and should use leaves and branches to insulate themselves from the cold earth or snow. Children should be advised not to eat anything with which they are not familiar. The program also reminds children that there are no animals "out there" in the United States that will hurt them (e.g., "lions, tigers, bears") and that they should yell at any noises that they hear. Finally, children should be reminded that they will not be punished for getting lost and that lots of people will be looking for them, so they should just stay put. Parents should be encouraged to mobilize search and rescue resources early, before time and foul weather obscure a child's tracks.

Older children and adolescents who plan on spending time in the wilderness should be encouraged to participate in a program that teaches basic survival and first-aid skills. Several organizations, such as Lifeschool's Go Adventures in Bodega, California (goadventure.org/), and the National Outdoor Leadership School (NOLS: nols.edu) provide instruction for children. Lifeschool is intended as an introduction to the backcountry for children ages 12 to 18 years, whereas NOLS provides more technical instruction in various forms of wilderness travel, in addition to first-aid and survival training.

HOMESICKNESS

Most children experience some degree of distress when faced with separation from home, particularly when they are not accompanied by a parent. Predisposing factors to the depression and anxiety referred to as homesickness include young age, little prior separation experience, high parental separation anxiety, great perceived distance from home, few initial positive experiences after separation, preexisting anxiety or depression, and little perceived control over the situation.[78] Parents should be

encouraged to introduce short periods of separation from home and family, leading up to longer periods. They should discuss the exciting aspects of any future adventure and encourage active decision making regarding activities and the destination. Parents should also try to alleviate their own separation anxiety and ensure positive early postseparation experiences for their child.[78] The presence of familiar faces, such as friends or favorite playmates, can significantly reduce a child's feeling of homesickness. Activities that include a child's favorite games and meals will be remembered by the child as fun experiences in which he or she would like to reengage. Through careful planning and coordination, parents can do much to allay the fear and anxiety of children as they travel away from home.

FOREIGN TRAVEL WITH CHILDREN

Visits to foreign countries provide superb educational, social, and cultural experiences for children. According to the CDC, an estimated 2.2 million U.S. children traveled abroad in 2010, a number that has steadily increased.[80] Traveling to wilderness or rural areas within developing nations entails not only the risks of wilderness travel but also those of poor sanitation conditions with exposure to bacteria, viruses, protozoa, and helminths not usually seen in the developed world. Although there is little consensus among experts, parents should be made aware of the greater risks of traveling to a developing country with a child under 2 years of age. This increased risk is the result of incomplete immunizations, an underdeveloped or naive immune system, poor hygiene practices (e.g., hands to mouth), and age- and weight-based contraindications for vaccinations and various medications.

It is the role of some physicians to provide guidance and information to parents planning foreign travel. Emergence and widespread availability of the Internet has provided physicians and travelers with easily accessible and up-to-the-minute guides to disease outbreaks, immunizations, and symptoms and treatments for various tropical diseases. Reliable sources for this type of information are listed in Table 91-5.

Preparation for foreign travel with children includes identification and avoidance of risky endeavors, administration of appropriate immunizations and prophylactic medications, knowledge of common childhood diseases and the means of treating them, understanding prevalent tropical diseases in the area of travel, and, finally, comprehensive follow-up after the trip with an informed physician. Physicians should be aware of the impact of foreign travel on children with chronic medical conditions.

GENERAL RECOMMENDATIONS FOR TRAVEL WITH CHILDREN

Physicians should emphasize to families that risk avoidance is the most important aspect of safe travel. The basic tenets of safe foreign travel with children are listed in Box 91-3. Parents should select modes of transportation, activities, and overnight settings carefully to avoid unnecessary hazards. Because traumatic injury is the leading cause of disorders and deaths among children, prevention is key. Protective devices, such as car seats, helmets, PFDs, and protective clothing and pads, should be used as often as possible (Figure 91-12). Do not assume that any of these items is available in the destination country. Freshwater swimming should be avoided in developing countries to prevent parasitic infections, such as schistosomiasis. Where swimming is appropriate, parents should provide close supervision. Drowning is the second leading cause of death among pediatric travelers.[80] Skin protection is also vital in the outdoors, particularly in tropical environments. Wearing closed shoes and avoiding play directly on the ground can prevent infections with various hookworms, *Strongyloides,* and other parasites that enter through the skin. Closed shoes also protect feet from injuries that can result in wounds infected with *Staphylococcus aureus* and other organisms that grow vigorously in the tropics. Clothing should be selected carefully based on ambient temperature and expected conditions. Even in hot, sunny climates, light, high-SPF clothing should cover as much body surface as possible to provide protection from parasites, insects, and UV light. Sunscreen should be used liberally and reapplied every few hours, particularly after swimming.

Parents should be advised to take great care in selecting foods and safe drinking water for themselves and their children, who are particularly vulnerable to disease (Box 91-4). All foods should

BOX 91-3 Risk Avoidance During Travel

Select appropriate settings: supervised swimming, safe campsites, protective devices.
Protect skin: sunscreen, repellents, protective clothing, closed shoes.
Eat and drink cleanly: water disinfection, careful food selection, "boil it, peel it, cook it, or forget it."
Avoid bugs and wild animals: clothing, netting, repellents, vigilance, safe practices.

BOX 91-4 Prevention of Food-Borne and Waterborne Diseases

Wash hands thoroughly before eating or preparing food.
Eat only well-cooked vegetables, meat, and seafood.
Eat only fruit that can be peeled.
Drink only disinfected or boiled water, carbonated drinks, hot teas, or coffee.
Drink or eat only pasteurized dairy products.
Avoid ice cubes or use only those made from disinfected water.
Breastfeed infants.
Prepare formula with disinfected or boiled water.
Brush teeth with disinfected water.
Choose well-cooked foods prepared freshly in front of you.

TABLE 91-5 Resources for Current Safe Travel, Immunizations, and Malaria Prophylaxis Recommendations

Resource Name	URL	Comments
U.S. Centers for Disease Control and Prevention (CDC)	cdc.gov	General website
	cdc.gov/travel/	Index of travel information, vaccines, disease outbreaks by destination country
	cdc.gov/mmwr	*Morbidity and Mortality Weekly Report* online (international bulletin on disease outbreaks)
	cdc.gov/travel/yellowbook/2014/chapter-7-international-travel-infants-children/vaccine-recommendations-for-infants-children	Vaccine recommendations for traveling children
World Health Organization	who.int/en/	Latest information on disease outbreaks
Travel Medicine Providers	tripprep.com	Vaccinations, epidemics, travel medicine providers
Travel Internationally with Your Kids	travelwithyourkids.com/	Parent-friendly website with much practical information

FIGURE 91-12 Proper use of helmet (**A**) and personal flotation device (**B**). *(Courtesy Judith R. Klein, MD.)*

be well-cooked, canned, or peeled. All milk products should be either pasteurized or boiled to avoid diarrheal illness and tick-borne encephalitis. Water should never be consumed from the tap; only water that is bottled, has been boiled for 1 minute, or has been treated with UV light (SteriPEN) or a chemical (iodine) and microfiltered (0.2-µm pore size) should be ingested. In certain areas, even bottled water is suspect. Breastfeeding is safest for young infants. If formula is used, only properly disinfected water should be used for its preparation. Finally, proper and frequent hand washing, particularly with infants and toddlers and especially around mealtimes, successfully interrupts the fecal-oral passage of disease. Hand sanitizer with an alcohol content of more than 60% is an alternative when hand washing is not convenient.

Parents should focus efforts on avoiding contact between children and insects or wild animals. Mosquitoes and ticks can be avoided by limiting outdoor activities between dusk and dawn and by wearing protective clothing and repellent (see Box 91-2 and Figure 91-10). As mentioned previously, DEET is an effective repellent but should not be used at concentrations greater than 35% in children because of the risk of toxicity.[42,80] Children's hands should be free of DEET to prevent accidental eye and mouth contact. Picaridin is an alternative repellent with efficacy against mosquitoes, ticks, and biting flies but has a shorter track record of success. As mentioned earlier, botanical oil repellents should not be used where there is a heavy concentration of biting insects and where these insects carry disease. Outer clothing and bed netting should be treated with permethrin. Check for ticks daily when in tick-infested areas. Children should be warned to watch where they place their hands and feet (e.g., not in crevices, unattended shoes, unchecked sleeping bags) to avoid the unexpected arthropod or snake.

IMMUNIZATIONS

Foreign travel with children requires advance planning because vaccines recommended for travel to certain countries may take up to 6 weeks to complete. The CDC website (cdc.gov/travel) provides up-to-date information on immunizations and prophylaxis based on the following:

Countries of travel
Length of time in each country
Location of destinations (rural versus urban)
Time of year
Types of lodging and eating facilities
Previous immunizations
Age and weight of the child

Vaccines may be categorized as routine (hepatitis B, polio, diphtheria-tetanus-pertussis, *Haemophilus influenzae* B, pneumococcus, rotavirus, measles-mumps-rubella, varicella, hepatitis A, meningococcus), seasonally or geographically indicated or required (influenza, yellow fever, typhoid, immunoglobulin), and indicated for extended stay (Japanese encephalitis, rabies)[82] (Table 91-6). Indications, dosages, and schedules for administration of these immunizations are listed in Table 91-7. The risk of acquiring diseases covered by many routine childhood immunizations is greater when traveling to developing countries because of inconsistencies in local immunization practices and subsequent loss of herd immunity. Children who have not completed their primary series of immunizations may require acceleration of the vaccination schedule or extra doses to maximize protection before travel. The minimum age at which some vaccinations can be given is listed in Table 91-7. In addition, seasonal influenza A vaccine should be given to all children older than 6 months

TABLE 91-6 Categories of Vaccines for Children

Type of Vaccine	Examples
Routine	Hepatitis B, polio, diphtheria-tetanus-pertussis (DTaP), *Haemophilus influenzae* B (Hib), pneumococcal (PCV-13), rotavirus (RotaTeq), measles-mumps-rubella (MMR), varicella virus (VZV), hepatitis A, meningococcal
Required or seasonally or geographically indicated for travel	Yellow fever, typhoid, meningococcal, influenza (seasonal), immunoglobulin
Extended stay	Rabies, Japanese encephalitis

From U.S. Centers for Disease Control and Prevention: cdc.gov/travel/yellowbook/2014/chapter-7-international-travel-infants-children/vaccine-recommendations-for-infants-children.

traveling during influenza season, which is December to April in the Northern Hemisphere and April to October in the Southern Hemisphere. Rotavirus vaccine is also strongly recommended for young infants traveling abroad. Rotavirus is the most common cause of acute gastroenteritis in young children, with 80% of children infected by the age of 5 years prior to vaccine introduction.[17] In the developing world, it is responsible for the deaths of more than half a million children per year under 5 years of age. As with many other diseases, children are more likely to develop acute gastroenteritis while traveling, so vaccination is an important preventive tool. Finally, the vaccine against meningococcus, now routine in adolescents, should be administered to

TABLE 91-7 Recommended Vaccines for Pediatric Travelers

Vaccine	Recommended Age at Vaccination (Earliest Possible Age)	Dosing Schedule	Comments and Contraindications
Routine Vaccinations			
Polio (IPV) (intramuscular)	2 mo (6 wk)	2, 4, 6-12 mo and 4-6 yr	Oral polio vaccine is no longer recommended because of risk of inactivated virus–associated paralytic polio in undiagnosed immunocompromised infants
Diphtheria-tetanus–acellular pertussis (DTaP)	2 mo (6 wk)	2, 4, 6, 15-18 mo and 4-6 yr	Large retrospective study indicated no increased risk of autism with DTaP
Tetanus-diphtheria-pertussis (Tdap)	10 years	Booster every 10 yr	Replaces dT to improve waning pertussis immunity
Haemophilus influenzae type B (Hib) polysaccharide conjugate	2 mo (6 wk)	2, 4, 6, 12-15 mo	Typically given as combination with DTaP; three or four doses depending on vaccine used
Pneumococcus (PCV-13): 13-valent conjugate	2 mo (6 wk)	2, 4, 6, 12-15 mo	Use protein polysaccharide vaccine (PPSV) for certain high-risk groups more than 5 yr old
Rotavirus (RotaTeq or Rotarix) live oral	2 mo (6 wk)	2, 4, 6 mo	Must give first dose before age 15 weeks (risk of intussception increases if first dose is given after 15 wk of age); two or three doses depending on type of vaccine used
Hepatitis B inactivated viral antigen	Birth	3 doses: 0, 1, 6 mo	Some protection after just one or two doses
Measles-mumps-rubella (MMR)	12-15 mo (6 mo)	12-15 mo booster at 4-6 yr	Give at least 2-3 weeks before any immunoglobulin; give one dose before international travel if 6-11 mo of age; give two doses 4 weeks apart if > 12 mo of age
Varicella live attenuated virus	12 mo	12 mo-12 yr: 12-15 mo booster at 4-6 yr > 12 yr: two doses, 4-12 wk apart	Give at least 2-3 wk before any immunoglobulin; may be given with MMR at different sites; avoid if child is immunocompromised
Hepatitis A inactivated virus	12 mo	Two doses, 6-12 mo apart	Preferred for hepatitis A protection if child is ≥ 2 yr (WHO recommendation is child ≥ 1 yr); effective in 4 wk; one dose enough for travel; two doses needed for long-term protection
Meningococcus (Menactra, Menveo, Menomune; MenHibrix for meningococcal groups C and Y and *H. influenzae* type B)	2 yr (9 mo)	9-23 mo: two doses Menactra, 3 mo apart > 2 yr: one dose any vaccine type	Recommended for all adolescents 11-20 yr Use for central Africa, Nepal, and epidemic areas Some efficacy of MenHibrix for children > 3 mo
Seasonally or Geographically Indicated or Required Vaccines			
Seasonal influenza A inactivated virus (intramuscular)	6 mo	If first vaccination, give two doses, 1 mo apart; otherwise, give single dose	Influenza season is December to April in Northern Hemisphere and April to October in Southern Hemisphere
Seasonal influenza A live attenuated virus (intranasal)	5 yr (2 yr)	Single dose	Live attenuated vaccine is given only to healthy, nonasthmatic, nonimmunocompromised children
Hepatitis A: immunoglobulin	Birth	0.02 mL/kg	Hepatitis A protection for those < 1 yr or > 1 yr and travel commencing in < 2 wk; beware of timing with live virus vaccines; effective for 3 mo
Yellow fever live virus	9 mo (6 mo)	Single dose given at least 10 days before departure; booster is given every 10 yr	Required for parts of sub-Saharan Africa and tropical South America; may give at 6-9 mo if infant is traveling to epidemic area, but there is a risk of vaccine-related encephalitis
Typhoid (ViCPS) intramuscular polysaccharide	2 yr	Single dose; booster every 2 yr	Important for Latin America, Asia, and Africa; vaccine is not a substitute for eating and drinking cleanly; only 50% to 80% effective
Typhoid (Ty21a) oral live attenuated	> 6 years	One capsule every 2 days for 4 days; booster every 5 years	Only 50% to 80% effective

TABLE 91-7 Recommended Vaccines for Pediatric Travelers—cont'd

Vaccine	Recommended Age at Vaccination (Earliest Possible Age)	Dosing Schedule	Comments and Contraindications
Vaccines for Extended Stay			
Japanese encephalitis inactivated virus	1 yr (2 mo)	At 0, 28 days; last dose > 10 days before travel; unclear booster interval	Indicated for parts of India and rural Asia if stay > 1 mo; no safety data for children < 1 yr of age; high rate of hypersensitivity
Rabies HDCV (Imovax) or PCEC (RabAvert)	Birth	Days 0, 7, 21-28 if child will be in endemic area for > 1 month	If child has been exposed and previously immunized, repeat either vaccine 1 mL IM days 0, 3 If child has been exposed but not previously immunized, • Give rabies immunoglobulin (RIG) 20 IU/kg as much as possible at site of exposure and the rest IM • Give either vaccine 1 mL IM on days 0, 3, 7, 14

Data from Centers for Disease Control and Prevention: Vaccine recommendations for infants and children: cdc.gov/travel/yellowbook/2014/chapter-7-international-travel-infants-children/vaccine-recommendations-for-infants-children.

all children older than 9 months of age traveling to endemic areas or locales with regional epidemics. If travel to such an area is essential for a younger child, the vaccine MenHibrix has some, albeit modest, efficacy in infants as young as 3 months.[82] Generally, children younger than 9 months should avoid travel to such areas. For families planning more prolonged stays, particularly in rural areas, the primary rabies vaccination series should be considered. Rabies is more common in children than adults, likely due to greater animal contact. Children are also more likely to be bitten on the face, increasing the likelihood of transmission due to a greater vascular supply in this area. If a bite occurs, it should be washed immediately with soap, water, and dilute iodine and the child should be taken to medical attention for primary vaccination and rabies immunoglobulin (if they have not previously been vaccinated).

In the United States, hepatitis A vaccine is recommended for children older than 1 year of age. For children younger than age 1 year or for those unable to receive this vaccine more than 2 weeks before travel, immunoglobulin can provide passive hepatitis A prophylaxis. Administration of immunoglobulin interferes with the humoral response to some of the live attenuated virus vaccines, such as the measles-mumps-rubella and varicella vaccines. If immunoglobulin is given first, these vaccinations should be delayed by at least 6 weeks, and preferably by 3 months, to obtain an adequate immunogenic response.[82] When both are needed for travel, it is best to give the measles-mumps-rubella or varicella vaccine first; the immunoglobulin can be given closer to the time of travel, at least 2 weeks and preferably 4 weeks later. Immunoglobulin does not interfere with antibody production after oral polio or yellow fever vaccines and may be given at the same visit. Yellow fever vaccination is often a requirement for travel to certain countries in Africa and South America. Infants older than age 9 months can receive this live virus vaccination, but younger infants are at risk for vaccine-related encephalitis and should not travel to areas where yellow fever is endemic.[82]

Ideally, a medical visit to discuss travel plans and start immunizations should be made 6 weeks before travel. As mentioned previously, not all immunologic agents recommended for travel are compatible and some require multiple doses. Therefore, selection of immunizations to be given at any one time and the interval between immunizations are important. Table 91-8 presents recommendations for the timing and sequence of specific travel immunizations. In general, all toxoid, recombinant, inactivated, and live attenuated vaccines may be given simultaneously. Live attenuated vaccines should be given either simultaneously or at least 30 days apart to avoid reduced immunoreactivity to each vaccine.

PROPHYLAXIS: MALARIA

In 2013, there were 198 million cases of malaria worldwide, with 584,000 deaths, the majority in sub-Saharan Africa.[88] Children younger than 5 years are particularly vulnerable and represent more than 80% of the fatalities from this disease. In Africa, malaria is responsible for 20% of all childhood deaths. The risk of acquiring malaria (see Chapter 40) during visits to developing countries in the tropics is significant. Even areas where the overall risk is relatively low may have foci of intense transmission. The number of cases of malaria diagnosed in the United States is steadily rising, with nearly 2000 cases reported in 2011.[53] Of these patients, nearly 70% came from sub-Saharan Africa, 22% from Asia, and 8% from Caribbean nations. Fifteen percent of these cases involved children under the age of 18 years. Of note, children with malaria can rapidly develop high levels of parasitemia and are, therefore, at greater risk of severe complications, including shock, seizures, coma, and death.

Protective measures to prevent mosquito bites help interrupt transmission of malaria but are not foolproof (see Box 91-2). Therefore, chemoprophylaxis is highly recommended for travelers to countries where malaria is endemic. *Plasmodium falciparum* (64%) and *Plasmodium vivax* (28%) are the two species

TABLE 91-8 Recommended Timing and Sequence of Nonroutine Immunizations for Foreign Travel*

4-6 Weeks Before Departure	1 Week After Initial Visit	7-10 Days Before Departure
Hepatitis A (need second dose 6-12 months later)	—	Immunoglobulin for hepatitis A prevention if vaccine not given
Yellow fever	—	
Typhoid ViCPS or Ty21a	—	
Meningococcal	—	
Japanese encephalitis		Japanese encephalitis
Rabies	Rabies	Rabies

*Give only immunizations indicated for area of travel, length of stay, and age of child.
Simultaneous administration of routine and travel-related vaccines is acceptable with the exception of measles-mumps-rubella vaccine or varicella vaccine with immunoglobulin. Administer immunoglobulin at least 3 weeks after these live virus vaccines.

TABLE 91-9 Malaria Chemoprophylaxis

Medication	Indications and Contraindications	Dosage
Chloroquine (Aralen) (liquid form Nivaquine not available in United States)	Travel to chloroquine-sensitive areas (Caribbean, Central America north of Panama, Middle East)	5 mg base/kg every wk up to 300 mg starting 1 wk before exposure until 4 wk after exposure; 10 mg/mL form available outside United States
Mefloquine (Lariam) (250 mg tab)	Travel to chloroquine-resistant/mefloquine-sensitive area; do not use in setting of epilepsy, psychiatric illness, cardiac arrhythmias	Give every week starting 1 wk before exposure until 4 wk after exposure Dosage: < 9 kg: 5 mg/kg/week 10-20 kg: 1/4 tab every wk 20-30 kg: 1/2 tab every wk 30-45 kg: 3/4 tab every wk > 45 kg: 1 tab every wk
Atovaquone (A) plus Proguanil (P) (Malarone) Pedi tab: 62.5 mg A/25 mg P Adult tab: 250 mg A/ 100 mg P	Travel to chloroquine- or mefloquine-resistant areas; contraindicated if creatinine clearance < 30 mL/min; give 2 days prior to exposure through 7 days after exposure	5-8 kg: 1/2 pedi tab every day 8-10 kg: 3/4 pedi tab every day 10-20 kg: 1 pedi tab every day 20-30 kg: 2 pedi tab every day 30-40 kg: 3 pedi tab every day > 40 kg: 1 adult tab every day For emergency treatment: take four times usual prophylaxis dose listed above every day for 3 days if NOT used for prophylaxis
Doxycycline	Travel to chloroquine- or mefloquine-resistant areas; > 8 yr of age only; beware of photosensitivity	2 mg/kg/day up to 100 mg/day for 1-2 days before exposure and for 4 wk after exposure
Artemether-lumefantrine (Coartem 20/120)	Emergency treatment if medical assistance > 24 hours away and malaria suspected; NOT for prophylaxis	5-15 kg: 1 tab every day for 3 days 15-25 kg: 2 tabs every day for 3 days 25-35 kg: 3 tabs every day for 3 days > 35 kg: 4 tabs every day for 3 days
Primaquine	Prevention of relapse with *P. vivax* or *P. ovale;* use after prolonged stay in malaria-endemic area; avoid if glucose-6-phosphate dehydrogenase deficient	0.5 mg/kg/day for 14 days

Data from Centers for Disease Control and Prevention: Information for health care providers: Malaria: cdc.gov/travel/yellowbook/2014/chapter-3-infectious-diseases-related-to-travel/malaria.

most often responsible for malaria. The most lethal plasmodium, *P. falciparum,* has developed widespread resistance to chloroquine and in some areas (extreme northern and southern Thailand, Cambodia, Myanmar), resistance to mefloquine.[52] Therefore, the choice of prophylactic agent is based primarily on the presence of resistant malaria in the area of travel. The age, weight, and medical history of the child are additional determinants of the appropriate prophylactic agent. Table 91-9 lists the available options for malaria chemoprophylaxis.

If a child is traveling to a chloroquine-sensitive area, such as the Caribbean, parts of Central America, or the Middle East, chloroquine is the drug of choice. Chloroquine prophylaxis should be given weekly, starting 1 week before travel, and continued for 4 weeks thereafter. Chloroquine passes through breast milk, but not in sufficient quantities to protect an infant. Therefore, a breastfed infant should receive chloroquine prophylaxis in standard recommended doses (see Table 91-9). Chloroquine is not readily available in a liquid form in the United States. The powder, which is extremely bitter, may be suspended in a syrup or mixed with food. Instant pudding effectively masks the bitter taste and makes the medicine more palatable. An acceptable-tasting chloroquine liquid (Nivaquine) is available outside the United States. Chloroquine should be kept out of the reach of children. As little as 300 mg may be fatal in small children.[72] If a toxic chloroquine ingestion occurs, the child should be transported promptly to a medical facility.

For children traveling to chloroquine-resistant areas, the next question is whether they are traveling to an area that is also mefloquine resistant. This includes parts of Myanmar (Burma), Cambodia, and Thailand. If the area is mefloquine sensitive, then mefloquine (Lariam) is a good option. The advantage of mefloquine is that the dose is given weekly, from 1 to 2 weeks before travel until 4 weeks after return. It should be avoided in children who weigh less than 5 kg and in those with psychiatric illnesses, epilepsy, or underlying cardiac arrhythmias. If the area is mefloquine resistant (or is mefloquine sensitive but contraindications to mefloquine exist or parents prefer not to use mefloquine), the two options are atovaquone plus proguanil (Malarone) or doxycycline. Malarone is approved in the United States for children weighing more than 5 kg, but requires daily administration. It must be taken 2 days before entry into a malarial area and continued for 7 days after leaving. It is contraindicated in the setting of severe renal impairment (creatinine clearance < 30 mL/min). Atovaquone-proguanil and mefloquine are available only in tablet form, but tablets may be administered crushed. Alternatively, a compounding pharmacist may prepare the child's dose in a gelatin capsule and the contents of the capsule can be placed in food just prior to administration. Doxycycline is indicated for children older than age 8 years traveling to mefloquine-resistant areas or with contraindications to mefloquine or atovaquone-proguanil use. It must be given daily. It is started 1 to 2 days before and continued for 4 weeks after travel to a malarial area. Side effects include diarrhea and photosensitivity. With all antimalarials, particularly those given daily, timing of medication ingestion is critical. Medications should be taken at the same time each day or week, to avoid a drop in blood levels below the level of efficacy. Given the difficulties in administering medications to children, weekly dosing (mefloquine) may be preferable when this is an option. The importance of proper prophylaxis against malaria cannot be overemphasized. In a review of pediatric malaria cases, 75% to 100% of patients had received no or inadequate chemoprophylaxis.[22,76]

Families traveling to remote areas where malaria is endemic but where medical care may not be immediately available should consider carrying a treatment regimen for the disease, to be administered if their child develops an acute febrile illness. This medication is not intended to be a replacement for definitive medical care; it is simply a temporizing measure. This treatment

may be either atovaquone-proguanil if it is not being used for prophylaxis or artemether-lumefantrine (Coartem). Full guidelines for medication choice and dosing regimens are found on the CDC website.[36] Of note, artemisinin-derived agents are not generally used for prophylaxis, because the short half-lives of these drugs would require multiple daily doses.

Primaquine is an antimalarial drug used to prevent emergence of *P. vivax* and *Plasmodium ovale* after heavy or prolonged (many months) exposure to mosquitoes. Routine chemoprophylaxis does not kill the exoerythrocytic stages of these *Plasmodium* species. Primaquine is taken daily for 2 weeks after leaving a malarial area. Primaquine should not be given to anyone with glucose-6-phosphate dehydrogenase deficiency.

TRAVEL-RELATED PROBLEMS

Next to boredom and restlessness, motion sickness and eustachian tube dysfunction are the most common problems encountered by children during travel. Parents can minimize the first two problems by preparing small activity packs or bags with paper, pencils, crayons, stickers, cards, travel puzzles, or small toys. Once at their destination, children most frequently suffer from diarrhea, fevers, rashes, and respiratory tract infections.[37] Parents should be aware of the basic elements of diagnosis and treatment and the indications for immediate medical attention.

MOTION SICKNESS

Motion sickness can occur with air, land, or sea travel (see Chapter 70), particularly in children ages 2 through 12 years. Emotional upset, noxious odors, and ear infections can make symptoms worse. Children experiencing motion sickness are often pale and diaphoretic, and feel nauseated and weak. They may vomit, but this does not provide prolonged relief. Children known to be susceptible to motion sickness should be seated in the middle or near the front of the boat, plane, or car, where motion is minimized. They should be encouraged to look at objects far away and avoid focusing on close objects, such as books. Some children get significant relief from using headphones to listen to music or stories.

Dimenhydrinate (Dramamine, 1 to 1.5 mg/kg) administered 1 hour before departure and repeated every 6 hours can help patients known to be prone to motion sickness. If dimenhydrinate is not available, diphenhydramine (Benadryl, 1.25 mg/kg every 6 hours up to 50 mg/dose) is also effective. Both medications may cause drowsiness, and diphenhydramine occasionally causes paradoxic excitability in children. Scopolamine patches, commonly used in adults, should not be used in children, because they are particularly susceptible to the side effects of belladonna alkaloids. It has been postulated that this particular administration system might release too much scopolamine and, consequently, produce serious side effects in children.

EUSTACHIAN TUBE DYSFUNCTION

Eustachian tube dysfunction is the result of disequilibrium between pressure in the eustachian tube and the surrounding atmospheric pressure. If atmospheric pressure rises (e.g., with descent in an airplane) and the pressure within the tube does not rise as quickly as the ambient pressure, the eustachian tube becomes compressed. If compressed enough, the eustachian tube cannot equalize pressure in the middle ear with that of the environment, resulting in a sense of compression on the outer aspect of the tympanic membrane. Far more children than adults (nearly 15% of the pediatric population) suffer from this problem, because of the relatively smaller, and hence more compressible, pediatric eustachian tube. Swallowing often helps relieve the pressure disequilibrium and may be facilitated by drinking, sucking on a pacifier, or, for the breastfed infant, nursing. Older children may wish to chew gum or yawn to equalize middle ear and atmospheric pressure. Contrary to popular belief, decongestants are not useful with eustachian tube dysfunction in children and should generally be avoided in young children.

TRAVELER'S DIARRHEA

Traveling to wilderness areas or developing countries requires leaving behind modern sanitation facilities and reliably disinfected tap water. Unfortunately, this places travelers at increased risk for diarrheal illness (see Chapter 82). Up to 60% of children younger than age 3 years develop prolonged diarrhea (> 10 days) during travel in tropical or subtropical areas.[3,14] This risk is highest in young visitors to Africa and India, followed by travelers to Asia and Latin America. Young children are at greater risk for traveler's diarrhea (TD) and its complications because of their relatively poor hygiene, oral exploration, immature immune systems, higher gastric pH, more rapid gastric emptying, and difficulties with adequate hydration.

TD is defined by the National Institutes of Health as a twofold or greater increase in the frequency of unformed stools, or any number of such stools when accompanied by symptoms of fever, abdominal cramping, vomiting, or blood or mucus in the stools. In small children, the course tends to be more severe and prolonged, lasting from 3 days to 3 weeks.[3,79] Most cases of TD (>80%) are caused by bacteria, followed by parasites (10%) and viruses (5% to 8%) (Table 91-10). Enterotoxigenic *Escherichia coli* alone is responsible for 50% of TD cases.[79] *Campylobacter* and *Shigella* are also prominent causes of TD, along with rotavirus and norovirus. *Giardia* is by far the most common parasitic cause of TD and more indolent in onset.

Prevention

Standard recommendations for prevention of TD are based primarily on known potential sources for transmission of illness (see Box 91-4). Transmission is through fecal-oral contamination, with water, food, and fingers the most common vehicles. Careful selection and preparation of food and beverages can decrease the risk of acquiring TD. As mentioned previously, washing hands thoroughly before eating decreases bacterial carriage and serves as a reminder to children of the need for precautions. If soap is unavailable, gross particles can be rinsed off with water and the hands then cleansed with a hand sanitizer that is more than 60% alcohol based. The "boil it, cook it, peel it, or forget it" rule implies that all raw vegetables and salads should be avoided, meats and seafood be well cooked, and fruits properly peeled. See Chapter 88 for a complete discussion of water disinfection.

Using antibiotics to prevent TD in children is not recommended by the CDC due to concerns about adverse drug effects and the development of drug resistance. Bismuth subsalicylate (Pepto-Bismol) has been shown in adults to be an effective form

TABLE 91-10 Causes of Traveler's Diarrhea in Children

Agent	Examples
Preformed toxin	Enterotoxigenic *Escherichia coli**
	Staphylococcus aureus
	Bacillus cereus
Viral	Rotavirus*
	Norovirus*
	Adenovirus
	Enterovirus
	Influenza virus
	Hepatitis virus
Bacterial	*Shigella**
	*Campylobacter**
	Salmonella
	Enteroinvasive *E. coli*
	Yersinia enterocolitica
	Vibrio cholerae
Parasitic	*Giardia lamblia*
	Entamoeba histolytica
	Cryptosporidium

*Most common.

BOX 91-5 Signs of Dehydration

Mild to Moderate (5% to 10%)
Irritability/restlessness
Sunken eyes/fontanelle
Dry mucous membranes
Very thirsty
Decreased urine output

Severe (>10%)
Lethargy
Very sunken eyes
Very dry mucous membranes
Unable to take liquids orally
Cool, mottled extremities
Rapid, thready pulse
Tachypnea
No urine output for several hours

BOX 91-6 Homemade Oral Rehydration Solutions

Glucose-Based Solutions*
1 teaspoon (5 mL) salt
8 teaspoons (40 mL) sugar
1 L disinfected/boiled water

Rice Cereal–Based Solutions*
1 teaspoon (5 mL) salt
1 cup (50 g) rice cereal
1 L disinfected/boiled water

Data from rehydrate.org.
*Can be used directly or diluted in half to reduce osmolarity. Add mashed banana to rice cereal–based solution to add K^+. Solutions left without refrigeration for more than 12 hours should be discarded.

of chemoprophylaxis against TD. The few small studies in children have demonstrated modest, if any, efficacy.[3,90] Therefore, and because of the risk of administering salicylates to children, using bismuth subsalicylate for TD prevention in children, particularly those younger than age 3 years, is not recommended. Probiotic agents, such as *Lactobacillus acidophilus,* have been shown to be effective for prevention and treatment of TD in children.[4,13,70] The mechanism of action of these nonpathogenic live microorganisms is not entirely clear, but most likely involves competition with pathogens for intestinal receptors and nutrients, improving immune function in the gut, increasing intestinal acidity, reducing intestinal permeability, and/or production of chemicals by the probiotic agent with efficacy against pathogens.[4] *Lactobacillus* is available over the counter; the dosage is one tablet or capsule a day for children younger than age 2 years, and two a day for children older than 2 years. Capsules can be opened and the contents placed in food or drink for children unable or unwilling to take pills.

Treatment

The major cause of illness and death in infants and small children with diarrhea is dehydration.[3,79] Signs of dehydration in children are listed in Box 91-5. According to the WHO, dehydration is best categorized as mild to moderate, or severe. This distinction is based on changes in behavior and mental state, quality of the mucous membranes, presence of oliguria or anuria, changes in vital signs, and evidence of decreasing peripheral perfusion. Parental assessment of dehydration using urine output, tearing, and fontanelle contour has been shown to be accurate.[3,20] Children young enough to be wearing diapers should have some urine output at least every 8 hours. If they do not, they are very likely dehydrated.

The cornerstone of treatment for TD is oral rehydration therapy (ORT), which if instituted early, can be used alone in 90% to 95% of cases.[5] It is as effective as intravenous hydration in mild to moderate dehydration caused by gastroenteritis. ORT is often tolerated by children who are vomiting if it is administered frequently in small quantities. The truly dehydrated child will typically drink an oral rehydration solution (ORS) eagerly. Parents traveling to developing countries or wilderness areas with children should carry powdered ORS or a recipe for a homemade solution (Box 91-6). Powdered ORS is readily available in most developing countries in pharmacies and drugstores. Most available ORS is glucose-based. In the past, the standard WHO ORS was not particularly effective in reducing stool frequency and volume. By reducing the osmolarity of an ORS, stool frequency in children with noncholera diarrhea is reduced and ORS requirements may be reduced by as much as 20%.[5] Many studies have looked at the efficacy of rice-based ORS relative to the WHO standard and reduced-osmolarity ORS. Rice-based ORS is less expensive and often better tolerated by children, particularly those in nations where people consume a great deal of rice. The rice-based ORS (e.g., CeraLyte: ceraproductsinc.com) has a slightly lower osmolarity and higher concentration of organic solutes, two aspects that promote enhanced absorption of Na^+ and water.[33] Although rice-based ORS appears superior to standard WHO ORS in several studies, there have not been studies with sufficient power to demonstrate any difference in efficacy relative to the reduced-osmolarity ORS. Therefore, either rice-based ORS or reduced-osmolarity WHO ORS can be used. All ORSs should be discarded 12 hours after reconstitution when left at room temperature, and after 24 hours if they have been refrigerated.

For rapid treatment of mild to moderate dehydration, 50 to 100 mL/kg of ORS should be administered over the first 4-hour period to rehydrate the child. An additional 10 mL/kg can be given for each diarrheal stool and 5 mL/kg for each episode of emesis. If vomiting develops, most children will tolerate ORS if a small volume (5 to 10 mL) is given every 5 minutes. Reduced-osmolarity ORS contains 75 mEq/L of sodium, 1.5% glucose, and 20 mEq/L of potassium (Table 91-11). If a solution with more glucose is used, the osmotic pressure exerted by the carbohydrate in the intestinal lumen produces fluid losses greater than the amounts of fluid absorbed, thereby exacerbating diarrhea. Most colas, sports drinks, and juices contain 6% to 15% carbohydrate and are not appropriate rehydration solutions. Once a child has been rehydrated, ORS may be rejected, and

TABLE 91-11 Field Treatment of Dehydration

	Low-Osmolarity Glucose-Based Oral Rehydration Solution*	Ceralyte, Rice Cereal–Based Oral Rehydration Solution*	Apple Juice
Volume	50-100 mL/kg/4 hours	Same	Not recommended
Electrolytes			
Na^+ (mEq/L)	75	50-90	0.4
Glucose (%)	1.5-2.5	4	12
K^+ (mEq/L)	20	20	44
HCO_3^- (mEq/L)	30	30	None
Osmolarity (mOsm/L)	245	220	730

Data from Atia AN, Buchman AL: ORS in non-cholera diarrhea, Am J Gastroenterol 104:2596, 2009.
*Add 10 mL/kg or about 4 oz for each diarrheal stool and 5 mL/kg or about 2 oz for each bout of emesis.

regular liquids can be resumed. There is no scientific basis for any highly restrictive diet during and following diarrhea, including the popular BRAT diet (bananas, rice, apples, toast). Feeding of solid food, particularly complex carbohydrates and yogurt, should be resumed as soon as vomiting resolves. Solid food promotes enterocyte regeneration and reduces duration of diarrhea.[2,4] Foods (e.g., juice) with high concentrations of simple sugars can exacerbate diarrhea because of their high osmotic load, as can lactose-containing foods due to transient lactase deficiency.[51] Both should be avoided in the recovery phase.

Although oral hydration is the cornerstone of therapy for TD, medications may occasionally be helpful. Children with large volumes of diarrhea can develop zinc deficiency. Zinc is important not only for cellular immunity but also for maintenance of gut mucosal cells. Zinc deficiency can lead to a vicious cycle of increasing duration and severity of diarrhea. Zinc supplementation in acute diarrhea has been shown to reduce the duration of diarrhea and the ORS requirement.[47,90] Presently, the WHO recommends zinc supplementation (20 mg/day for 10 to 14 days for children ≥ 6 months of age and 10 mg/day for children < 6 months of age) with ORS in children in the developing world with acute diarrheal illness.[47] Given current evidence, this recommendation should be followed by young travelers with acute diarrhea.

The American Academy of Pediatrics does not support the use of antimotility agents in children because of concern for ileus and decreased mental status. However, a recent Cochrane Database review demonstrated a modest benefit of loperamide in children, reducing the duration of diarrhea and the stool frequency.[20] High-volume, frequent, and prolonged diarrhea can not only lead to significant dehydration but also significant perianal skin breakdown and superinfection in children still in diapers. Based on this and other data, antimotility agents, specifically loperamide (Imodium) should be considered in children over the age of 3 years. The dosage is 1 to 2 mg for the first dose followed by 1 to 2 mg after each loose stool with a maximum of 3 mg daily in 3- to 5-year-olds, 4 mg daily in 5- to 8-year-olds, and 6 mg daily in 8- to 12-year-olds. Diphenoxylate (Lomotil) is not recommended, because its use has been associated with toxic megacolon in individuals with bacterial invasive diarrhea. Other antidiarrheal agents, such as bismuth subsalicylate or attapulgite, have not been convincingly shown to be effective in children and should be avoided, given the dangers of aspirin products in children under the age of 12 years.[3,20,79]

Empirical treatment with antibiotics for TD is safe and effective in reducing TD severity and duration in adults and children, but concern about adverse effects and development of bacterial resistance has made recommendations for pediatric use inconsistent. Currently, the CDC recommends using antibiotics in children to reduce duration of diarrhea acquired in areas with high rates of TD, particularly cases with fever, bloody stool, and/or abdominal distention.[79] Caution is advised if shiga-toxin producing *E. coli* is suspected, because antibiotics can increase the risk of hemolytic-uremic syndrome. With increasing bacterial resistance to trimethoprim-sulfamethoxazole, azithromycin is now the drug of choice for treatment of bacterial diarrhea.[3,79,90] The dosage is 10 mg/kg/day up to 500 mg a day for 3 days. In children over 12 years of age, ciprofloxacin at a dose of 15 to 20 mg/kg (maximum 500 mg) every 12 hours for 3 days may be used. Bacterial resistance to quinolones is increasing, particularly in Southeast Asia, making azithromycin the best choice.[79,90] Severe dehydration, high fever, failure of ORT, failure of antibiotic therapy for bloody diarrhea, or altered mental status require prompt medical attention and administration of intravenous fluids for rehydration (Box 91-7). Typhoid fever caused by *Salmonella typhi* should be managed initially in a hospital setting with a quinolone, azithromycin, or a third-generation cephalosporin, such as ceftriaxone, depending on regional resistance patterns and the appearance of the child.[50,81]

BOX 91-7 Indications for Seeking Immediate Medical Attention for Children With Diarrhea

Severe dehydration
High fever
Failure of oral rehydration therapy
Failure of antibiotic treatment for bloody diarrhea
Altered mental status
Suspicion of typhoid fever

CONSTIPATION

Although not as serious a problem as diarrhea, constipation can be a significant and uncomfortable issue for children during travel. Several factors can contribute to development of constipation:

Change in diet
Decline in fruit, vegetable, and water consumption because of sanitary concerns in developing countries
Viral illnesses
Dehydration

Constipation is defined as decrease in stool frequency and increased firmness of the stool. Firm stool is more difficult to pass and can result in painful anal fissures and hemorrhoids. Children who experience anal pain during defecation may choose to retain stool, exacerbating the constipation problem.

The best approaches to constipation are prevention and, if that fails, early management. To prevent constipation, parents should provide safe fruits and vegetables or dried prunes for their children and should actively encourage clean water consumption. Anal fissures and hemorrhoids should be managed with sitz baths, vitamin A and D ointment, and antiinflammatory hemorrhoidal creams such as Anusol. If these approaches fail, bulk stool softeners (e.g., Metamucil) and, in extreme cases, hypertonic phosphate enemas (e.g., Fleets) or polyethylene glycol (Miralax) can be used in children older than 1 year. Laxatives are not generally recommended, because chronic use can actually result in paradoxic constipation. If constipation is accompanied by severe abdominal pain, distention, vomiting, or fever, children should be brought to medical attention for further evaluation.

ABDOMINAL PAIN

Abdominal pain is a common complaint in children. The causes range widely, from extremely benign viral infections or constipation to serious or life-threatening conditions such as appendicitis or ectopic pregnancy. Caregivers accompanying children into the backcountry or to developing countries should be taught the basic indications for seeking medical treatment for this complaint. Abdominal discomfort accompanied by vomiting or diarrhea may be observed for 12 hours with appropriate hydration. If the pain worsens or fails to resolve, or the child develops high fever, vomiting for more than 24 hours, focal abdominal tenderness, or abdominal distention, the child should be brought to medical attention. If a child complains of suprapubic pain and dysuria, a 7-day course of antibiotics (e.g., cephalexin or ciprofloxacin in older children) may be administered for presumed bladder infection. If the symptoms do not improve in 2 to 3 days, or if high fever or back pain develops, the child should be brought to medical attention because these symptoms suggest pyelonephritis. In adolescent girls, the presence of lower abdominal pain, amenorrhea, or vaginal bleeding suggests the possibility of ectopic pregnancy. If this is suspected, immediate medical evaluation is indicated.

RESPIRATORY INFECTIONS AND OTITIS MEDIA

Respiratory tract and otolaryngologic infections are very common in the pediatric population. The majority of infections, including acute otitis media, sinusitis, pharyngitis, croup, bronchiolitis, and bronchitis, involve the upper respiratory tract. The vast majority of these are viral in etiology; a minority are the result of infections with *Streptococcus pneumoniae, Haemophilus influenzae,*

or *Moraxella catarrhalis*.[71,91] Because definitive diagnoses based on otoscopy and auscultation of the lungs often cannot be made in the course of wilderness travel, parents must rely on symptoms and the presence of fever to determine whether treatment is necessary. Presence of high fever plus otalgia for more than 2 days, or sore throat without cough or rhinorrhea, probably merits both antimicrobial and symptomatic treatment. Mucopurulent nasal discharge lasting longer than 10 days may indicate a bacterial cause of sinusitis and also merits antibiotic therapy. It should be noted, however, that acute otitis media and streptococcal pharyngitis cases typically resolve without intervention.[71,91] Furthermore, antibiotic treatment of upper respiratory tract infections, such as bronchitis, bronchiolitis, croup, and most cases of pharyngitis, does not shorten the course, minimize symptoms, or decrease complications. If streptococcal pharyngitis is suspected on the basis of absence of cough or coryza and the presence of fever, cervical lymphadenopathy, and tonsillar exudate, then antibiotic therapy may be warranted. Antibiotics for streptococcal pharyngitis mildly reduce duration of disease, incidence of suppurative complications, such as peritonsillar abscess, and incidence of rheumatic fever.

With increasing use of antibiotics, bacterial resistance to these agents has risen dramatically. Forty to fifty percent of *S. pneumoniae* isolates now produce beta lactamase. Introduction of the 13-valent pneumococcal vaccine has changed the microbial representation in acute otitis media, with *H. influenzae* and *M. catarrhalis* now more common.[41] Nonetheless, minimal inhibitory concentration testing has demonstrated sensitivity of these bacterial agents to high-dose amoxicillin, even among resistant strains. First-line therapy for suspected bacterial acute otitis media or sinusitis is, therefore, high-dose amoxicillin at 80 mg/kg/day divided into two doses per day. Second-line therapy is high-dose amoxicillin-clavulanate (80 mg/kg/day divided into two doses per day) or cefuroxime (15 mg/kg twice a day). Uncomplicated acute otitis media in children older than 2 years may be treated for 5 to 7 days; otherwise, the standard treatment for acute otitis media is 10 days, and for sinusitis 14 days.[16] Suspected streptococcal pharyngitis can be treated for 10 days with amoxicillin, or for 5 days with azithromycin (10 mg/kg on day 1; then 5 mg/kg/day on days 2 to 5).

Often more important for patients than antibiotics are medications for symptomatic relief. Judicious use of acetaminophen (15 mg/kg every 4 hours) and/or ibuprofen (10 mg/kg every 6 to 8 hours) along with a topical analgesic (e.g., antipyrine-benzocaine otic drops) is strongly recommended.

If influenza is suspected based on the season of the year, regional epidemics, and symptoms (e.g., high fever, respiratory symptoms, myalgias), parents should consider administering oseltamivir (3 mg/kg/dose twice daily) to high-risk children. High-risk children are those younger than age 5 years (particularly < 2 years), with chronic lung or other organ dysfunction, who are immunocompromised (e.g., infection with human immunodeficiency virus, diabetes), or are taking long-term aspirin therapy.[40] Treatment is most effective in reducing length and severity of disease if it is given within the first 48 hours of illness. Any child with suspected influenza who appears ill or has signs of lower respiratory tract infection should immediately be given oseltamivir and taken to the nearest medical facility.

Coughing is a common symptom associated with viral upper respiratory infections in children. A cough may persist for weeks after resolution of other viral symptoms. Its persistence is not an indication for antibiotics unless pertussis is strongly suspected based on exposure, severity of cough (plus persistence), and vaccination history. Generally, antitussives such as dextromethorphan are not recommended for children due to concerns regarding the effects of narcotic products on young children. Humidifiers and steam from a running shower have anecdotally provided significant relief for coughing children, particularly at night when the cough tends to worsen. Several studies have also looked at the salutatory effects of honey on a pediatric cough and found it to be equivalent in efficacy to traditional antitussives.[74] Honey should not be used in children under the age of 1 year because of the risk of botulism. If there is concern for foreign body aspiration or if the child has a significant voice change or signs of respiratory distress, caregivers should bring the child to immediate medical attention.

BOX 91-8 Indications for Seeking Immediate Medical Attention for Children With Fever

Appearance of being ill
< 3 mo of age and temperature > 38° C (100.4° F)
< 3 yr old and fever ≥ 40° C (104° F) without clear source for ≥ 3 days
< 3 yr old and unvaccinated or incompletely vaccinated with fever ≥ 39° C (102° F) for 2 to 3 days without clear source
≥ 5 days of fever
Immunocompromised or serious chronic medical condition
Malaria, typhoid, or other serious tropical disease suspected based on regional epidemic or endemic disease patterns

FEVER OF UNCLEAR ETIOLOGY

High fever that develops in a child during the course of foreign travel may be the result of a common infection (e.g., viral syndrome, pharyngitis) or the manifestation of a tropical disease. Box 91-8 lists the indications for prompt medical attention in a child with fever. The leading tropical cause of fever in travelers to Africa is malaria. If malaria is suspected, the child should immediately be taken to the closest medical facility because most cases of illness and most deaths related to malaria occur in children. If a medical facility cannot be reached within 24 hours, any child weighing more than 5 kg (11 lb) should be given atovaquone-proguanil or artemether-lumefantrine as standby treatment, as previously described and indicated in Table 91-9.[36]

In adult and child travelers to most other parts of the world, dengue is the most common cause of tropical fever.[37] Unfortunately, 95% of dengue cases worldwide are among children under the age of 15 years.[83] The result of a mosquito-borne arbovirus, dengue is characterized by fever, headaches, a maculopapular rash, and myalgias. Symptoms range from mild fever to hemorrhagic shock, with infants younger than 1 year and children between the ages of 4 and 9 years at greatest risk of severe disease.[83] With the exception of hemorrhagic dengue, treatment of dengue fever is purely symptomatic. The southeastern United States and Hawaii have substantial populations of dengue-carrying *Aedes aegypti* mosquitoes that cause sporadic cases. Mosquito avoidance is the best approach to preventing disease. Unlike the malarial vector, the mosquitoes bearing dengue are most active during the daytime, so protective clothing and repellents should be used during all of the child's waking hours. There is no prophylaxis or vaccine available to prevent dengue.

Typhoid fever, caused by the bacteria *Salmonella enterica* serotype Typhi, is another common cause of tropical fever in children. The risk is highest among travelers to southern and Southeast Asia (6 to 30 times as high).[81] Onset of the disease is insidious with gradually increasing fever, headache, and anorexia; diarrhea develops later in the course of the disease. Children who appear ill may have invasive typhoidal disease and should be treated in a medical facility. Resistance to antibiotics is rising in developing countries, but strains are typically susceptible to azithromycin and third-generation cephalosporins (e.g., ceftriaxone). Quinolones, once the mainstay of therapy, are becoming less effective and are generally not indicated in children under 12 years of age.[1] Transmission of typhoid is strictly fecal-oral between human hosts, so thorough hand washing is essential. Food and water precautions mentioned previously should be observed. Two vaccinations are available to prevent typhoid fever and are 50% to 80% effective in preventing disease. The Vi capsular polysaccharide vaccine (ViCPS) is recommended for children over 2 years of age and consists of a single dose of vaccine administered 2 weeks prior to travel. A booster is required every 2 years. An alternative is an oral, live attenuated vaccine (Vivotif) that consists of a series of four capsules, with one taken

every other day. Repeat dosing is required every 5 years. This vaccine is not recommended in children under 6 years of age.

HEADACHE

Headache is a common travel-related problem in the adolescent population. The most common causes of headaches in children are viral illnesses, migraines, dental infections, sinusitis, tension, or fatigue. Life-threatening causes of headache, such as meningitis, spontaneous or posttraumatic intracranial bleeding, or mass lesions, should be considered in any child with this complaint. Parasitic diseases, such as dengue fever and malaria, can also cause severe headache.

A child with a tender tooth or tenderness to palpation of the sinuses should be managed with analgesics (e.g., acetaminophen or ibuprofen) and antibiotics. Dental infections respond well to amoxicillin and a visit to the dentist for definitive management. (See Respiratory Infections and Otitis Media, earlier, for information on antibiotic treatment of sinus infections.) If a child has had a previous migraine headache or has a history that is classic for migraine (e.g., unilateral headache, aura, visual scotoma, photophobia, nausea, family history of migraine), analgesics and rest in a quiet, dark room are appropriate first-line therapies. Caffeine in the form of a strong cup of coffee is also a helpful improvisational treatment for migraine headaches. If a child's headache is accompanied by high fever, neck stiffness, vomiting, confusion, neurologic abnormalities, or a recent history of trauma, the child should be brought to medical attention immediately.

CONJUNCTIVITIS

Conjunctivitis, or "pinkeye," is a common pediatric problem. Most conjunctivitis in children is either allergic or infectious (e.g., adenovirus, *Staphylococcus, Streptococcus,* or *Haemophilus*). Itching and clear discharge suggest an allergic cause best treated with a topical or systemic antihistamine (e.g., diphenhydramine). Absence of itching, along with a slightly thicker or colored discharge from one or both eyes, is more consistent with an infectious cause of conjunctivitis. Distinguishing between viral and bacterial causes can be very difficult, so all patients with suspected infectious conjunctivitis should be treated with a topical antibiotic, such as erythromycin ointment (four times a day for 7 days), or polymyxin B sulfate plus trimethoprim (Polytrim) ophthalmic solution (1 drop every 3 hours for 7 days). Drops are preferred when the child is willing to accept them because they do not obscure vision. Eye discharge should be wiped from the eye with a warm moist cloth, and contact precautions should be exercised to prevent spread of what is a very infectious condition until the discharge resolves.

If the presence of a foreign body in the eye is suspected or there is chemical exposure to the eye, a drop of topical ocular anesthetic, such as proparacaine, should be applied and the eye flushed vigorously with water. Caregivers should then administer oral analgesics to the child and apply topical antibiotic ointment or solution for 24 to 48 hours. If the foreign body sensation persists after 1 to 2 days, there is likely to be a retained foreign body and the child should be brought to medical attention. In addition, the presence of eye pain, periorbital swelling, fever, photophobia, or visual blurring with or without a history of antecedent eye trauma or contact lens use suggests a more serious diagnosis and should prompt immediate medical attention.

RASHES

Identification of rashes in children is an art. Although parents cannot be expected to become familiar with all types of rashes, they may be able to distinguish common rashes from potentially dangerous exanthems. Petechial, purpuric, or mucosal lesions are markers for potentially serious diseases and should prompt parents to seek medical attention immediately. Standard dermatology textbooks with photographs can be used to instruct parents to recognize common viral exanthems and rashes caused by varicella, scabies, and contact dermatitis (e.g., poison oak or poison ivy). Scabies can most safely be abolished with permethrin. Contact dermatitis often can be simply treated with 1% hydrocortisone cream and diphenhydramine (see Chapter 64). When dermatitis covers the face, genitals, or large portions of the child's skin, systemic corticosteroids may be indicated.

LACERATIONS

Soft tissue injuries are extremely common among children, particularly as they become more ambulatory. All wounds should be thoroughly irrigated with clean water and explored to ensure that no foreign bodies remain. Children with lacerations that require suturing should be brought to medical attention. In general, lacerations should not be sutured in the backcountry or in a remote area, outside a medical facility, because of the risk of infection. Such lacerations should be covered with a water-resistant dressing, splinted if located over a joint, and observed. If no evidence of infection develops over 4 to 5 days, the laceration may be repaired by delayed primary closure. One exception is a laceration to the face. The face has an excellent blood supply and infections are rare. After thorough irrigation via a 14-gauge intravenous catheter attached to a syringe, relatively superficial facial wounds can be approximated with adhesive wound closure strips and then repaired with tissue glue. Scalp lacerations that are relatively superficial and uncontaminated can also be repaired after thorough irrigation. The most straightforward technique that can be used in children with hair longer than 3 cm is that of hair apposition. Strands of hair are taken from each side of the wound, twisted to achieve wound closure, and "locked" in place with cyanoacrylate glue (Figure 91-13).

If a wound becomes infected, it should be kept elevated and warm compresses applied. Given the rising incidence of methicillin–resistant *Staphylococcus aureus* (MRSA), antibiotics effective against this bacteria should be initiated promptly. Trimethoprim-sulfamethoxazole is an excellent agent. The dose is 8 to 10 mg/kg/day of the trimethoprim component divided twice daily. This is often paired with cephalexin 25 to 50 mg/kg/day (maximum 4 g/day) divided into two doses per day to cover *Streptococcal* infection. Doxycycline (2 mg/kg/day divided into two doses per day) is an option for children over 8 years of age and offers good coverage for *Staphylococcus* and some coverage for *Streptococcus* species.

ANIMAL BITES

Bites from stray dogs and other animals are more frequent during travel to the developing world. Prevention techniques primarily involve keeping children away from stray dogs and other wild

FIGURE 91-13 Hair apposition technique for scalp wound closure. *(Courtesy Judith R. Klein, MD.)*

animals and a strict "no feeding of animals" rule. Sleeping areas should be protected from bats, which are frequent carriers of disease. If a bite occurs, it should be irrigated copiously. In general, lacerations from animal bites should not be repaired primarily, with the exception of certain facial wounds. All victims of animal bites should receive antibiotic prophylaxis, ideally with amoxicillin-clavulanate (80 mg/kg/day divided into two doses) or azithromycin (10 mg/kg on day 1; then 5 mg/kg/day for 5 days) in individuals who are allergic to penicillin.[26]

Rabies is endemic in many parts of the world, including much of South and Central America, India, Southeast Asia, and the Phillipines.[65] Unlike in the United States, where bats and raccoons are the most common carriers, in the developing world, domesticated animals, such as dogs and cats, are most frequently implicated in rabies transmission. Current CDC guidelines recommend that children traveling to endemic areas for more than a month or those who will be spending a great deal of time outdoors should receive rabies prophylaxis prior to travel.[65] All animal bites that occur in areas endemic for rabies, no matter how superficial, require postexposure rabies prophylaxis (see Table 91-7 for the schedule of vaccination). Any contact between a child and a raccoon, bat, fox, or skunk in an endemic area should be considered a high-risk event and treated with rabies postexposure prophylaxis. If a bite occurs in a child who has been previously vaccinated, two more doses of the vaccine should be given. If a bite occurs in a child with no preexposure vaccination, the child should begin the four-dose rabies vaccination series *and* receive rabies immunoglobulin (HRIG: 20 IU/kg with as much as possible in and around the wound and the remainder intramuscularly in a large muscle).

POISONING

In their first few years of life, children explore the environment with their hands and mouths. Plants, flowers, mushrooms, and medications, including those in the pediatric first-aid kit, are all potentially tasty treats to a toddler. Travel into the wilderness expands the repertoire of available objects for a child to orally explore. In an urban environment or during travel in the United States, a call to a poison center (1-800-222-1222) can provide immediate information regarding the dangers of a particular ingestion and the possible need for emergency evaluation and treatment. In the wilderness and when traveling abroad, particularly in developing countries, this is rarely an option. Because it is unrealistic to expect a parent to know whether a certain medication, cosmetic, plant, or mushroom is toxic, the best advice is prevention.

All medications and cosmetics should be kept out of reach and stored in child-resistant containers. One should never try to encourage a child to take a medication by referring to it as "candy." During forays into the wilderness, parents should not let toddlers out of their sight and should explain to their children why plants or mushrooms should not be put in their mouths. If a child's skin or eyes are exposed to a toxic substance, the area should be flushed vigorously with clean water for 15 to 20 minutes. Ipecac syrup, a powerful emetic and once a mainstay of home treatment for ingested poisons, is no longer recommended by the American Academy of Pediatrics. If a child ingests a plant, mushroom, or medication with a level of toxicity that is unknown to the caregiver, and calling a poison center is not an option, the child should be taken to a medical facility for evaluation.

FOREIGN BODIES

In addition to exploring the world around them with their mouths, toddlers and even young school-age children enjoy placing objects into their noses and ears. Such objects, particularly if they are organic in nature, can result in infection of the sinuses and external ear, respectively, and should be removed promptly.

Objects that are easily visible in the nose near the nares can be removed by two caregivers. While one person holds the child's head motionless, the other carefully removes the object with forceps or tweezers. If the object is not near the nares or cannot be easily visualized, a "mouth-to-mouth" technique can be used to try to remove the object. While occluding the uninvolved nare with one finger, the parent should place her mouth over the child's mouth and blow hard several times. Ideally, this creates enough pressure to expel the object from the nasal passage. If an object is lodged in the child's ear, it is best removed with forceful irrigation with clean, warm (37°C [99°F]) water using a bulb syringe. If the object is an insect and the tympanic membrane is not perforated, the ear should first be filled with isopropyl alcohol for several minutes to kill the insect prior to irrigation. If these techniques fail to remove the foreign body from the child's ear or nose, the child should be brought to medical attention so that the object can be removed by direct visualization under proper procedural sedation.

SPECIAL CONSIDERATIONS FOR CHILDREN WITH CHRONIC MEDICAL PROBLEMS

ASTHMA

Parents of children with asthma face unique challenges when traveling into the wilderness or to the developing world. In both situations, access to medical care may be limited and parents may need to treat exacerbations that would normally require advanced medical attention. In addition, exposure to known asthma triggers, such as tobacco and specific allergens, may not be as controllable while traveling. A study of adult adventure travelers demonstrated that the major risk factors for asthma exacerbations while traveling include poorly controlled asthma prior to departure and intensive physical exertion.[21]

To prepare for travel, parents should work with their pediatrician to stabilize their child's asthma to the extent possible. Any physical exertion planned should be graded so that the child's response can be gauged and activities scaled back as necessary. In locales with heavy particulate pollution or in settings with significant tobacco exposure, the child's activities should be limited. In addition to packing extra canisters of the child's inhalers and an extra spacer or aerochamber, parents should carry a course of high-dose steroids for administration during an acute exacerbation not responding immediately to an inhaled bronchodilator (e.g., albuterol). Options for steroids include prednisone or prednisolone (2 mg/kg on day 1, then 1 mg/kg on days 2 to 5, up to a maximum of 60 mg/day) or dexamethasone (0.6 mg/kg/day for 2 days, up to a maximum of 10 mg/day). For children 5 years and older, a peak flow meter is a useful item to assist in gauging the severity of an asthma exacerbation. For families with children with life-threatening asthma (i.e., prior intubation), an EpiPen is an essential first-aid kit item.

DIABETES

Traveling with a child with diabetes requires thorough advance preparation and vigilance throughout the trip. Families traveling to the developing world or remote areas should assume that no supplies or medications will be available at their destination and should travel with sufficient insulin, syringes, alcohol wipes, lancets and test strips, and a spare glucometer. Urine test strips can be extremely useful for parents trying to decide whether their child needs to be evacuated to medical care if traveling in a remote location. The presence of ketones in the urine in a diabetic child who appears ill mandates immediate medical evaluation. Parents should also prepare a list of medical providers and/or hospitals capable of providing medical assistance to their child should the need arise.

Diabetic children should be encouraged to drink fluids frequently, particularly at high altitude and in warm climates. Parents of diabetics should always carry glucose tablets and small snacks that they know their child will eat. Older children should carry these items for themselves. Daily trip planning should guarantee that meals and snacks are not skipped by a diabetic child. Parents should also be aware that with the increased

activity that occurs during travel, insulin dosing may need to be reduced to prevent hypoglycemia. Finally, diabetic children are at greater risk for infections, particularly those of the skin. All wounds should be thoroughly cleaned with soap and clean water. Any redness, warmth, or edema should be treated with antibiotics, preferably trimethoprim-sulfamethoxazole to cover MRSA. Marine wounds require quinolones and animal bites require amoxicillin-clavulanate to cover specific organisms. Diabetic children with wounds that progress despite oral antibiotics should receive prompt medical evaluation.

SICKLE CELL DISEASE

For children with sickle cell disease, the focus during travel should be on prevention. Parents should be aware of the triggers for pain crisis, and emphasize hydration and hygiene to prevent diarrheal illness. Travel to high altitude should in general be avoided, because of the possibility of altitude-related hypoxia resulting in a pain crisis. If a crisis develops, the child should be treated with rest, oral hydration, and appropriate pain medications (ibuprofen or narcotics). If this therapy is ineffective or if the crisis involves chest or abdominal pain, parents should seek immediate medical attention for their child.

Fever is a common and significant problem for children with sickle cell disease. By the age of 1 year, children with this disease are effectively asplenic as a result of sickling-related infarction. As a consequence, infections with encapsulated organisms normally cleared by the spleen can rapidly lead to sepsis. Vaccinations against *H. influenzae, Streptococcus pneumoniae,* and *Neisseria meningitidis* are the first line of defense. In addition, the American Academy of Pediatrics recommends penicillin prophylaxis (125 mg twice a day) for sickle cell patients under the age of 5 years to effect a significant (85%) reduction in pneumococcal bacteremia.[39] Children with sickle cell disease who develop fever should receive prompt medical attention. If this is not immediately available, initiate treatment with an antibiotic, such as amoxicillin-clavulanate (80 mg/kg/day divided into two doses). Children under the age of 5 years are at particularly high risk for sepsis.

CONGENITAL HEART DISEASE AND PULMONARY HYPERTENSION

Traveling with children with cardiac or pulmonary problems can be a challenge. During flight, most airline cabins are pressurized to allow a fraction of inspired oxygen (FiO_2) of 0.17 to 0.18 as opposed to the typical FiO_2 of 0.21 at sea level. Depending on the nature and severity of the child's disease, this may require arranging for an oxygen tank and delivery apparatus during flight. Travel to high altitude should be cleared by the child's primary or specialty physician for the same reasons. Respiratory infections are more common during travel. Because of the potentially significant impact of seemingly minor respiratory infections (e.g., influenza) on children with cardiopulmonary disease, hand hygiene is particularly important to prevent inoculation with infected secretions via hand-to-nose and hand-to-eye contact. An emergency plan should be available for every country on the child's itinerary, including a specialist contact and full description of the child's condition and health care needs.

EPILEPSY

Traveling with children with epilepsy involves early pretrip planning. Every effort should be made to get the child's seizures under control with medications, ideally with a 3- to 6-month seizure-free period prior to departure. In addition to a child's typical triggers for seizures (e.g., missed medication doses, fever, dehydration), travel to distant lands may involve jet lag and sleep deprivation, both of which can precipitate an event. Parents of an epileptic child should allow extra time on arrival at a destination for acclimatization to a new time zone and for adequate sleep. The child's activities during travel should be selected carefully, because rescue after a seizure event may be challenging in remote locations in the developing world. Parents should also be encouraged to carry a generous supply of the patient's antiepileptic medications, assuming that these might not be available at the destination. In addition, a rescue medication, such as rectal diazepam (0.3 to 0.5 mg/kg), should be included in the medical kit in case the child has a lengthy (> 5 minutes) seizure or multiple seizures. Children with seizures in the setting of trauma or high fever, who do not return to the baseline mental status within an hour or two following the seizure, or who have atypical or multiple seizures within a short period of time, should be brought to medical attention.

TRAVELING WITH INFANTS AND NEONATES

A family traveling with an infant should be particularly vigilant about monitoring their child's state of health. Infants become hypothermic, hyperthermic, septic, and dehydrated more rapidly than do adults or older children. A thermometer and appropriate lubricant should be included in the medical kit for monitoring rectal temperature. Digital thermometers are recommended, because they are less likely to break, are easy to read, and acquire a temperature reading three to four times faster than does a glass thermometer. Rectal temperature above 38°C (100.4°F) in a child younger than age 3 months requires immediate medical evaluation.

Infants are less tolerant of problems that generate excess mucus. Until the age of 6 months, infants are obligate nose breathers, so obstruction of the nasal passages with mucus can cause significant respiratory distress. A bulb syringe is handy for suctioning mucus from the oropharynx and nasal passages. A few drops of saline solution (1/4 tsp of salt in 1 cup of water) instilled into the nares a few minutes before aspiration helps to loosen mucus. Nasal aspiration should be reserved for times of most need, such as before feeding and sleep, because the procedure is irritating to a child. Other uses for a clean bulb syringe include flushing foreign bodies from ears and administering enemas.

Away from the conveniences of home, diapers tend to be changed less frequently. Diaper rash can become a problem. A barrier cream containing zinc oxide may be helpful, and should be used at the first sign of irritation. If the rash progresses to intense erythema with satellite lesions despite appropriate cleaning and barrier cream use, an antifungal cream, such as miconazole or clotrimazole, should be applied two to three times a day until the rash resolves. The child should also be left for a few hours each day without a diaper to make the perineal area less hospitable to fungus. Children with severe diarrhea can develop diaper-area dermatitis from irritant stool. These children should be treated with a topical antiinflammatory, such as 1% hydrocortisone topped by a barrier cream.

In very young infants, 3 to 12 weeks of age, colic can be a challenging and vexing problem. A few hours of inconsolable crying a day is not uncommon in this age group, but should still prompt investigation. If the infant is feeding well, urinating and stooling regularly, and has neither fever nor rash, the most likely cause for this recurrent, seemingly inconsolable crying is colic. Colic is defined as a pattern of daily paroxysms of irritability and crying without a significant identifiable cause. The pathophysiology of colic is not clear but has been postulated as immaturity in the gastrointestinal or nervous system, response to maternally ingested foods in breastfed babies, or a product of over- or understimulation of an infant. Colicky infants can often be soothed with rocking motions and close parental contact. Gentle abdominal massage can also be helpful. Breastfeeding mothers should consider eliminating caffeine, spicy foods, citrus, and/or dairy from their diets. Colic typically resolves by 3 to 4 months of age.

Box 91-9 outlines indications for immediate medical evaluation of young infants. As mentioned previously, parents are strongly advised against traveling to the developing world with children under the age of 2 years. Immature immune systems, an incomplete vaccination status, contraindications to prophylactic medications and travel vaccines, and frequent hand-to-mouth

BOX 91-9 Indications for Immediate Medical Attention for Neonates and Young Infants

Appearance of being ill
Fever in a child < 3 mo of age
Respiratory distress or apnea
  Capillary refill time > 2 sec and/or no urine output in 8 hr
Lethargy/persistent irritability
  Vomiting > 24 hr
Bloody stools
Rash: vesicles, petechiae, or purpura

contact make infants and very young children extremely susceptible to disease. Only essential travel should be undertaken.

PEDIATRIC WILDERNESS MEDICAL KITS

When a family travels in remote areas, the medical kit must be adapted to meet the special needs of children. Items carried vary depending on the ages of the children, preexisting medical conditions, length of travel, specific environmental conditions likely to be encountered, and medical sophistication of the adults. Although there is considerable room for individual preference in assembling a medical kit, certain items are essential for management of problems commonly encountered during wilderness travel with children (Box 91-10).

To reduce weight and bulk, medications selected for a wilderness medical kit should have multiple uses (Table 91-12). For example, diphenhydramine is effective for allergic symptoms, pruritus, motion sickness, nausea, and insomnia. Desitin, best known for its use in preventing diaper rash, is an excellent sunblock, because it contains 40% zinc oxide. A broad-spectrum antifungal cream, such as miconazole or clotrimazole, covers not only tineal infections (ringworm, jock itch, and athlete's foot) but also *Candida* infections (diaper rash and vaginitis). Medications in liquid form should generally be avoided because they add excess weight to the medical kit and can leak. If an infant under the age of 6 months is traveling, liquid medications can be carried in light- and leak-proof powder form. Most children are able to chew tablets once their first molars are present (by about 15 months). Before that time, chewable medications or tablets can be crushed between two spoons and mixed with food. If a child dislikes the taste of a medication, it may be camouflaged in food such as instant pudding, which is easily carried in powdered form.

BOX 91-10 Pediatric Wilderness Medical Kit: Basic Supplies

- Identification and basic health information for child: past medical history, medications, allergies, blood type, weight
- First-aid supplies: adhesive bandages, gauze pads, gauze roll, tape, nonadherent dressings, moleskin/Spenco 2nd Skin/New-Skin, benzoin, steri-strips, cyanoacrylate glue, alcohol wipes, povidone-iodine solution for dilution and disinfection, safety pins, tweezers, lightweight malleable splint (SAM splint), syringe (20-35 mL), and 14-gauge plastic catheter for wound irrigation
- Powdered oral rehydration solution (homemade or commercially available formula that meets the World Health Organization recommendations)
- Sunscreen: SPF 15 or greater
- Insect repellent: DEET < 35% or picaridin
- Whistle for child
- For infant < 3 months: rectal thermometer, bulb syringe

DEET, *N,N*-diethyl-*m*-toluamide; SPF, sun protection factor.

Painful musculoskeletal injuries are a potential complication of wilderness activities, so pain medication for children should be included in every medical kit. Acetaminophen not only relieves minor aches and pains but also is effective for fever control. It is well tolerated by most children and available in many pleasant-tasting forms for children unable to swallow pills: chewable 80- or 160-mg tablets, elixir (160 mg/5 mL), and concentrated drops (80 mg/0.8 mL). Ibuprofen is effective for pain and fever control. Its duration of action is 6 to 8 hours, compared with 4 to 6 hours for acetaminophen. Ibuprofen is available in many forms: infant drops (40 mg/mL), children's elixir (100 mg/5 mL), 50- or 100-mg chewable tablets, and 100- or 200-mg caplets. Analgesics that contain narcotics are generally not recommended for children, particularly for the first few years of life, due to respiratory depression. Many recent studies suggest that such analgesics are no more effective for severe pain in children than ibuprofen given in the proper dosage.[64]

Two or three antibiotics will treat most bacterial infections encountered in children. The ages of children traveling, their allergies or chronic medical conditions, their intolerance of medications, and past experience, as well as knowledge of the disease prevalence or epidemics at the travel destination, must be taken

TABLE 91-12 Pediatric Medications in the Wilderness Medical Kit

Medication	Indication	Dose
Topical Medications		
Antiseptic ointment (e.g., bacitracin or polymyxin)	Superficial skin infections	Apply as directed qd to tid
Topical corticosteroid (e.g., 1% hydrocortisone)	Contact or atopic dermatitis, insect bites, sunburn	Apply to affected areas bid to tid (use sunscreen aggressively; avoid > 1% corticosteroid on face)
Antifungal cream (e.g., clotrimazole or miconazole)	Yeast at diaper area, groin, scalp, feet; ringworm	Apply bid for 7-10 days and for several days after rash has resolved
Desitin cream	Sunblock, diaper-area erythema	Apply thick coat as sunscreen or thin coat for diaper area
Permethrin (Elimite)	Scabies, lice, treatment for clothing and mosquito netting	Apply 5% cream from chin to soles of feet and wash after 8-14 hr; do not use in children < 2 mo of age or on eyes, nose, mouth
Anesthetic eye drops (e.g., proparacaine)*†	Removal of superficial ocular foreign body	1 drop in affected eye for removal of foreign body; must patch eye for protection for at least 1 hr
Antibiotic eye ointment (e.g., erythromycin)† or drops (e.g., polymyxin B sulfate plus trimethoprim [Polytrim])†	Purulent conjunctivitis, suspected corneal abrasion	Ointment: thin line upper lid margin tid to qid Drops: 1 drop every 3 hr for 7 days

TABLE 91-12 Pediatric Medications in the Wilderness Medical Kit—cont'd

Medication	Indication	Dose
Antipyrine-benzocaine otic drops†	Ear pain (otitis externa or media); avoid if < 3 mo or tympanic membrane rupture suspected	3-4 drops in affected ear every 2-3 hr as needed to relieve pain
Oral Medications		
Diphenhydramine 12.5 mg/5 mL elixir 25- or 50-mg capsules	Allergy symptoms, pruritus, insomnia, nausea, motion sickness	1.25 mg/kg/dose every 6 hr (up to 25-50 mg/dose); may cause paradoxic restlessness in children
Acetaminophen 80 mg/0.8 mL drops 160 mg/5 mL elixir 80- and 160-mg chewable tabs	Fever control, pain	15-20 mg/kg every 4-6 hr up to 650 mg/dose
Ibuprofen 40 mg/1 mL drops 100 mg/5 mL elixir 50- or 100-mg chewable tabs 100- or 200-mg caplets	Fever control, pain, antiinflammatory	10 mg/kg/dose every 8 hr up to 600 mg/dose
Dimenhydrinate (Dramamine) 12.5 mg/5 mL elixir 50-mg chewable tabs	Motion sickness	1-1.5 mg/kg/dose 1 hr before departure and every 6 hr after; may cause drowsiness
Oral Antibiotics (as Appropriate for Age of Child)		
Amoxicillin†	Acute otitis media, sinusitis, pharyngitis, pneumonia	80 mg/kg/day in divided dose bid for 10 days if < 5 yr or for 5 days if > 5 yr 125- or 250-mg chewable tabs 250-mg capsule
Amoxicillin-clavulanate (Augmentin)†	Penicillin-resistant organisms, acute otitis media, sinusitis, animal bites	80 mg/kg/day in divided dose bid 200- and 400-mg chewable tabs 200 and 400 mg/5 mL elixir
Azithromycin (Zithromax)†	Acute otitis media, sinusitis, pharyngitis, pneumonia, traveler's diarrhea, skin infections, animal bites	10 mg/kg on day 1, then 5 mg/kg/day for 4 days 125 and 250 mg/5 mL elixir 250-mg tabs (best)
Ciprofloxacin (Cipro)†	Not first line < 18 yr due to adverse effects: urinary tract infection, traveler's diarrhea, wounds acquired in an aquatic environment	20-30 mg/kg/day in divided dose bid up to 500 mg bid 100-, 200-, 500-mg tabs
Trimethoprim-sulfamethoxazole (Septra)†	Suspected methicillin-resistant *Staphylococcus aureus* skin infection 80/400 SS tab; 160/800 DS tab	8-10 mg trimethoprim/kg/day in divided dose bid > 2 months old
Oseltamivir (Tamiflu)†	Influenza treatment (12 mg/mL susp 30-, 45-, 75-mg caps)	Not recommended < 3 mo old; treat for 5 days 3-12 mo: 3 mg/kg/dose twice daily > 12 mo or < 15 kg: 30 mg bid 15-23 kg: 45 mg bid 24-40 kg: 60 mg bid > 40 kg: 75 mg bid
Other Preparations		
Epinephrine (premeasured)† 0.15 mg EpiPen Jr 0.3 mg EpiPen	Anaphylaxis, severe asthma	0.15 mg intramuscularly up to 15 kg (33 lb); 0.3 mg intramuscularly if > 15 kg (> 33 lb)
Oral rehydration packet	Dehydration	See Table 91-11 for administration guidelines
Foreign Travel		
Loperamide 1 mg/5 mL 1 mg caps	Nonbloody diarrhea, minimally febrile, significant diarrhea older than age 2 years	13-20 kg (29-44 lb): 1 mg tid; 20-30 kg (44-66 lb): 2 mg bid; > 30 kg (> 66 lb): 2 mg tid;
Appropriate malaria prophylaxis†	—	See Table 91-9 if indicated†
Zofran ODT† 4 mg tab	Nausea/vomiting, dehydration	6 mo-1yr: 1 mg 1-4 yr: 2 mg > 4 yr: 4 mg
Travel to High Altitude		
Acetazolamide (Diamox)† 30 or 50 mg/mL suspension 125-mg tab	Recurrent acute mountain sickness despite graded ascent	5 mg/kg/day divided bid up to 250 mg/day

*Administration of this medication by other than trained medical personnel is strongly discouraged, given the risk of overuse and subsequent worsening of eye injury; if significant eye irritation persists, medical attention must be sought to evaluate for corneal injury.
†Available by prescription only.

into account when antibiotics are selected. Given increasing bacterial resistance to common antibiotics, choices should be reevaluated periodically to ensure that infections likely to be encountered can be successfully treated with these agents. All oral antibiotics require a prescription. Amoxicillin is available in pleasant-tasting chewable tablets (125 and 250 mg) and in powdered form for suspension (125 and 250 mg/5 mL). Because of current resistance patterns, high-dose therapy with 80 mg/kg in divided doses, twice daily, is indicated. Amoxicillin is familiar to and well tolerated by most children. Amoxicillin-clavulanate provides excellent coverage when a penicillin-resistant organism is suspected for recurrent pharyngitis, soft tissue infections, animal bites, and other infections. The most common side effect is diarrhea, but this is reduced with newer formulations. Both are available in 200- and 400-mg (amoxicillin component) chewable tablets and as 200 and 400 mg/5 mL liquid. Azithromycin (Zithromax) is a long-acting macrolide without the gastrointestinal side effects of erythromycin. It is effective for treating otitis media, sinusitis, pharyngitis, lower respiratory tract infections, TD, skin infections, typhoid fever, and common animal bites. It is particularly useful in children with penicillin allergies. Because of its broad utility, azithromycin is an excellent antibiotic choice for a pediatric medical kit. Dosing is extremely convenient because of azithromycin's long half-life; a dose of 10 mg/kg on day 1 is followed by 5 mg/kg/day for a total of 5 days. Ciprofloxacin has broad-spectrum coverage and is useful for treatment of bacterial diarrhea, complex urinary tract infections, typhoid fever, and wounds acquired in an aquatic environment. Its use has not been approved for children younger than age 18 years in the United States because of a potential problem with arthropathic effects on weight-bearing joints. However, a study involving more than 600 children found only a 1.3% rate of reversible arthralgia and no evidence of arthropathy.[1] Nonetheless, ciprofloxacin should not routinely be recommended for children unless a special situation arises in which the benefits of its use outweigh the risks (e.g., complex pyelonephritis, typhoid fever). Trimethoprim-sulfamethoxazole (Septra) is a sulfa antibiotic useful against skin infections where MRSA is a concern. In many areas, the presence of MRSA in infected wounds and cellulitis is so high that the recommendation is to always use an agent with bactericidal activity against MRSA. The dose is 8 to 10 mg/kg/day of the trimethoprim component in divided doses twice daily. Finally, for children younger than age 5 years, those with chronic medical conditions, or those receiving long-term aspirin therapy who will be traveling in areas with influenza activity, parents should consider including oseltamivir (Tamiflu) in their medical kit.[40] It is available in suspension or capsule form. The dose is 3 mg/kg/day in two divided doses.

Parents of children with special medical conditions should carry a pertinent medical summary and have resources to gain access to specialty physicians in the destination countries. A generous supply of necessary medications with instructions for caregivers and consulting physicians on treatment plans for various complications should be included in the medical kit. An extra supply of all essential medications should be kept with either the parents or the patient in case the medical kit gets lost or separated from the patient when the medication is needed. Some travelers in areas endemic for hepatitis B or C and acquired immunodeficiency syndrome carry their own needles and syringes for emergency use. The International Association for Medical Assistance to Travelers (iamat.org) maintains a directory of qualified physicians worldwide who speak English.

ENVIRONMENTAL CONCERNS AND CHILD HEALTH

Because of their physical, physiologic, and cognitive immaturity, children are particularly vulnerable to adverse health effects from environmental hazards. Children breathe more air, drink more water, and eat more food per unit of body weight than adults. They play more outdoors and have more life-years during which to suffer any long-term ill effects of environmental degradation and climate extremes. It is estimated that by 2100, there will be an additional 60,000 to 250,000 pediatric deaths each year due to health conditions related to climate change.[6,10]

Specifically, children are more susceptible to thermal stresses that can lead to dehydration and hyperthermia, particularly during exercise. Higher average temperatures may further increase this risk. The rates of sunburn in children and of subsequent melanoma are likely to rise. Warmer temperatures typically result in higher levels of ozone and other air pollutants. Because children tend to spend more time outdoors and have higher minute ventilation, increased air pollution can significantly affect children with asthma and other respiratory diseases. Warmer winters and rising carbon dioxide levels may result in earlier and more abundant release of pollens derived from grasses and other plants, which could increase incidence and severity of atopic syndromes in children.[10] Higher temperatures, along with changes in humidity and flood frequency, are likely to result in significant increases in vector- and rodent-borne disease transmission. Recent modeling experiments suggest that global distribution of malaria, a disproportionate killer of children, is likely to expand over the coming decades.[18,63] The rate of dengue virus replication in *A. aegypti* mosquitoes increases directly with temperature. Higher global temperatures may result in a higher infection rate, particularly in children who are less able to protect themselves from mosquitoes. Tick-borne diseases may become more prevalent as flooding expands the rodent population that is an integral part of the tick life cycle. Extremes of precipitation, specifically flooding, increase the likelihood of drinking contaminated water and contracting waterborne gastrointestinal illnesses. As discussed previously, children suffer disproportionate rates of morbidity and mortality from acute gastroenteritis.

If for no other reason than preserving our children's health, it is incumbent upon us to mitigate these effects of fossil fuel consumption. Physicians and other health care professionals can educate communities about the impacts of climate change on child health and emphasize the need for policies supportive of a clean, healthy environment.

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CHAPTER 92

Women in the Wilderness

RENEE N. SALAS AND SUSAN ANDERSON

> Travel not only stirs the blood … it also gives birth to the spirit.
> Alexandra David-Neel, French explorer and writer (1868-1969), who walked 2000 miles (3220 km) across the Himalayas to enter Lhasa at the age of 55 in 1924

Women travel to remote areas of the world at all stages of life. Wilderness travel health issues vary according to a woman's life stage and style. Travel may include adolescent women kayaking in Amazonian jungles, pregnant women climbing 5000-m (16,000-foot) peaks, and senior researcher scientists working for a year in Antarctica.

Wilderness experiences may increase a woman's self-esteem. Physical activity has numerous health benefits for women, including stress reduction and prevention of osteoporosis, heart disease, diabetes, breast cancer, cognitive decline, osteoporotic fractures, and depression.[41,54,149] Women defy daily prior boundaries in outdoor achievement. Companies have taken notice. Active clothing and recreational equipment designed specifically for women represent a multibillion-dollar industry.

Problems unique to women can diminish the wilderness experience or place travelers at risk. Wilderness travel health recommendations for a particular woman should consider her age and life stage, background and health history, level of fitness, itinerary, and planned activity. Physicians and other health care providers can assist women embarking on wilderness experiences by providing individualized prevention and treatment guidelines. Because wilderness journeys may include travel to remote locations, special considerations for wilderness travel to developing countries are discussed.

GENDER-BASED RESEARCH

In 2001, the Institute of Medicine of the National Academy of Sciences released the report "Exploring the Biological Contributions to Human Health: Does Sex Matter?"[112] The institute's report was the first significant review of biomedical research to date related to sex and gender differences. The report confirmed the importance of gender and recommended more funding for multidisciplinary research to address issues of gender and health in all areas of medicine.

Since then, women's health- and gender-based research initiatives have been developed at academic institutions and organizations around the world. New training programs and fellowships have grown exponentially, and more journals, textbooks, and other related publications have focused on women's health and gender medicine.[30,31,131-133,150,183,210,211]

Wilderness medicine research exploring gender issues is increasing (e.g., study of effects of extremes of environment on fertility and pregnancy outcome). Pregnant women who live at altitude experience a high rate of fetal intrauterine growth restriction (IUGR). Ramifications of this for pregnant short-term travelers to altitude are being studied. Certain infectious diseases (e.g., malaria, typhoid, and amebiasis) carry special risks for women (e.g., an accelerated or more severe course), especially during pregnancy.[180] Women exposed to schistosomiasis by swimming, canoeing, or rafting may become infected. Female genital schistosomiasis can lead to subtle genital tract inflammatory changes that increase the risk of future infertility.[65,72,74,86,106,183,210] For a woman, exposure to certain environmental extremes or pathogens at a particular stage of life may lead to severe long-term consequences.

Many practical questions need to be answered. What is the safety of recommended immunizations and medications for a specific itinerary in pregnancy? What is the risk for deep thrombosis in a breast cancer survivor taking tamoxifen who wants to trek over a 5500- m (18,000-foot) mountain pass? Do antimicrobials prescribed for malaria chemoprophylaxis or for self-treatment of traveler's diarrhea interfere with efficacy of oral contraceptive pills? Gender and life-stage issues are important when considering a woman's risks for wilderness and environmental exposure, preventive measures, treatment options, and possible long-term complications.

PRE–WILDERNESS TRAVEL WOMEN'S HEALTH ASSESSMENT

Key areas to address for any female wilderness traveler are outlined in the pre–wilderness travel checklist for women (Box 92-1). Priorities are to identify each patient's life-stage and medical issues that could be exacerbated by physical demands and the wilderness setting. Environmental and infectious disease risks should be assessed. Consider the duration of the excursion, need for additional conditioning and acclimatization, and any difficulty in gaining access to sophisticated medical care.

Prior to undertaking physically challenging activities or prolonged remote travel, women should undergo a thorough medical assessment (Box 92-2). The physician collects historical information and performs a comprehensive physical examination, with special attention to the genitourinary tract, breasts, and cardiovascular, respiratory, and musculoskeletal systems. Laboratory screening should be guided by the patient's age, medical status, and risk factors. Consider assays for hemoglobin and hematocrit, thyroid panel, urinalysis, urine culture, pregnancy test, Pap smear, and screening for sexually transmitted infections (STIs) and hepatitis. In women more than 40 years of age, consider an electrocardiogram with stress testing and pulmonary function tests. In women with a strong family history of breast cancer, consider a mammogram. Bone densitometry should be considered in perimenopausal and postmenopausal women and in young women with a history of fractures or abnormal menses consistent with a hypoestrogenic state.

Recommendations for a medical kit should be adapted to life-stage and health needs. Provide maintenance medications for optimal control of medical conditions for the planned duration of travel, emergency needs, and expected dose adjustments. Review contraceptive needs and options. Include basic supplies for hygienic and anticipated therapeutic needs related to menses, the urinary tract, and vaginitis. Suggestions are given in Table 92-1 and Box 92-3.

After the medical evaluation, a final risk assessment should be discussed with guidelines for prevention and treatment versus adaptation of the itinerary to decrease any particular risk.

WHAT MAKES WOMEN DIFFERENT?

GENDER-RELATED PERFORMANCE

Gender-specific differences in anatomy and physiology are mainly due to hormonal differences that vary across the life span. Typically, women are smaller than men, have less lean muscle

BOX 92-1 Pre–Wilderness Travel Checklist for Women

Current age or life stage
Personal level of risk taking
Itinerary
Gender-specific recommendations related to:
- *Environmental risks*
  - Altitude, heat, cold, water, etc.
  - Preventive measures
- *Infectious disease risk*
  - Vaccine-preventable diseases
  - Chemoprophylaxis
  - Personal protective measures
- *Sports and exercise*
  - Level of fitness
  - Equipment

Practical issues
- *Genitourinary issues*
  - Menstruation or dysfunctional uterine bleeding
  - Contraception and emergency contraception
  - Breast health
  - Vaginal health
  - Urinary tract issues
  - Sexually transmitted infection risk
- *Pregnancy*
  - Planned or unplanned
  - Lactation
- *Perimenopausal and menopausal issues*

Medical issues
- *Past medical history*
- *Long-term travel*
  - Pap smear and mammogram
  - Copy of electrocardiogram if older than 50 years or cardiac history

Psychological issues
Cultural issues
Personal safety issues
- *Self-defense training*
- *Personal protection devices*

Wilderness medicine kit
Emergency plans
- *Medical and evacuation insurance*
- *Copy of medical data*

BOX 92-3 Supplies for the Medical Kit for Women

Menstrual supplies
- Calendar to keep track of menses
- Supplies and devices
  - Pads, tampons, menstrual cups
  - Towelettes, plastic disposal bags, matches
  - Premenstrual symptom medications
  - Dysfunctional uterine bleeding medications

Urinary voiding
- Medications for urinary tract infections and burning
- Toilet tissue, towelettes
- Funnels, paper or plastic
- Pads for incontinence
- Urinary dipstick to screen for infection

Vaginitis
- Self-treatment medications (yeast, bacterial vaginosis)
- pH paper
- Vaginal speculum and gloves if trained medical professional on expedition

Contraception
- Contraception options
- Emergency contraception
- Chart to keep track of pills, patches, or ring use
- Timer, special wristwatch or cell phone "alarm"

Pregnancy tests
Perimenopausal and menopausal issues
- Stress incontinence, pads
- Atrophic vaginitis, vaginal moisturizers and lubricants

Pregnancy supplies
- Prenatal vitamins
- Blood pressure cuff
- Urine protein and glucose strips to screen for diabetes and preeclampsia
- Urine leukocyte esterase strips to check for urinary tract infection

Supplies for lactation
- Breast pump
- Nipple cream
- Self-treatment, mastitis

Personal safety
- Alarms
- Pepper spray
- Other self-defense measures

BOX 92-2 Assessment of a Woman's Health: Screening Highlights

Menstrual History
Age at menarche, regularity, characteristics, timing, extent of blood flow (length, amount), intermenstrual bleeding, perimenstrual symptoms (e.g., dysmenorrhea, headache, premenstrual syndrome), plans for managing periods (hygienic, therapeutic)

Sexual History
Age at coitarche, number of partners, sexual orientation, sexually transmitted infections, contraceptive history, plans for sexual activity in the wilderness, dyspareunia

Gynecologic History
Ovarian cysts, uterine fibroids, endometriosis, cervical dysplasia, surgical history, pelvic pain, vaginal discharge, vaginal infections and treatment, pregnancy and complications

Breast
Galactorrhea, discharge, masses, surgery

Gastrointestinal System and Urinary Tract
Ulcers, irritable bowel syndrome, gallbladder disease, constipation, urinary tract infections, nephrolithiasis, stress incontinence, urgency incontinence

Musculoskeletal System and Skin
Injuries (exercise related and accidents), limitations, muscle cramps, joint pain and swelling, arthritis, rashes, acne, sun sensitivity, hirsutism, hair loss

Exposure to Abuse
Battering, sexual harassment, sexual assault

Habits
Smoking, alcohol, illicit drug use

Current Problems
Condition, medications, status of control, complications

Immunizations
Measles, mumps, rubella, polio, diphtheria, tetanus, hepatitis, others

Family History
Thyroid disease, hypertension, autoimmune disorders, diabetes, breast and gynecologic malignancies, osteoporosis

Allergies
General, drug related, bite and sting sensitivities

Nutritional
Eating disorders, weight changes, food sensitivities, dietary preferences (e.g., vegetarianism), caloric intake, assessment of mineral and vitamin intake in diet, supplements (e.g., iron, vitamins, calcium), including homeopathic compounds

TABLE 92-1 Medications for the Medical Kit for Women*†

Indication	Medication	Dosage
Dysmenorrhea	Ibuprofen	200 mg PO 3 tabs q 6-8 hr
Headache/pain/fever	Acetaminophen	325-650 mg PO q 6 hr; max 3 g/24 hr
Nausea and vomiting	Promethazine (tablet or suppository)	12.5-25 mg PO or per rectum q 4-6 hr prn for nausea
	Ondansetron ODT (orally dissolving tablet)	4-8 mg SL (under the tongue) q 6-12 hr prn for nausea
Urinary tract infection	Nitrofurantoin	100 mg PO BID for 5 days
	Ciprofloxacin	250-500 mg PO BID for 3 days (for pyelonephritis, 500 mg BID for 7-14 days)
	Trimethoprim-sulfamethoxazole	160 mg/800 mg PO BID for 3-5 days
Pyelonephritis: Nitrofurantoin does not have appropriate renal penetration and thus should not be used. Other antibiotics listed can be used for an extended length of treatment (7-14 days) when pyelonephritis is clinically suspected.		
Urinary analgesic	Pyridium	200 mg PO TID for 2 days prn for burning
Yeast vaginitis	Miconazole cream or suppository	One applicator qhs for 1-7 days
	Fluconazole	150 mg PO single dose
Bacterial vaginosis	Metronidazole tablets	500 mg PO BID for 7 days
	Tinidazole	1 g PO qd for 5 days 2 g PO qd for 2 days
	Metronidazole vaginal gel/clindamycin vaginal cream	One applicator qhs for 3-7 days
Menstrual regulation or breakthrough bleeding	Oral contraceptive pills	1 qd
	Conjugated estrogen	2.5 mg PO qd
	Medroxyprogesterone acetate	5-10 mg PO qd (For abnormal uterine bleeding, duration is 5-10 days starting day 16 or 21 of menstrual cycle.)
Nutritional supplements	Ferrous sulfate	325 mg PO qd-TID
	Calcium carbonate	1000-1250 mg PO qd
	Multivitamin	1 PO qd

BID, Twice daily; PO, by mouth; prn, as needed; q, every; qd, daily; qhs, at bedtime; TID, three times daily.
*These recommendations are in addition to the ones recommended for a general medical kit in Chapter 102.
†Suggested medications or equivalent depending on tolerance, allergy history, and patient preferences.

mass, and have 8% to 10% more fat mass for a given body size. These differences are attributed to increased estrogens in females and increased androgens in males. Females reach physiologic and skeletal maturity and achieve peak height at an earlier age than do males. Women have a larger surface area–to–body mass ratio. The blood volume and hemoglobin, stroke volume, and cardiac output are all lower in women. These and other factors contribute to lower maximal aerobic power (even for similar training status) in women. $\dot{V}O_2max$ is the gold standard as an index of cardiorespiratory fitness. Women of comparable training status usually have $\dot{V}O_2max$ values that are 5% to 15% lower than those of men. Correction of $\dot{V}O_2max$ values for lean body mass does not correct the discrepancy between genders completely, which may relate to lower hemoglobin concentrations in women, leading to less oxygen-carrying capacity.[66]

Estrogen and progesterone influence ventilation and thermoregulation during exercise. Women have a smaller lung capacity than men, which may limit women's extreme exercise performance. Control of ventilation is influenced by progesterone that increases the central ventilatory drive and affects breathing responsiveness during exercise and at altitude.[66]

Thermoregulatory control is affected by the menstrual cycle. In the menstrual cycle's luteal phase, when progesterone and estrogen are elevated, thresholds at which cutaneous vasodilation and sweating are initiated increase approximately +0.5° C (+1.8° F) as compared with the early follicular phase, when these hormones are low. These subtle thermoregulatory differences across the menstrual cycle have not been found to affect exercise performance. Physiologic mechanisms that affect adaptation and performance in women are subtle. There is substantial biologic variability among individuals.[2,123]

GENDER-RELATED ISSUES CONCERNING ENVIRONMENTAL EXPOSURE

Women and Altitude

Differences in how men and women respond to altitude are thought to be hormonally mediated. Adaptation to high altitude involves a series of physiologic responses triggered by hypoxemia. The sigmoidal shape of the oxyhemoglobin dissociation curve prevents a drop in the oxygen saturation below 90% in healthy persons until an altitude of approximately 2400 m (8000 feet) is reached. At higher altitudes, hypoxia stimulates respiratory, cardiovascular, and hematologic changes influenced by degree and duration of hypoxia.

Increased minute ventilation (i.e., increased tidal volume and respiratory rate) is the central initial response to high altitude. This hypoxic ventilatory response (HVR) is mediated by carotid body chemoreceptors that respond to a decrease in arterial oxygen pressure (Pa_{O_2}) and signal the medullary respiratory center to increase ventilation. The HVR has been closely related to adequacy of acclimatization and risk for developing acute mountain sickness (AMS).[185] The degree of HVR to a given Pa_{O_2} varies among individuals and is genetically influenced. The HVR is inhibited by respiratory depressants (e.g., alcohol and sedatives) and stimulated by respiratory stimulants (e.g., caffeine and cocoa). Progesterone is a potent respiratory stimulant and acts primarily through activation of peripheral arterial chemoreceptors. Progesterone is produced by all steroid-forming glands (e.g., ovaries, testes, adrenal cortex, corpus luteum, and placenta).

The effect of hormones on ventilatory control is debated.[43,179] Some studies have shown no gender variation between hypoxic sensitivity differences; others have shown a difference.[45,143,159,175] Evidence suggests that the HVR is less pronounced in women. This has been attributed to testosterone's ability to increase the chemoreflex.[60,156,170,208,213] There does not appear to be any difference between the sexes in the hypercapnic ventilatory response.[117,175] Women appear to be less susceptible to periodic breathing during sleep at altitude, possibly because of a decreased chemoreflex sensitivity to hypoxia.[60,140] Acetazolamide reduces periodic breathing during sleep in both sexes.[60] Extended altitude exposure in women causes a decreased $\dot{V}O_2max$ but no change in the maximal heart rate and work capacity.[84] In one study, women had a 13% decrease in $\dot{V}O_2max$ versus 17% in men.[44]

No gender difference exists in the incidence of AMS. The AMS incidence is not affected significantly by the menstrual phase.[93]

Even in the menstrual cycle's luteal phase, when progesterone levels increase as much as 10-fold, no difference has been observed between males and nonpregnant females in AMS incidence.[98] Early studies reported an increased incidence of pulmonary edema in men. These studies were skewed by a vast predominance of male subjects and may not reflect a true gender predilection.[91,99,141] Women have a higher incidence of peripheral edema at high altitude.[98] Extended high-altitude exposure is known to cause decreases in body weight, from 0% to 5% of fat free mass. Women were found to have a smaller fat loss than males and to adapt more slowly.[84,223]

Women incur a risk of physical trauma and delayed medical care during remote travel. Evidence, recommendations, and guidelines for pregnant women traveling to altitude are discussed in the pregnancy section.

Women and Hot and Cold Environments

Because of a lower basal sweat rate, women rely more heavily on circulatory mechanisms for heat dissipation in hot environments.[186] In hot, humid environments (e.g., jungle), a lower sweat rate allows females to adapt more easily and decreases the risk for dehydration.[32] In hot, arid environments (e.g., desert), if adequate fluid replacement is available, a higher sweat rate is advantageous because perspiration decreases the hyperthermia risk. Following acclimation to dry heat, women's sudorific response begins to equal that of men. With similar acclimatization and physical training, women tolerate physical activity in hot environments as well as do men. Women planning wilderness expeditions to hot, dry destinations are advised to plan a 1- to 2-week acclimation period in a hot environment. In general, heat tolerance depends more on cardiovascular fitness than on gender.

In moderately cold environments, women typically adapt better than men, partly because they have a thicker layer of subcutaneous fat. At extremely cold temperatures, women may be at a disadvantage because of decreased muscle mass. Although adaptation to cold environments depends more on body size, physical fitness, and degree of acclimation than on gender, exercise performed during cold exposure may be more effective in maintaining body heat in women than in men.[146] Primary Raynaud's syndrome precipitated by a cold environment is more common in women and may result in numb or painful extremities, typically of the digits. Rewarming an affected area is therapeutic. Preventive measures (e.g., wearing gloves and using hand and boot warmers before exposure) are helpful. Treatment with a calcium channel blocker (e.g., nifedipine) remains a widely used therapy, although evidence of its efficacy is not conclusive.[82] Suggested treatment doses are nifedipine IR (immediate release) tablets 10 to 30 mg orally three times a day or nifedipine SR (sustained release) tablets 30 to 90 mg orally once a day, titrated to symptom relief. Other treatment options include topical 1% nitroglycerin or L-arginine, sildenafil, L-arginine, and botulinum toxin A.[113,129]

GENDER-RELATED ISSUES CONCERNING INFECTIOUS DISEASES

Wilderness travel may increase exposure to infectious diseases. Gender-related anatomic or physiologic differences (e.g., pregnancy) can influence the risk.[135,193] Women should update routine and travel-related immunizations prior to becoming pregnant. Maternal vaccination decreases the risk to the unborn child. Preconception immunizations are preferred to vaccination during pregnancy. Because as many as 50% of pregnancies are unplanned, women of reproductive age should be encouraged to update their regular and travel-related immunizations at all routine visits. Travel-related infections (e.g., malaria and hepatitis E) for which there are no preventive immunizations can create increased risks during pregnancy.

To advise women on infectious risk issues, especially for long-term or adventure travel to endemic and remote areas, consider the geographic location; mode of transmission, clinical manifestations, and diagnosis of possible infections; how infections might affect a pregnancy or lead to changes in the female genital tract; and other gender-related issues.

Schistosomiasis is caused by the *Schistosoma* trematode and is believed to infect nearly 200 million individuals in 76 countries.[94A,148] Female genital schistosomiasis has been associated with a wide range of pathologies (e.g., infertility, miscarriage, preterm delivery, and increased susceptibility to superinfections and human immunodeficiency virus [HIV]).[125,172] Women may have lesions of the vulva, vagina, cervix, uterus, and fallopian tubes. The risk for schistosomiasis in female adventure travelers and expatriates living in endemic areas is considerable.[67,134,198,215] Nearly all cases occur in individuals who travel to Africa, with an additional risk factor being a month or more of travel.[148] Centers for Disease Control and Prevention (CDC) investigators found a high incidence of schistosomiasis among expatriates in Malawi. Of 917 persons serologically tested, 302 (33%) had the schistosomal antibody. Of these, 292 (93%) had the antibody to *Schistosoma haematobium*.[65] After recreational exposure (e.g., swimming, wading, kayaking) in the Nile River in Uganda, 17% had evidence of schistosome infection. Physicians may be confronted with parasitic infections causing gynecologic pathologic conditions. This occurs not only in women who have lived in endemic countries but also in women who travel to subtropical countries for work or wilderness expeditions.[74] Women should be educated about the risk of female genital schistosomiasis and the need to avoid exposure to it.[72] The diagnosis is made by microscopic identification of parasite eggs in stool or by serologic tests in lesser infections, where egg shedding may be inconsistent. Antibody tests do not distinguish between prior and current infections. The CDC has an excellent test for *Schistosoma mansoni* (i.e., FAST-ELISA). The World Health Organization recommends preventive chemotherapy with praziquantel on a yearly basis for high-risk populations living in endemic areas, but not for women who travel to endemic regions.[219] Although this recommendation does not prevent infection or development of the disease, it seems to decrease the incidence and severity of complications, and reduces egg production. Praziquantel acts against mature schistosome parasites. It is most effective if taken after the parasite has developed to the adult stage, which is at least 4 to 6 weeks after exposure. Recommended dosing for praziquantel is 40 mg/kg/day orally divided into one or two doses for 1 day for *S. haematobium*, *Schistosoma intercalatum*, and *S. mansoni*. Praziquantel 60 mg/kg/day divided into two or three doses for 1 day is recommended for *Schistosoma japonicum* and *Schistosoma mekongi*. An alternative treatment choice for *S. mansoni* is oxamniquine 15 mg/kg orally one time.[81] Using praziquantel as a postexposure prophylaxis (PEP) pill to prevent schistosomiasis immediately after a high-risk freshwater exposure is not effective and not recommended for travelers. More information on testing and diagnosis can be found through the CDC Parasitic Diseases Branch at 1-404-718-4745 or at cdc.gov/parasites/schistosomiasis.

PRACTICAL ISSUES FOR WOMEN DURING WILDERNESS TRAVEL

Women between the ages of 10 and 50 years menstruate on average once a month, with a high degree of individual variability. Women should be prepared to experience changes in their cycle and premenstrual symptoms during wilderness travel. Changes in exercise, diet, sleep patterns, and time zones can affect the hypothalamic-pituitary axis and cause menses to become irregular or cease. It is helpful for women on long-term expeditions to chart their cycles. Follow guidelines in cases of amenorrhea or dysfunctional uterine bleeding.[4,25,62,] Reproductive-age women sexually active with men should carry pregnancy tests to rule out pregnancy if they miss a menstrual period. Consider the best options for feminine hygiene products (e.g., product weight, bulk, and disposal options) for a particular trip. A number of alternative menstrual products are available, including soft reusable intravaginal rubber cups (Keeper, DivaCup) (Figure 92-1). Another option is a menstrual cup (Instead Softcup). Although sold for a single use, it can easily be washed and reused. Feminine hygiene products can also be used for wilderness first aid or survival. Tampons may be used as a medical bandage, nasal packing for epistaxis, crude water filter, fire fuel, cord, or ear plugs. Menstrual pads have many of the same applications, as well as potential to act as a compression dressing for wound management (Figure 92-2).

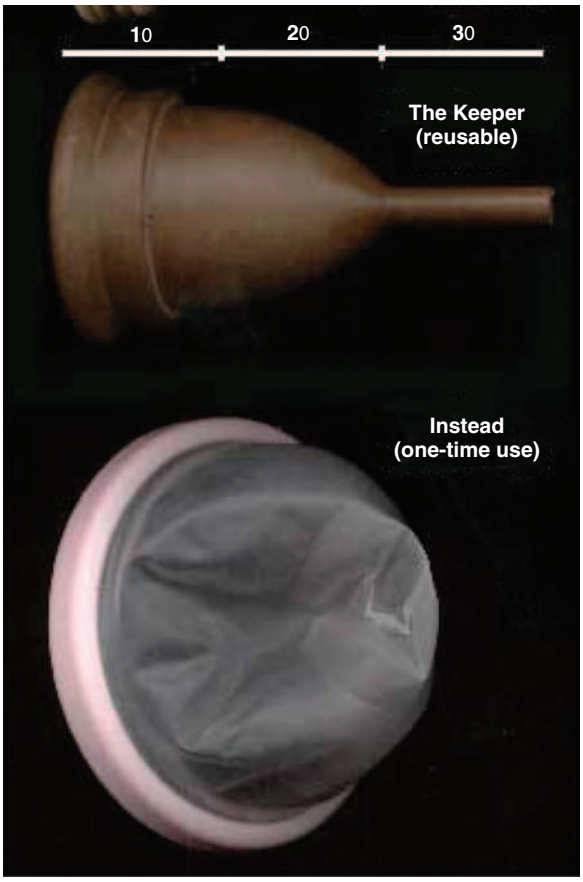

FIGURE 92-1 Options for feminine hygiene. *(Courtesy Harry Finley: mum.org/MenCups.htm.)*

DYSMENORRHEA

Women may experience premenstrual symptoms while traveling, even if they have never experienced symptoms before. Include medications for self-treatment of these symptoms (e.g., ibuprofen) in the medical kit.

CONTROLLING THE MENSTRUAL CYCLE

Some women prefer not to have a menstrual period during long-distance trekking, bicycling, or other endeavors. Options to control the menstrual cycle include oral contraceptives (OCs) or using a contraceptive patch or ring without a hormone-free interval. "Tri-cycling" involves taking three to four cycles continuously by not observing the pill-free days. This decreases the need for menstrual supplies and reduces premenstrual symptoms. Women should be warned that a small amount of breakthrough bleeding may occur, because the endometrium may not remain stable without the physiologic curettage of the pill-free interval.[62]

Another option to decrease menstrual bleeding is to try a method of contraception that leads to endometrial thinning over time and amenorrhea. Examples of such methods include progestin-only pills, Depo-Provera, or the progesterone intrauterine device (IUD) (Table 92-2). In some women, progestin-only contraception may be less predictable for cycle control and lead instead to irregular bleeding or spotting between menses. If a progestin-only method is chosen, start at least 3 to 6 months in advance of departure in order to evaluate menstrual cycle effects.

MENSTRUAL CYCLE DISTURBANCE

Menstrual cycle disturbance is one of the most frequent reasons a woman seeks medical care.[108] Among highly trained athletes and in environments that impose extreme physical and psychological demands, disturbances can be found in more than 50% of women not taking OCs. Menstrual problems during long-distance hiking were found to be the most common complaint of women backpackers. A study of backpackers on the Appalachian Trail found that 87% of women with regular menstrual cycles prior to travel had menstrual abnormalities while backpacking.[50] High altitude, in combination with other stressors (e.g., time change, cold, and weight loss) is likely to modify the menstrual cycle.

Understanding menstrual cycle abnormalities requires a basic understanding of the normal menstrual cycle (Figure 92-3). In premenopausal women, progesterone and estrogen fluctuate. Normal cycles occur at regular intervals, require ovulation, and typically average 28 days (range 21 to 35 days). By convention, the menstrual cycle's first day corresponds to the first day of menstrual bleeding. This typically lasts approximately 4 days (range 3 to 7 days). Menstrual bleeding represents desquamation of functional endometrium, results from progesterone withdrawal in the absence of conception during the previous cycle, and coincides with recruitment of a new group of primordial follicles for maturation. The first menstrual cycle stage (i.e., up to the time of ovulation) is referred to as the *follicular phase* or *endometrial proliferative phase*. In the early follicular phase, estrogen and progesterone levels are low. In the *late follicular phase* (also called the *preovulatory phase*), typically days 8 to 11, there is a brief surge in estrogen levels, which promotes ovulation. The second menstrual stage is the *luteal phase* or *endometrial secretory phase*. After ovulation, estrogen and progesterone levels peak (typically days 19 to 21) and then decrease until the following menstrual phase. Throughout the menstrual cycle, pulsatile release of gonadotropin-releasing hormone (GnRH) by the hypothalamus occurs hourly during the follicular phase and every 1.5 hours during the luteal phase. Factors that disrupt normal pulsatile release of GnRH or reduce the pituitary ability to respond are the major contributors to menstrual cycle abnormalities in premenopausal women.[51] In women who use OCs, or contraceptive patches or rings, hormone levels are elevated during use of active hormone pills (or patch or ring) for 3 weeks and decreased during the week of placebo (no pill, patch, or ring) use. After menopause, levels of circulating estrogen and progesterone decrease substantially. Estrogen replacement (or combined estrogen and progestin) increases levels of these hormones.

FIGURE 92-2 Multiple uses of feminine hygiene supplies in the wilderness. *(Courtesy Susan Anderson.)*

TABLE 92-2 Common Contraceptive Choices

Methods	Mechanism	Advantages/Disadvantages	Wilderness Travel Issues
Barrier Methods			
Spermicides, creams, jellies, foams, melting suppositories, sponges, foaming tablets, films	Surface-active agents that damage the cell membranes of sperm, bacteria, and viruses.	Chronic exposure may cause mucosal injury that increases risk for HIV transmission.	Available over the counter. Store in cool dark place.
Sponge	Polyurethane sponge containing nonoxynol-9. Sponge traps and absorbs semen before sperm reach cervix. Leave in place for 6 hr after intercourse.	One size. Over the counter. Moisten with water before insertion. Loop for removal. Do not wear longer than 30 hr owing to rare risk for toxic shock syndrome.	Available over the counter. Use disinfected water for moistening in countries with questionable water supply. Protects for 24 hr no matter how many times intercourse occurs.
Cervical cap	Mechanical barrier. Requires spermicide.	Requires clinician fitting. Can use for up to 48 hr. Small risk for toxic shock syndrome. Small risk for cervical dysplasia.	Easy to carry. Rubber may deteriorate in heat and humidity.
Diaphragm	Dome-shaped rubber cup. Use with spermicide. Protection for 6 hr.	Requires clinician fitting. Insert extra spermicide with repeated intercourse. After use, leave in for 6 hr.	Carry in climate-resistant case. Spermicide may not be available in developing countries.
FemCap	Silicone rubber sailor hat–shaped cap intended for use with a spermicide.	Latex free. Two sizes; clinician fitting required. Can be worn up to 48 hr.	Easy to carry. In the future, may be used with spermicide and microbicide for protection against STIs.
Condom			
Female condom (Reality)	Polyurethane pouch. Spermicide not required. One use only.	Can be inserted 8 hr prior to intercourse.	Female controlled. Does not deteriorate in heat and humidity. Bring own supply.
Male condom	Latex	Possible allergy. Do not use oil-based lubricants.	Quality varies from country to country. Bring supply from reliable source of latex and polyurethane types.
	Polyurethane	Thinner and stronger. More resistant to deterioration.	May break down in heat and humidity.
	Lambskin/natural	Can use oil-based lubricants. Small pores permit passages of viruses (hepatitis B virus, herpes simplex virus, HIV). Use ONLY for contraception. Brands and materials differ in quality.	Estimated to last 1 mo in wallet; check expiration date. Use emergency contraceptive if condom breaks, no backup method in place (i.e., OC pill, diaphragm, sponge). Store in cool, dry place.
Hormonal Methods			
Combined pill: estrogen + progesterone Many different types: Monophasic Triphasic Continuous use	Inhibition of ovulation by blocking LH surge. Thickens cervical mucus to prevent sperm penetration to upper genital tract. Inhibits capacitation of sperm, limits ability of sperm to fertilize egg. Slows tubal motility, delaying sperm transport.	Increased menstrual cycle regularity. Less blood loss. Less cramping. Reduces ectopic pregnancy. Less pelvic inflammatory disease. Fewer cysts or fibroids. Less endometriosis. If nausea and vomiting, need to take backup method or consider placing pill in vagina for absorption (still use backup method). May use as emergency contraception; check instructions. Slight increase in risk for DVT and stroke, especially in smokers.	Convenient, effective, easy to carry. Need to take every 24 hr. May use to delay menses by starting next package of active pills after 3 wk of previous package, or use "continuous use" package. Risk breakthrough bleeding with continuous use. Consider drug interactions. Rare risk of DVT. Bring own supply. Research availability of OC pills and/or other method of contraception to use if OC pills lost or stolen.*
Transdermal patch (Ortho Evra)	Matchbook-size device placed on skin. One patch/wk for 3 wk, followed by 1 wk patch free. Each 20-cm^2 patch contains 6 mg norelgestromin and 0.75 mg ethinyl estradiol.	Side effects and contraindications similar to those of combined OC pills. Better compliance than with OC pills. Place on nonexposed area of skin.	Better compliance due to weekly dosing. Absorption not affected by gastrointestinal illness.

TABLE 92-2 Common Contraceptive Choices—cont'd

Methods	Mechanism	Advantages/Disadvantages	Wilderness Travel Issues
Vaginal ring (NuvaRing)	Flexible and colorless vaginal ring used for 3 wk followed by 1 wk ring free. Releases combination of progestin with estrogen for absorption across vaginal wall.	Side effects and contraindications similar to those of combined OC pills. Leave ring in place for 3 wk. Do not remove for intercourse. Ring can be removed for up to 3 hr without losing efficacy. If > 3 hr, need backup method for 7 days.	Better compliance due to dosing. Less breakthrough bleeding. Absorption not affected by gastrointestinal illness.
Nestorone/ethinyl estradiol contraceptive vaginal ring (awaiting FDA approval)	2¼-inch-diameter ring similar in design and mechanism to NuvaRing. 103 mg Nestorone/17.4 mg ethinyl estradiol. Use for 3 wk, followed by 1 wk ring free. Designed for 13 cycles (1 year) of use.	Leave ring in for 3 wk. One ring is effective for up to 1 year. Does not require health care visit for placement.	Ideal for extended international travel, especially in settings with few resources. Keep in safe place during week off so as not to lose method of contraception. Bring backup ring for extended travel in case lost or misplaced.
Progestin-Only Methods			
Progestin-only pills	Inhibition of ovulation (may occasionally ovulate). Thickened and suppressed cervical mucus. Suppression of midcycle LH and FSH.	Use if cannot take estrogen. Take same type of pill every day (no pill-free week). Decreased menstrual cramps, less bleeding. Can use if breastfeeding. Decreased risk of thrombotic complications. Older women, smokers can use.	Need to be prepared for irregular bleeding. MUST take pill at same time every day (set alarm to help with time zone changes).
Depo-Provera	150 mg by intramuscular injection or 104 mg administered subcutaneously every 3 mo. Blocks midcycle LH hormone surge and inhibits ovulation.	Good choice for women who cannot take estrogen. Good compliance. Side effects: weight gain, menstrual irregularities, acne, mood changes, decreased libido, decreased bone density. Not possible to discontinue immediately.	Use if compliance issues (e.g., unable to remember OC pills). Contraceptive coverage for 3 mo. If travel > 3 mo, need to get injection or switch method. Need to be prepared for irregular bleeding.
Implanon or Nexplanon (second generation)	4-cm long implant that releases progestin etonorgestrel at a rate of 60 mcg daily. Suppresses ovulation, thickens cervical mucus, leads to atrophic endometrium.	3 years of contraception. Can be reversed any time by removing this one implant. Menstrual cycle disturbances.	Great option for travel. Lasts 3 years.
Progering	Progestin-only vaginal ring. Each ring releases 10 mg progesterone daily.	Replace every 3 mo or once a year, depending on formulation. Safe for lactating women.	Easy for travel.
Intrauterine Device			
Three approved for use in the United States (others available worldwide)	Inhibition of sperm migration, fertilization, and ovum transport. Creates environment that is spermicidal by provoking a sterile inflammatory reaction that is toxic to sperm and implantation.	Option for nullgravid and multiparous women at low risk for STIs who desire short-term contraception. Small risk of IUD-induced infection: At insertion More than one partner Option for women with History of diabetes History of DVT who are breastfeeding	Long-term contraception for 5-10 years Need fewer supplies for contraception. Need to know how to check for string. Need backup method if falls out. Need to protect against STIs. Need medical evaluation for missing string Excessive vaginal bleeding Abdominal pain Vaginal discharge Pregnancy
ParaGard T 380A Copper	T-shaped polyurethane frame holding 380 mg of exposed surface of copper.	Increased menstrual bleeding and cramping may occur in first few months following insertion; relieved with NSAIDs.	Effective for 10 years. Need fewer supplies.

Continued

TABLE 92-2 Common Contraceptive Choices—cont'd

Methods	Mechanism	Advantages/Disadvantages	Wilderness Travel Issues
Mirena—levonorgestrel-releasing intrauterine system (LNG-IUS)	T-shaped with a polydimethylsiloxane sleeve delivering 20 mcg levonorgestrel. Size: 32 mm horizontally by 32 mm vertically by 4.75 mm insertion tube	Less bleeding and cramping due to effect of levonorgestrel.	Effective for 5 years. Need fewer supplies.
Skyla—levonorgestrel-releasing intrauterine system (LNG-IUS)	Similar to Mirena system in design and mechanism. 14 mcg of levonorgestrel per day. Size: 28 cm horizontally by 30 mm vertically by 3.8 mm insertion tube.	Smallest IUD marketed to adolescent and nulliparous women.	Effective for 3 years.
Methods of Contraception Undergoing Clinical Trials			
Microbiocide/spermicidal creams (e.g., ACIDFORM)†	Combination spermicidal and microbiocide to be used alone or with barrier methods above.	Dual protection against pregnancy and STIs.	
Transdermal spray contraception	Daily progestin-only "spray-on" contraceptive. Progestin Nestorone inhibits ovulation.	Metered-dose aerosol delivers preset amount. Absorbed immediately. Safe for breastfeeding women.	
Transdermal gel	Two versions: Nestorone (19-norprogesterone derivative) only. Combination estradiol and norprogesterone.	Application in periumbilical region.	Cutaneous contamination could limit absorption when showering limited.
Disposable diaphragms (Duet with BufferGel)	Diaphragms that release spermicide/microbicide. They may be used up to 24 hr with multiple acts of intercourse.		Easy to use. No extra spermicide/microbicide required.

DVT, Deep vein thrombosis; FDA, Food and Drug Administration; FSH, follicle-stimulating hormone; HIV, human immunodeficiency virus; LH, luteinizing hormone; OC, oral contraceptive; STI, sexually transmitted infection.
*See ec.princeton.edu/worldwide/default.asp#country.
†See Bayer LL, Jensen JT: ACIDFORM: a review of the evidence, Contraception 90(1):11-18, 2014.

CAUSES OF ABNORMAL UTERINE BLEEDING

Understanding the physiology of the normal menstrual cycle and differential diagnosis of dysfunctional uterine bleeding at each phase of a woman's reproductive life will help to diagnose and manage these conditions.

Abnormal uterine bleeding (AUB) is any aberration in the normal menstrual bleeding pattern in premenopausal women or any bleeding episode in postmenopausal women. The most common causes of AUB are problems related to pregnancy and hormonal contraceptive therapy. Initial evaluation of AUB in any premenopausal woman includes a pregnancy test (i.e., urine or serum screen for human chorionic gonadotropin [hCG]), regardless of contraceptive history. Non–pregnancy-related causes of AUB include uterine and extrauterine causes.

The history helps identify a presumptive cause and empirical therapeutic approach for AUB, particularly in the absence of laboratory resources. The pertinent history includes age at onset of menses, regularity of menses, usual length of menses and blood flow, perimenstrual symptoms, medical problems, a basic review of endocrine symptoms, and a history of any prior pregnancies, STIs, and surgeries.[108] Characterize the current complaint, including changes in the frequency of bleeding, amount of flow, new symptoms, relationship to activities, recent sexual history, systemic symptoms, weight change, change in medications or use of other health-related products, and change in exercise patterns.

OVULATORY WOMEN

When a premenopausal woman with consistent, regular cyclic menses presents with a progressively increasing amount and duration of menstrual flow, the most common causes are uterine fibroids, particularly submucosal (i.e., just beneath the endometrium) fibroids, endometriosis, and adenomyosis (i.e., endometriosis of the uterine muscle wall). These conditions are frequently associated with progressive dysmenorrhea and are more likely to occur with advancing age. Consider medications (e.g., estrogen, tamoxifen, warfarin, nonsteroidal antiinflammatory drugs) or homeopathic compounds as possible causes of AUB. An abrupt change in duration or amount of blood flow suggests either a corpus luteal cyst (often associated with unilateral lower abdominal discomfort) or acute pelvic inflammatory disease (PID) that is often accompanied by more diffuse abdominal pain and systemic symptoms. In ovulating women, endometrial hyperplasia is unusual and uterine or ovarian (estrogen-secreting) malignancies are rare. Perimenopausal women who are still ovulatory may have progressively more frequent menses accompanied by changes in flow and duration, with or without the underlying causes noted above.

Evaluate women with intermenstrual or postcoital bleeding for cervicovaginal infections (e.g., bacterial vaginosis (BV), yeast, trichomoniasis, and condylomas). Endocervical polyps, cervical dysplasia, and invasive cervical carcinoma can lead to profuse coital bleeding and dyspareunia. Acute pain with coitus not accompanied by bleeding is more likely due to PID, ovarian cyst rupture, or adnexal torsion.

ANOVULATORY WOMEN

Anovulatory uterine bleeding is more common than are ovulatory abnormalities among women who partake in wilderness experiences. Divide anovulatory bleeding problems into those occurring with adequate estrogen and those accompanied by low estrogen production. Women with adequate estrogen stores are often characterized by hypersecretion of gonadotropins and frequent heavy bleeding (e.g., polycystic ovary syndrome). OCs help stabilize the endometrium and decrease the menstrual flow.

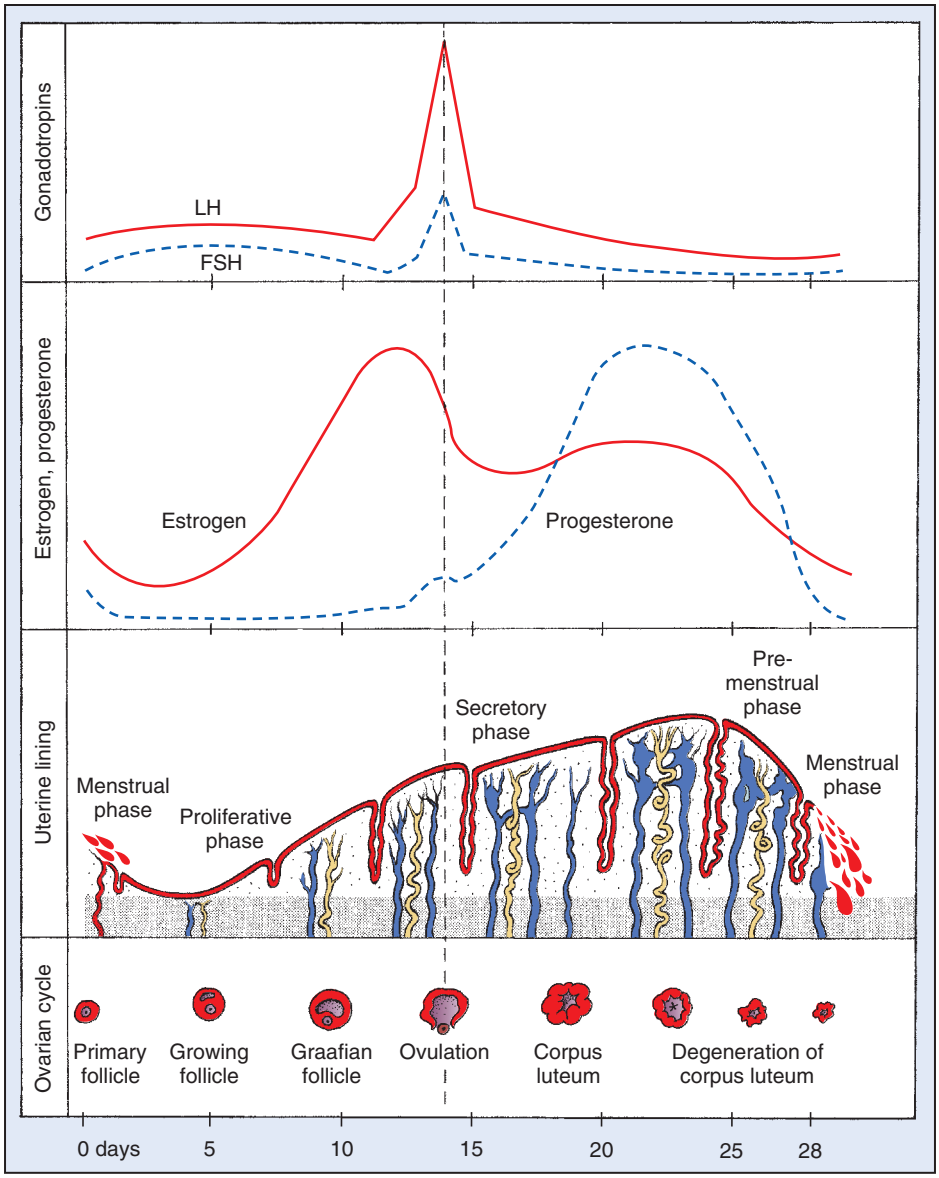

FIGURE 92-3 Normal human ovarian and endometrial (menstrual) cycle. FSH, follicle-stimulating hormone; LH, luteinizing hormone. *(Modified from Shaw ST Jr, Roche PC: Menstruation. In Finn CA, editor:* Oxford reviews of reproduction and endocrinology, *vol 2, Oxford, United Kingdom, 1980, Oxford University Press.)*

Anovulation can be caused by inadequate release of pituitary gonadotropins that leads to decreased estrogen production and presents as amenorrhea. Amenorrhea can be a symptom of the female athletic triad historically defined by disordered eating, amenorrhea, and osteoporosis.[114] More recent consensus statements use a more encompassing diagnostic term, relative energy deficiency in sport (RED-S), because there are more impaired physiologic states with this condition than those listed in the triad. RED-S has also been exhibited in males.[157] More commonly, anovulatory cycles and amenorrhea result from changes in a woman's usual routine of sleep, diet, and exercise patterns, all of which are extremely common to a wilderness experience.

The American College of Obstetrics and Gynecology guidelines for workup of acute abnormal uterine bleeding can be found at acog.org/Resources-And-Publications/Committee-Opinions/Committee-on-Gynecologic-Practice/Management-of-Acute-Abnormal-Uterine-Bleeding-in-Nonpregnant-Reproductive-Aged-Women.[25]

To evaluate vaginal bleeding in the wilderness, it is critical to differentiate a true emergency (e.g., ectopic pregnancy or miscarriage) from a more benign cause that can be stabilized and evaluated later. If the pregnancy test is positive, immediate medical evacuation should be arranged. If the pregnancy test is negative and there is no other evidence of an anatomic abnormality or systemic illness, vaginal bleeding is likely a form of dysfunctional uterine bleeding. Use the following measures to attempt to stop bleeding until further evaluation can be obtained.

For women without contraindications to estrogen or progestin, hormonal therapy with either estrogen or progestin or a combined hormonal preparation may be used to stabilize the endometrial lining. One option is to take an OC pill containing 30 to 35 mcg of ethinyl estradiol every 4 to 6 hours until bleeding is under control, and then continue taking one tablet a day until the 21 active pills are finished. A few days later, synchronized withdrawal bleeding will occur. A woman may opt to continue taking one OC pill a day to prevent withdrawal bleeding until evaluation can be obtained. Although the mechanism of action of a bolus of estrogen and progesterone is not well understood, its effect is thought to be mediated by accelerated proliferation of the endometrial basal layer that seals the bleeding vessels.

In perimenopausal women with irregular bleeding, a low-dose OC containing 20 mcg ethinyl estradiol may be tried. Advantages include predictable cycle control, reliable contraception, decrease in perimenopausal symptoms (e.g., mood swings, irritability, decreased libido, and hot flashes), and possibly prevention of accelerated bone and mineral loss during perimenopausal years.

Menopause is associated with amenorrhea as a result of cessation of ovarian estrogen production and inactive atrophic

endometrium. Occasionally, a menopausal woman may produce sufficient estrogen from peripheral conversion of ovarian and adrenal androgens to stimulate the endometrial lining and cause resumption of bleeding. Postmenopausal bleeding can also be due to atrophy. Although postmenopausal bleeding is usually mild and does not need emergent treatment, a medical evaluation is important to rule out more serious causes (e.g., underlying malignancy).[4]

PREGNANCY TESTS

Pregnancy tests are helpful to evaluate amenorrhea, vaginal bleeding, pelvic pain, and other symptoms that may be related to a pregnancy. Pregnancy tests should be carried in the medical kit. Urine pregnancy kits are not always available in remote areas, and outside developed countries, test reliability can vary. Pregnancy test kits have limited shelf lives. Check expiration dates. Environmental extremes can also affect test accuracy. Observe manufacturer's recommendations regarding storage. As with most self-diagnostic tests, review test procedures with the woman before travel.[69]

CONTRACEPTIVE OPTIONS DURING WILDERNESS TRAVEL

Address contraceptive options for all women wilderness travelers of reproductive age (see Table 92-2). Contraceptive options include lower-dose OC pills, several new oral progestins, progestin-only implants, and a progestin-bearing IUD. Certain delivery methods (e.g., contraceptive patch and vaginal ring) are excellent options for wilderness travelers. They do not require daily compliance with taking a pill at the same time every day or rely on drug absorption that could be affected by a gastrointestinal (GI) illness (e.g., nausea, vomiting, or diarrhea). Contraceptive efficacy is improved with use of the contraceptive patch or ring, and there is less risk for irregular bleeding due to fluctuating hormone levels.[47,103]

The best contraceptive method for a particular woman depends on the planned activities and itinerary. Consider accessibility and ease of use, weight and bulk, effects of extremely hot or cold environments, effects of immersion into water, and method reliability under perfect and imperfect use.

Wilderness medicine providers should take advantage of current journal articles, reference books, and Internet websites with information regarding contraception. This is a rapidly changing field.[3,47,68, 85,103,128] Relevant websites include the

American College of Obstetrics and Gynecology at acog.org,

Hormonal Birth Control at acog.org/publications/patient_education/bp159.cfm,

International Planned Parenthood Federation at ippf.org, and the

Princeton Emergency Contraception site at ec.princeton.edu.

In women already using a contraceptive method, evaluate the method's ease of use and reliability as well as any special recommendations concerning use during travel. Begin any new method several months before travel, especially if planning overseas or remote travel or a long-term assignment. Backup methods should be discussed. The International Planned Parenthood Federation maintains a worldwide guide to contraceptives and a list of family planning clinics. The Princeton Emergency Contraception website also lists emergency contraception (EC) options available worldwide.

BARRIER CONTRACEPTIVES

The most common barrier contraceptives used during travel include the diaphragm, cervical cap, sponge, vaginal spermicide, and male condom.[103] Barrier contraceptive methods have a reassuring safety profile (limited to latex allergy and method failure resulting in pregnancy), but all have disadvantages for regular use in a wilderness setting. Even under ideal use, failure rates with a spermicidal foam or gel are relatively high (estimated at 20% to 30% with "typical use" and 6% to 20% with "perfect use.") Barrier devices may be susceptible to extremes of heat or cold that may compromise membrane tensile strength and effectiveness. Some couples find these methods inconvenient and messy enough to discourage compliance in environments not conducive to cleanup. Bulk and weight complicate transport of sufficient spermicidal compound. Barrier methods decrease the risk for STIs, including gonorrhea, chlamydial infection, and HIV transmission, but offer variable protection against human papillomavirus or genital herpes simplex virus, even if used correctly.

HORMONAL CONTRACEPTIVES

Combination (estrogen and progestin) OCs, either monophasic or multiphasic, offer the most reliable, convenient, and cost-effective risk-to-benefit ratio for healthy reproductive-age women. Consider previous experience of use, complications of therapy, menstrual history, and skin type. Failure rates with optimal use are extremely low (1%) but may be worsened by difficulty with compliance or GI illness during travel. Common side effects include nausea, vomiting, weight gain, and breakthrough bleeding. In most patients, breakthrough bleeding decreases with consistent use, and there is no need to change the brand of OC as a result. Potential benefits of OCs include normalization of cycles, fewer midcycle ovulatory (e.g., mittelschmerz) and perimenstrual (e.g., dysmenorrhea, headaches) symptoms, lighter menstrual flow, suppression of ovarian cyst formation, reduced risk for endometrial cancer, prevention of osteoporosis, and increased bone mass. Condoms must still be used to prevent STIs. Major contraindications include a history of thromboembolic disease, certain autoimmune disorders with thromboembolic risk factors, uncontrolled hypertension, hepatic dysfunction, diabetes with complications, and cigarette smoking.

TRANSDERMAL HORMONAL CONTRACEPTION

The U.S. Food and Drug Administration (FDA) approved the first transdermal contraceptive patch in 2001. The contraceptive patch is a matchbook-sized device that is placed on the skin (abdomen, upper outer arm, buttocks, or upper torso but not the breasts). It consists of a three-layer matrix with an outer polyester protective layer and a medicated adhesive layer that contains the contraceptive steroids. A clear, polyester release liner, which protects the adhesive layer, is removed before application. The patch releases 22 mcg of ethinyl estradiol and 150 mcg of norelgestromin daily. Hormones are absorbed into the blood and reach a steady state in 2 days. Each patch lasts 7 days. Apply a patch on day 1 of menses and replace it weekly for 3 weeks. No patch is used during the fourth week. Place each patch at a different site. The efficacy is similar with various application sites. Contraceptive efficacy is not thought to be affected by humid climates, vigorous exercise, exposure to saunas, or water baths. The patch has similar side effects to OCs. In addition, users may experience occasional mild to moderate application-site reactions and an increased incidence of breast tenderness during the first few months of use. Most women have found the patch to be more convenient than a daily pill when traveling, and it is easy to check to make sure it is in place. To discard a used patch, fold it in half and discard it in solid waste garbage. Do not flush it down a toilet. There are no hormonal peaks and troughs. Oral antibiotic use is not believed to interfere with efficacy. The FDA has issued a warning about Internet sales of counterfeit contraceptive patches.[73]

VAGINAL RING

The NuvaRing is a soft, flexible, and transparent ring made of an ethylene vinyl acetate copolymer. It has an outer diameter of 54 mm and cross section of 44 mm. Two steroid reservoir cores in the ring provide daily hormone release of 15 mcg of ethinyl estradiol and 120 mcg of etonorgestrel (an active metabolite of desogestrel). The NuvaRing provides hormone bioavailability comparable with an OC (e.g., desogestrel ethinyl estradiol [Ortho-Cept]). The device is inserted in the vagina and removed after 3 weeks. Following one "ring-free" week, a new ring is inserted. If the ring is expelled accidentally, it can be washed and reinserted.

If the ring is out for more than 3 hours, a backup contraceptive method is recommended. Advantages include good contraceptive efficacy with continuous release, leading to better compliance. The ring does not depend on GI absorption, so will continue its effectiveness despite GI illness.[92] Side effects are rare, and include prolonged menstrual bleeding, vaginal discomfort, and foreign-body sensation. Use of common antibiotics (e.g., amoxicillin and doxycycline) does not appear to affect the efficacy.[78]

INTRAUTERINE DEVICES

An IUD is a highly effective and convenient form of contraception, especially for parous women in a monogamous relationship. Women who cannot take estrogens (i.e., history of breast cancer, thromboembolism, diabetes, or breastfeeding) are candidates for an IUD.[15] The IUD should be inserted at least 3 months before departure, because complications occur most often within the first month after insertion. IUDs are occasionally associated with increased menstrual flow, dysmenorrhea, intermenstrual spotting, and expulsion. However, the Copper T 380A IUD (ParaGard) and the levonorgestrel systems, or LNG-IUS (Mirena/Skyla), carry minimal risks for these side effects. Mirena releases approximately 20 mcg of levonorgestrel per day, approximately 10% of that provided by a levonorgestrel-containing OC. The Mirena requires replacement every 5 years, and the Skyla is replaced every 3 years. The Copper T 380A IUD is effective for 10 years or longer. For certain women, an IUD is a great option for wilderness travel.[10]

The IUD's most serious risk, affecting less than 1% of users, is an acute or indolent pelvic infection that might become clinically significant in the wilderness. The risk is greatest within the first month after IUD insertion or replacement and among women at increased risk for STIs. Women with multiple partners, previous pelvic infections, unrecognized chlamydial infection or gonorrhea, recurrent episodes of bacterial vaginosis, or tobacco use are at highest risk. When acute PID occurs with lower abdominopelvic pain, peritonitis, purulent vaginal discharge, and fever, remove the IUD immediately by simple traction on the string protruding from the external cervical os. Start a broad-spectrum antibiotic. Evacuation is mandatory when the device cannot be removed. Pelvic infection should be suspected, even without fever and peritoneal signs, if irregular bleeding occurs, particularly when accompanied by pelvic discomfort and discharge. When the IUD is removed at this stage, infections may respond to therapy with oral or parenteral antibiotics.[10]

Another potentially serious risk for IUD users is pregnancy, occurring in approximately 1 in 1000 users per year with the levonorgestrel systems. Both intrauterine and extrauterine pregnancies can occur with an IUD in place. The latter is more common, but the risk is still only half that of women who use no contraception. Confirmed or suspected pregnancy in a woman with an IUD is an indication for immediate evacuation.

EMERGENCY CONTRACEPTION

Emergency contraception (EC) is defined as a method of contraception that women can use after unprotected intercourse or contraceptive failure to prevent pregnancy (Table 92-3). EC should be used when desired in cases of unprotected intercourse, contraceptive failure, or sexual assault. EC should be included in every woman's wilderness medical kit. It decreases a woman's risk for pregnancy from approximately 8% to 1% or 2%. The Princeton Emergency Contraceptive website (ec.princeton.edu) has an excellent review of EC options, commonly asked questions, and a chart of dosing options for specific OC brands being used as EC, as well as OC options available in different countries.[23,103,130]

Three major categories of EC are available worldwide: progestin-only pills, estrogen-progestin combined OC pills, and nonhormonal options.[68,128] Nonhormonal options include a selective progesterone receptor modulator (ulipristal acetate, or Ella), copper IUD insertion, and mifepristone (only available in select countries). Ulipristal acetate is more effective than levonorgestrel and combined pill regimens, and maintains its efficacy for up to 5 days.[27] EC options available in most countries include a progestin-only option (i.e., levonorgestrel) or estrogen-progestin combination OC pills. Studies have shown that Plan B (i.e., levonorgestrel) is equally effective when both doses of pills (1.5 mg total) are taken at the same time, rather than when the 0.75-mg tablets are taken 12 hours apart.[103] The "one-dose" option may improve compliance and effectiveness. Plan B is better tolerated than are other ECs that contain estrogen. In the United States

TABLE 92-3 Emergency Contraceptive Methods*

	No. of Pills per Dose	Ethinyl Estradiol (µg)	Levonorgestrel (µg)	Instructions
Progestin Only				
Levonorgestrel (Plan B)	1 tab	0	750	Take 2 tabs (150 µg Levonorgesterl) as soon as possible within 120 hr of risk.
Ovrette	20 tab	0	750	Take 20 tabs (150 µg Levonorgesterl); then take 20 pills 12 hr later. May take both doses at once.
Combined Over-the-Counter (take first dose within 72 hr of risk)				
Alesse	5 pink	100	500	Take first dose as soon as possible.
Lo/Ovral	4 white	120	600	Take second dose 12 hr later.
Nordette	4 orange	120	600	May need antiemetic medication.
Levlen	4 orange	120	600	
Levora	4 white	120	600	
Seasonale	4 pink	120	600	
Tril-Levlen	4 yellow	120	500	
Triphasil	4 yellow	120	500	
Trivora	4 pink	120	500	
Nonhormonal Options				
Ulipristal Acetate (Ella)	30 mg	Progestin receptor modulator with antiprogestin activity.		No change in efficacy with time if taken within 120 hr.
Copper IUD	Insertion of single IUD	Sterile inflammatory reaction creating spermicidal environment not conducive to implantation.		Insertion within 120 hr.
Mifepristone	10-50 mg	Synthetic steroidal antiprogesterone/antiglucocorticoid.		Available only in Armenia, China, Russia, and Vietnam.

*See emergency contraceptive website for current recommendations and for options available worldwide: ec.princeton.edu/worldwide/.

and Canada, progestin-only ECs are available over the counter and ulipristal acetate (Ella) is available by prescription. Complete EC as soon as possible, preferably within 72 hours after unprotected intercourse. Ulipristal acetate is effective up to 120 hours after unprotected intercourse. New data indicate that all EC options may be effective for up to 120 hours.[94,130] Although inserting a copper IUD has the best efficacy, this is not feasible in a wilderness environment. Administer an antiemetic when using OCs containing estrogen and progesterone. If there are persistent nausea and vomiting, EC pills may be administered vaginally.[23]

Following EC use, initiate a combined hormonal method (e.g., OC pill, patch, ring). Two to three weeks later, perform a urine pregnancy test to rule out pregnancy. In pregnancies following EC, combined hormonal contraception use has not been found to increase teratogenic risk.[47]

SPECIAL ISSUES RELATED TO HORMONAL CONTRACEPTIVES AND WILDERNESS TRAVEL

Changes in Time Zone

Many low-dose OC formulations are time sensitive. Failure to take a pill in a timely manner because of time zone changes or a change in schedule could result in ovulation. Use a wristwatch or mobile phone alarm dedicated to OC dosing control for precise determination of 24-hour intervals.

Absorption of Oral Contraceptives

Nausea, vomiting, or diarrhea during travel may decrease pill absorption. If vomiting occurs within 3 hours of taking a pill, take another. If a replacement pill cannot be retained, use a backup contraceptive method for the rest of the month (equivalent to missing a pill). If the missed pill was less than 7 days from the end of the monthly package, consider eliminating the pill-free interval and starting the next package right away. For continued nausea and vomiting, some clinicians recommend inserting the OC pill into the vagina for absorption, although efficacy has not been evaluated in clinical trials. Estrogens are absorbed better through the vaginal mucosa than through the GI tract.[6,38] For women at risk for GI illness during travel, a contraceptive patch or a ring is ideal.

Drug Interactions That May Affect Oral Contraceptive Efficacy

A common question is whether antibiotics affect OC efficacy. OC metabolism is increased by any drug that increases liver microsomal enzyme activity. Despite numerous case reports of penicillins, tetracyclines, metronidazole, and nitrofurantoin causing contraceptive failure in humans, the general consensus of large-scale studies is that antibiotics other than rifampin do not lower steroid blood concentrations[34,103,107,126,203] However, individual women have been shown to have decreased ethinyl estradiol levels while taking antibiotics. Because these women cannot be identified in advance, most clinicians and the OC package insert take a conservative approach and advise women to use a backup method of contraception when taking antibiotics.[77] Recent data suggest that contraceptive patch and ring efficacy are not affected by concurrent antibiotics.[78]

GENDER AND RISK FOR VENOUS THROMBOEMBOLISM: CONTRACEPTION, PREGNANCY, AND BEYOND

The incidence of venous thromboembolism (VTE) in young women is estimated to be 1 to 3 per 10,000 per year.[19] Pregnancy increases this risk three- to five-fold. Low-dose contraceptives increase the risk three- to four-fold.[137] The association between pregnancy and VTE is well established. Pulmonary embolism is one of the leading causes of peripartum mortality.[202] Increased VTE risk is also associated with hormone replacement therapy and estrogen-antagonist therapies. These exposures are unique (i.e., pregnancy and OCs) or nearly unique (i.e., estrogen agonist and antagonist therapies) to the female gender.[155] The VTE risk may be important to consider in some wilderness settings (e.g., high-altitude expeditions) that may include risk factors (e.g., immobility due to bad weather).

OCs are believed to effect thrombosis by altering endogenous coagulation and fibrinolytic systems. OC use is associated with increases in prothrombin, fibrinogen levels, and factors VII, VIII, and X, and with decreases in factor V levels. Use of OCs is associated with a twofold to threefold increase in the risk for VTE. Use of third-generation OC drugs containing gestodene, desogestrel, drospirenone, or cyproterone acetate as the progestin component likely confers up to a six-fold greater risk than use of second-generation preparations.[138] This may be due to a greater estrogen effect. Expert consensus statements deem this risk to be acceptable.[26,192] Inform patients of possible risks and make joint decisions that are best for each individual case. Obese patients and smokers are also at increased risk.[207]

The term *hormone replacement therapy* refers to use of a variety of estrogen or combined estrogen and progestin formulations prescribed to relieve menopausal symptoms and prevent osteoporosis. Effects of hormone replacement therapy on the coagulation system appear to be similar to those of OCs, with evidence for increased markers of coagulation, factor VII levels, and activated protein C resistance, and a decrease in antithrombin levels.[178]

Two selective estrogen receptor modulators are used. Tamoxifen is used primarily for adjuvant treatment of breast cancer, and raloxifene has been approved for prevention of osteoporosis. Both are approved for breast cancer prevention.[209] Although these agents have antiestrogenic properties, they also have partial agonist effects at selected receptors and might be expected to have some of the same side effects and associated risks as do other estrogens. The Breast Cancer Prevention Trial[88] reported a threefold increased risk for pulmonary embolism and no significant increased risk for deep vein thrombosis among women with breast cancer receiving tamoxifen. Aromatase inhibitors, also used for treatment and prevention of breast cancer, are associated with a lower incidence of venous thrombosis than is tamoxifen.[29,209]

Pregnancy is a well-recognized risk factor for thromboembolic disease. Physiologic changes that occur during pregnancy pose several risks for VTE. Hypercoagulability results from increased levels of fibrinogen and several clotting factors (II, VII, VIII, IX, X, XII), as well as decreased levels of inhibitors of coagulation (e.g., protein S). Altered coagulation persists throughout pregnancy and for up to 6 weeks postpartum. Venous stasis occurs from hormonally induced increases in venous distensibility and capacity, as well as vena cava compression by the gravid uterus.[202] Vascular injury resulting from childbirth, especially cesarean birth, further escalates the risk for peripartum VTE. Cesarean birth is associated with an increased incidence of VTE compared with vaginal delivery. Other risk factors for VTE during pregnancy include obesity, advanced maternal age, parity, whether a woman has had prolonged bed rest, the presence of infection or thrombophilia, and a history of VTE.

Exposure to high altitude has been reported as a potential risk factor for thromboembolic events, because of hypoxia, polycythemia, dehydration, cold, and periods of venous stasis, but data are limited.[97] VTE risk from the use of OCs or other types of hormonal therapy has not been systematically studied at high altitude. As a precaution, women planning high-altitude excursions who desire hormonal contraception should consider a combination pill containing the lowest dose of ethinyl estradiol (20 mcg) or its equivalent or a contraceptive patch or ring.[118,144] Contraceptive options for women at high risk of thrombolic events include an IUD or a progestin-only method.[15]

If a thrombotic or thromboembolic event is suspected, aspirin therapy may be started empirically while awaiting medical evacuation. Aspirin prophylaxis has been shown to reduce the incidence of VTE and pulmonary embolism in high-risk medical and surgical patients, but no studies have evaluated aspirin in reducing deep vein thrombosis/pulmonary embolism related to altitude or air travel.[177]

BREAST HEALTH

Women should examine their breasts for masses before travel. Women older than 40 years of age and women with a strong family history of breast cancer should have a breast examination and mammography screening. Although there are reports of self-diagnosis and treatment in the field,[105] a breast mass would ideally be evaluated before travel to a remote location. A woman who has had a prior mastectomy and lymph node dissection with resulting lymphedema may want to use an arm sleeve to decrease swelling during air travel and extended backpacking or trekking expeditions.[102] These women should be taught how to recognize cellulitis and how to treat it with appropriate antibiotics.[195]

There have been no large studies on breast implant safety at altitude or during scuba diving. In one small study evaluating breast implants in simulated dives, there were no ruptures, but morphologic distortions occurred in some implants. Repetitive stress associated with the total number and depth of dives may decrease the implant life span.[80,96] Test any clothing and sports equipment ahead of time for breast comfort. Sports bras are helpful for many women. Issues pertinent to breastfeeding are discussed in the section on pregnancy.

URINARY TRACT ISSUES

Women are prone to urinary tract infections (UTIs) during wilderness travel. Contributing factors include dehydration, less frequent urination owing to lack of convenient toilets, fewer available facilities for hygiene, and increased sexual activity. Sexual intercourse increases the risk for UTI at all ages because of urethral massage, which introduces bacteria into the urethra and bladder. Voiding after intercourse lessens this risk. The UTI risk is increased during pregnancy because of urinary stasis and ureteral compression by the uterus. UTIs in older women may be due to changes in the urogenital epithelium. Women of all ages should be taught to recognize symptoms of UTI and how to self-treat with oral antibiotics and a urinary analgesic agent. Urinary dipsticks to check for leukocytes and nitrites may be carried in a medical kit.

Measures to prevent UTIs include adequate hydration and urination when needed, even if there is no facility or object behind which to seek privacy. Some women find squatting positions to be awkward. It may be helpful to practice deep knee bends before the trip. Women should consider attire (e.g., a free-flowing skirt) that would both facilitate squatting and add privacy. A number of plastic and paper funnels have been designed to assist women to urinate while standing (Figure 92-4). These methods require practice. To use, place one's back to the wind and point the funnel downward while leaning slightly forward. If wearing pants, make certain that zippers or other openings are long enough to accommodate the device. Funnels are especially useful in extremes of cold weather and high altitude when wearing a skirt or pulling down pants is undesirable. Funnels may be connected to a longer tube that is attached to a container for urine storage (traveljohn.com) if it is too cold to urinate outside the tent or during a long road trip. One product (e.g., the Whiz) mixes an antibacterial agent into the plastic and coats the device so that it repels fluid and is easily cleaned. The device may be hand washed or cleaned in a washing machine.

FIGURE 92-4 Urine director. *(Courtesy Susan Anderson.)*

Options for reusable and/or disposable female urine devices include:

Freshette: freshette.com
GoGirl: go-girl.com
Lady Elegance P Ez
Sheewee: shewee.com
Traveljohn: traveljohn.com
Urinelle
Urifemme: urifemme.com
WHIZ all-terrain director: whizproducts.co.uk

Patients with stress incontinence or bladder control should consult a physician specializing in female urinary tract problems before the trip. For minor symptoms, pelvic floor exercises and a supply of panty liners may prove helpful. Older women may experience vaginal dryness and urinary frequency or urgency without dysuria. Data suggest that estrogen vaginal cream, vaginal rings, or a low-dose pill inserted intravaginally may decrease urogenital dryness and frequency symptoms.[33,39,40]

VAGINAL DISCHARGE OR ITCHING

Environmental conditions and constraints on hygiene during wilderness travel promote changes in a woman's vaginal ecosystem that may result in increased vaginal discharge and vulvar itching and irritation. Because diagnostic capabilities in the wilderness are limited, clinical features (Table 92-4) can help guide diagnosis and treatment. Women should be taught self-diagnostic skills and carry appropriate treatment. Even if a woman has never had a vaginal infection, she should be prepared for this possibility, especially during extended itineraries. Advise women to seek medical evaluation if the symptoms do not improve with self-treatment. The normal vaginal pH is less than 4.5 (a range of 3.8 to 4.2 is common). The most common causes of vaginitis during wilderness travel are yeast infection, BV, and chemical irritation.

VULVOVAGINAL CANDIDIASIS

Symptomatic yeast infections are often referred to as vulvovaginal candidiasis. About 80% to 90% of these result from overgrowth by *Candida albicans*. Risk factors for yeast infections include pregnancy, hormonal therapy, recent antibiotic use, corticosteroid therapy, postovulatory phase of menstrual cycle, frequent coitus, condom use, and intravaginal use of spermicidal compounds.[11]

The most common complaint of women with vulvovaginal candidiasis is vulvar pruritus or burning, not vaginal discharge. In more severe cases, redness, irritation, burning, soreness, swelling, and external dysuria are variably present. Characteristic white, flocculent, and adherent discharge ("cottage cheese") is often diagnostic but is not consistently present or visible externally. Yeast discharge is thicker than that seen with BV or trichomoniasis, is usually not frothy or malodorous, and often has a pH of 4.5 or less unless a mixed infection is present. In the emergency department, approximately 50% of yeast infections are confirmed by direct microscopic examination of discharge diluted in saline. Diagnosis is most reliably accomplished by detection of budding yeast hyphae or spores using a slide preparation with 10% potassium hydroxide added to lyse background epithelial cells and bacteria.

Treatment consists of azole derivatives, many of which (e.g., butoconazole, clotrimazole, miconazole, tioconazole) are available over the counter as topical creams, vaginal tablets, and suppositories. Therapy periods range from 1 to 14 days depending on the formulation and infection severity. Treatment regimens

TABLE 92-4 Differential Diagnosis of Vulvovaginitis

Factors	Normal	Bacterial Vaginosis	Vulvovaginal Candidiasis	Trichomoniasis	Atrophic Vaginitis	Other
Discharge	White, clear, finely granular	Gray-white, thin, homogeneous, adherent, frothy	White, thick, curd-like, adherent	Gray to yellow-green, occasionally frothy, adherent	Thin, clear to serosanguineous	Normal
pH	3.8-4.2	>4.5	≤4.5	>4.5	>4.5	3.8-4.2
Amine odor	Absent	Present	Absent	Variably present	Usually absent	Absent
Primary complaints	None	Malodorous discharge	Pruritus, irritation	Severe pruritis, discharge, dyspareunia, dysuria	Burning, soreness, dyspareunia	Burning, irritation, swelling, soreness
Microscopic appearance	Normal epithelial cells, lactobacilli	"Clue cells," no WBCs	Budding yeast, hyphae, spores	Trichomonads, many WBCs (PMNs)	Small, round (parabasal) epithelial cells, many PMNs	Normal
Other findings and diagnostic features	None	Minimal vulvar involvement	Vulvar and vaginal erythema, predisposing medical conditions	Intense vulvovaginal erythema, "strawberry cervix," other STIs	Atrophy of vulva and vaginal epithelium	Highly variable

PMNs, Polymorphonuclear neutrophil leukocytes; STIs, sexually transmitted infections; WBCs, white blood cells.

of at least 3 days' duration result in a greater initial response rate and a decreased chance of immediate recurrence. Symptoms related to inflammatory vulvar involvement respond most rapidly to topical creams, although application may be accompanied by burning pain. Oral fluconazole (150 mg, single dose) is a convenient therapeutic agent to include in the basic pharmacopoeia of a wilderness expedition. Women with frequent recurrences or predictable outbreaks at specific times in their cycle (most often premenstrually) should consider prophylactic weekly suppressive therapy with fluconazole (150 mg orally) or clotrimazole (1% intravaginal applicator).[191] To treat local symptoms, a low-potency steroid cream can be used in conjunction with a topical antifungal.

BACTERIAL VAGINOSIS

Bacterial vaginosis (BV) is the most common cause of vaginitis in women of childbearing age.[11] The most common complaints of women with BV are discharge and odor, itching, and irritation of the vulva and vagina. More than half of women with BV do not complain of symptoms or are unaware that symptoms result from a treatable condition. BV is believed to result from a disturbance in the normal vaginal flora, whereby the normal level of hydrogen peroxide–producing lactobacilli is replaced by less dominant organisms.[189] Discharge accompanying BV is typically thin, watery, grayish white, frothy, and homogeneous (not flocculent), uniformly coating the vaginal walls and introitus. More than 50% of women with BV complain of a fishy odor, particularly during menstruation and immediately after unprotected sexual intercourse. Blood and semen can alkalinize the vagina and volatilize a variety of amines (e.g., cadaverine) produced by anaerobic organisms.

BV diagnosis is confirmed by the presence of three of the following: discharge, pH greater than 4.5, release of amines (fishy odor) when discharge is exposed to 10% KOH ("whiff test"), and microscopic detection of "clue cells" (epithelial cells coated with bacteria) in saline solution. The microscopic appearance of pure BV is characterized by few, if any, leukocytes and a few motile and curved rods (lactobacilli). BV is treated with metronidazole, which can be administered orally (500 mg twice daily for 7 days) or as a 0.75% vaginal gel (once daily for 5 days). These regimens have initial response rates in excess of 90%. Tinidazole is a second-generation nitroimidazole with a longer half-life than metronidazole. The recommended oral dosage schedules are 1 g/day for 5 days or 2 g/day for 2 days. Clindamycin (300 mg orally twice daily for 5 to 7 days or 2% vaginal gel daily for 7 days) has comparable efficacy, but is expensive, has deleterious effects on normal vaginal lactobacilli, and increases the risk for pseudomembranous enterocolitis (a rare side effect that could be life-threatening in the wilderness). There may be treatment failures with any of the options above.[11]

TRICHOMONAS VAGINITIS

Trichomonas vaginalis is a single-celled parasite that causes vaginitis in 2 to 3 million women annually in the United States.[217] It is predominantly sexually transmitted and is found most often in individuals with multiple sex partners and those with a history of or current STIs. Diagnosis and treatment of a woman and her sex partner are best accomplished at a screening visit before departure on a wilderness excursion. Unlike BV and yeast vaginitis, detection of *T. vaginalis,* even in asymptomatic women, is an indication for treatment and more complete STI screening.

The most common complaints include severe vulvovaginal pruritus, dyspareunia, and dysuria. Physical examination often reveals intense vaginal erythema and petechial cervical lesions (i.e., "strawberry cervix"). Vaginal discharge is typically gray or yellow-green, somewhat cloudy, and variably frothy and malodorous. The presence of frothy and malodorous discharge frequently indicates a mixed infection with the amine-producing organisms seen in BV. The vaginal fluid pH is elevated, typically above a numeric value of 5.0, and frequently exceeds a value of 6.0.

Because of diagnostic difficulties in the wilderness, empirical therapy is justified. Options include metronidazole administered as a single 2-g oral dose; in severe cases or cases that are not resolved by a single dose, it is given for a week (500 mg orally twice daily) or longer. Tinidazole given as a single dose of 2 g orally is also an option. For optimal results, sexual partners should be treated simultaneously and sexual activity stopped during therapy. To minimize GI side effects, metronidazole or tinidazole should be taken with plenty of water. This may not reduce the unpleasant metallic taste, but may reduce the risk for nausea, vomiting, and gastric irritation. Because a disulfiram-like effect is possible, alcohol should be avoided while taking metronidazole or tinidazole. Metronidazole 0.75% vaginal gel is not appropriate for treatment of trichomoniasis.[190]

ATROPHIC VAGINITIS

A decrease in estrogen levels during perimenopause and menopause can cause vaginal atrophy. This effect can also occur in hypoestrogenized premenopausal women (e.g., some amenorrheic athletes and women taking ovarian suppressive therapy with GnRH agonists). Thinning of vaginal epithelium due to a lost estrogen effect is the presumed cause. Reduced epithelial

cell glycogen, an important substrate for lactobacilli, leads to increased vaginal pH and alterations in flora with subsequent overgrowth of nonacidophilic organisms. Symptoms include burning or soreness, dyspareunia, and watery or even serosanguineous vaginal discharge. Typically, the vaginal mucosa is uniformly erythematous and may have areas of petechiae. The vaginal pH usually exceeds a numeric value of 5.0 (often 6.0 to 7.0), and microscopic evaluation of discharge reveals small, round, immature epithelial cells (parabasal cells), increased neutrophils, and a paucity of lactobacilli. Treatment includes the use of topical or oral estrogen replacement therapy.[167] Treatment with low-dose topical estrogen (cream, ring, or tablet) usually provides complete relief of symptoms within weeks. In the interim, women may obtain relief with use of vaginal moisturizers and lubricants (e.g., Astroglide, Replens).

NONINFECTIOUS VULVOVAGINITIS

Vulvovaginitis due to environmental exposures can cause local irritation. It may be of greater significance when the ability to attend to personal hygiene is limited.[100] Common causative agents include latex condoms, spermicidal compounds, soaps, detergents, fabric softeners, deodorant products, menstrual pads and tampons, and topical medications such as antimycotics and povidone-iodine. Exclude an infectious cause and identify the source of the reaction to make the diagnosis. Once a potentially offending cause is identified (e.g., recent change in laundry detergent), exposure is avoided and symptoms can be treated (i.e., pain relief, antihistamines, sitz baths). Topical corticosteroid creams may be tried, but in rare instances, they may exacerbate symptoms.

SEXUALLY TRANSMITTED INFECTIONS

If a woman has a new discharge or pelvic pain following a sexual encounter, she may have a sexually transmitted infection (STI) and should be evaluated as soon as possible. Discussion of safe-sex practices and risks associated with STIs pertinent to the destination should be included in the pre–wilderness travel visit.[104]

Women are at a higher risk for acquiring an STI from infected men than men would be from infected women. Long-term complications related to STIs include PID, chronic pelvic pain, and infertility. To prevent acquisition of STIs, women should avoid casual sex and always practice safe sex by using condoms, no matter what other means of contraception are used simultaneously. High-quality latex condoms are an essential part of a sexually active traveler's medical kit, regardless of gender. A male or female condom made of polyurethane is an effective alternative for persons allergic to latex. Patients with a history of genital herpes simplex virus infection should bring a supply of antiviral medication (e.g., acyclovir, valacyclovir) to treat an outbreak during travel.

NONOCCUPATIONAL POSTEXPOSURE HIV PROPHYLAXIS

Women should be educated about the availability of postexposure HIV prophylaxis for high-risk sexual exposures or sexual assault.[63,169,176,204] If a woman is traveling to a remote area, include the initial week of treatment in the traveler's medical kit. Travelers should check with the CDC (cdc.gov) or World Health Organization (int/hiv/topics/prophylaxis/en/) for the latest information on nonoccupational postexposure HIV prophylaxis recommendations. The National HIV/AIDS Clinician Consultation Center at the University of California, San Francisco, operates the National Clinicians' Postexposure Prophylaxis Hotline. The hotline is available 24 hours a day, 7 days a week (1-888-448-4911) or one can use the website at nccc.ucsf.edu/clinician-consultation/pep-post-exposure-prophylaxis/. Ideally, one should do research and obtain an option for a personal HIV postexposure prophylaxis starter kit prior to travel so testing can be started immediately following a high-risk exposure while waiting for a consultation. Home testing kits for HIV are available in many countries. Sensitivity and specificity of these tests vary. HIV testing should be repeated with a reliable laboratory analysis.[8,196]

PERSONAL SAFETY

Women of all ages should take a self-defense course. There are many personal self-defense devices available, such as pepper spray (made from cayenne pepper), Mace (tear gas), capsules that let out a pungent odor, and sound devices or alarms. One should also consider carrying a portable smoke alarm because they are not provided in many international accommodations.

SEXUAL ASSAULT

Sexual assault of women in the wilderness is assumed to be rare but is probably underreported. One in every three women will be physically, sexually, or otherwise abused in her lifetime.[220] Wilderness morbidity and mortality statistics are limited, but one study of eight National Park Service areas in California over 3 years reported only one incident of sexual assault.[152] Many wilderness incidents are likely not reported. Overall, only 7% of all rapes are estimated to be reported.[46] All women should be prepared and practice measures to prevent assault.

The best defense against sexual assault is not going into the wilderness with unfamiliar people. The chance of meeting an assailant is quite low. A woman traveling into the wilderness alone or with someone she does not know well is advised to tell friends or family exactly where and with whom she is traveling and when she anticipates returning.

If sexually assaulted, women are advised to seek medical attention as soon as possible. Most emergency departments can evaluate and treat sexual assault victims. It may be impossible to reach a medical facility for many hours or even days, but an attempt should be made to preserve potential evidence. Women are advised to avoid douching, gargling, brushing teeth, or changing clothes. If clothes are removed, they should be placed in a paper bag and brought to a medical facility. The CDC recommends STI prophylaxis, postexposure prophylaxis for HIV, and EC for women at risk.[63,204] Posttraumatic stress counseling should also be offered.

WILDERNESS TRAVEL DURING PREGNANCY

Many women involved in wilderness activities expect to continue their adventures at all stages of pregnancy. These women understand the benefits of exercise and the positive effects that participating in a wilderness experience have on their general health and well-being.[18] However, pregnancy is considered a relative contraindication to wilderness activities unless access to medical care is available or provisions are made for rapid evacuation. Review the pregnant traveler's itinerary and assess for risks relating to the destination or specific activity that may be a risk to the mother or fetus. Counsel pregnant travelers to take preventive measures or consider an alternative plan. Although a successful prior pregnancy is a relatively good predictor of outcome after the first trimester, pregnancy is unpredictable. A pregnant woman should consider potential risks of unexpected complications and how she would feel if the outcome resulted in preventable maternal or fetal morbidity and mortality.

Information on the pregnant traveler is based on small studies, anecdotal information, and extrapolation from nonpregnant travelers. Evidence-based recommendations are lacking for pregnant women.

PRE–WILDERNESS TRAVEL EVALUATION DURING PREGNANCY

Box 92-4 is a checklist for pregnant travelers. Basic questions to ask when counseling pregnant women prior to travel to remote places include[31]:

What are the medical and obstetric risks associated with wilderness travel?

BOX 92-4 Checklist for Pregnant Travelers

Pretravel Risk Assessment
- Stage of gestation
- Obstetric risk factors
- Medical risk factors
- Destination risk considerations
  - Access to care
  - Medical services available during transit and at destination
  - Emergency evacuation insurance
  - Review emergency signs and symptoms: vaginal bleeding, abdominal pain, contractions, proteinuria, headache with visual change, severe edema and/or accelerated weight gain, decreased fetal activity, and rupture of membranes
  - Due to infectious disease
  - Chloroquine-resistant *Plasmodium falciparum* malaria
  - Outbreak of disease requiring a live virus vaccine
  - Outbreak of disease for which no vaccine is available and that has a high risk for maternal and fetal complications and death
  - Due to food and water exposure
  - Due to insect exposure
  - Due to environment
  - Exercise risk
  - Altitude
  - Heat
  - Cold
  - Open-water bodies
  - Dehydration

Recommendations
- Medical insurance and evacuation coverage
- Immunizations to reflect actual risk for disease and probable benefit
- Medications: review safety during pregnancy
- Preventive measures
  - Medical kit adaptations for pregnancy and infant care
  - Plans for emergency delivery and infant resuscitation
  - Emergency delivery kit
  - Infant resuscitation kit
- Postpone wilderness travel if risks outweigh benefits, or adapt itinerary to decrease risks

What medical services are available during transit and at the intended destinations?
What does health insurance cover for a woman who is out of the area for delivery or pregnancy-related complications?
What are the signs of serious pregnancy-related illness for which emergency medical help should be sought?
What are some general guidelines to follow for medical management of illness that will safeguard a pregnant woman and her fetus?
Are required and recommended immunizations for the proposed itinerary safe in pregnancy?
What medications are safe in pregnancy?
Are there special concerns related to environmental conditions or activities?
Is the woman prepared for a "wilderness delivery"?
Is there need for an infant resuscitation kit?

Pre–wilderness travel preparation starts with a review of the woman's obstetric and medical history. Health practitioners who advise pregnant women should work closely with a woman's obstetrician to assess potential benefits and risks involved in a particular wilderness trip. Any history of pregnancy problems (e.g., vaginal bleeding, preterm labor, or chronic illness) increases the risk. Categories of potential high-risk pregnancies for which travel should be delayed or the itinerary adjusted are summarized in Box 92-5. The obstetric history should be reviewed for complications for which there may be a high risk of recurrence (e.g., preterm labor, premature rupture of membranes, preeclampsia, gestational diabetes, fetal growth restriction, group B hemolytic streptococcal infection, UTI, chorioamnionitis, blood group isoimmunization, thromboembolic event, surgical delivery, and postdelivery complications). Perform a complete physical examination.

Laboratory evaluation before departure includes standard blood tests recommended by the ACOG: complete blood count, blood type, antibody screen (and screen of partner if the woman is Rh negative or isoimmunized), and basic serologic measurements (rapid plasma reagin, rubella, hepatitis B, HIV). Serologic screening for varicella and herpes simplex virus 2 should also be considered in the woman with no history of varicella or genital herpes because of the potential for first-time outbreaks during pregnancy in women with unrecognized infection. Individuals at risk and those not previously evaluated should also be offered hemoglobin electrophoresis to assess for hemoglobinopathies. Urinalysis and urine culture are performed because of the high frequency of asymptomatic infections during pregnancy that can complicate outcomes. Vaginal fluid should be assessed for BV because treatment early in pregnancy may prevent premature rupture of membranes and preterm labor. Perform a Pap smear. A woman beyond 10 weeks' gestation should undergo routine genetic and biochemical screening (e.g., maternal serum α-fetoprotein, estriol, hCG) to assess for certain congenital and chromosomal abnormalities. Abnormal biochemical markers may indicate complications (e.g., fetal growth restriction and preeclampsia) due to early abnormalities in placentation that can become clinically significant later in gestation. These conditions also increase the risk for premature delivery, as well as for maternal and fetal complications and death.[16,17,22]

Screen for diabetes. Gestational diabetes with a previous pregnancy is associated with increased risk during subsequent gestations. Proper dietary counseling and regular blood sugar monitoring with a portable plasma glucose monitor should be conducted throughout the pregnancy. Insulin, sufficient syringes, and alcohol wipes should be included with basic medical supplies in the event that glycemic control deteriorates. The goal is to maintain fasting plasma glucose levels at 90 mg/dL or less and lower than 120 mg/dL 2 hours after meals. Physical conditioning reduces the risk for developing diabetes during pregnancy. Women with pregestational diabetes of any duration should have a baseline electrocardiogram and possibly an echocardiogram before participation in any wilderness-related activities.

All pregnant wilderness travelers should have an obstetric sonogram before departure.[22] Early in the pregnancy, ultrasonography can accurately confirm gestational age, viability, intrauterine location, and number of fetuses. It may also rule out the

BOX 92-5 Potential Contraindications for Wilderness Travel During Pregnancy

Obstetric Risk Factors
- Extremes of maternal age
- Vaginal bleeding this pregnancy
- Multiple gestation this pregnancy
- Fetal abnormalities or growth issues (IUGR)
- History of gestational diabetes or hypertension
- History of miscarriage, preterm labor, abnormal implantation of placenta, or premature rupture of membranes

Medical Risk Factors
- History of thromboembolism
- Cardiac disease
- Severe anemia
- Medical disease requiring ongoing assessment and medication such as diabetes, pulmonary disease, or renal disease

Risk Factors at Wilderness Destination
- Lack of access to medical care
- High altitude
- Disease requiring a live virus vaccine (e.g., yellow fever, measles)
- Mefloquine-resistant *Plasmodium falciparum* malaria
- Epidemic of infectious disease leading to high-risk maternal and fetal illness
- Natural disasters

Risk Factors Due to Sports Activity
- Scuba diving
- High risk for trauma

presence of an ectopic pregnancy, adnexal mass, abnormal placental implantation, or molar pregnancy. Second-trimester ultrasonography can estimate gestational age and assess major fetal abnormalities, location of the placenta in relationship to the cervix, cervical length, and integrity of the internal cervical os. Beyond 20 weeks' gestation, normal fetal growth and blood flow patterns in umbilical and middle cerebral arteries can be assessed by Doppler velocimetry. Normal results indicate a lower risk for complications (e.g., IUGR, preeclampsia, and preterm labor). Findings that significantly increase maternal or fetal risk are contraindications to travel.

Counseling on the timing of wilderness activity should be done, although no interval during pregnancy is considered absolutely safe. Guidelines of the American Association of Obstetricians and Gynecologists state that the safest time to travel is during the second trimester because the pregnancy is established and extra weight is not usually a functional limitation for the mother.[21] Risk for miscarriage is highest during the first trimester. The first trimester is also when effects on a fetus from medications or vaccines needed by the mother would be greatest. The primary risks in the third trimester are complications (e.g., bleeding, preeclampsia, and preterm labor and delivery).

One of the most important considerations for a pregnant woman planning wilderness travel is assessment of available options in case of an emergency. The complete itinerary should be evaluated with attention to both availability and quality of medical care during transit and at the final destination. Access to high-quality care during travel is essential in case of preterm labor or an unexpected complication of pregnancy.

Pregnant women traveling to a more remote area or to a less developed country should review their health insurance policy coverage guidelines. An additional travel health and evacuation insurance policy that provides a worldwide 24-hour medical assistance hotline number may need to be purchased. This service would provide telephone contact with medical personnel to help arrange emergency medical consultation and treatment, monitor care, and provide emergency evacuation to a more advanced medical facility if necessary. Patients must be aware that medical evacuation can take hours to days from remote locations. Each policy must be reviewed carefully to make sure that it covers expenses associated with a normal pregnancy (e.g., delivery), as well as with the possible complications of pregnancy (e.g., miscarriage early in pregnancy or third-trimester preeclampsia). Policies should also cover expenses associated with emergency care of the fetus and newborn.

Teach pregnant patients warning signs of potentially serious problems (e.g., bleeding, passing tissue or clots, abdominal pain or cramps, rupture of membranes, decreased fetal movement, headache, or visual changes) and develop a plan for what they should do if these occur. Each woman should carry a copy of her medical record (including blood type and Rh) and her physician's phone number, fax number, and email address. This information may be helpful for routine questions or if there is an emergency.

PHYSIOLOGIC CHANGES ACCOMPANYING PREGNANCY

Normal physiologic changes of pregnancy (e.g., reduced exercise and heat tolerance, elevated heart rate related to physiologic anemia, and increased plasma volume) may have an impact on wilderness travel. Within weeks of conception, hormonal changes accompanying pregnancy result in physiologic adaptations affecting every organ system. Increased progesterone has smooth muscle relaxation effects to maintain uterine quiescence, but also contributes to vasomotor instability, hypotension, gastric reflux, and constipation. Estrogens stimulate hepatic production of many hormone-binding globulins and of coagulation factors II, V, VII, VIII, IX, X, and XII, and fibrinogen that contributes to the hypercoagulable state of pregnancy and increased risk for VTE.[19]

Cardiovascular Adaptation

Pregnancy affects maternal hemodynamics by inducing increases in blood volume, heart rate, and stroke volume, and decrease in systemic vascular resistance. Cardiac output increases 30% to 50% by the end of the first trimester owing to an increase in stroke volume secondary to an increase in preload. Gradual increases in the maternal heart rate usually peak between 24 and 28 weeks' gestation. Uterine blood flow increases from 50 mL/min to more than 500 mL/min, corresponding to an increase from approximately 1% to 20% of total cardiac output. Systemic vascular resistance decreases primarily from the low-resistance placental vascular bed, which is the equivalent of a large arteriovenous shunt. Peripheral vasodilatory effects of progesterone, estrogen, and other factors also contribute. These hemodynamic changes help to provide the circulatory reserve necessary to provide nutrients and oxygen to the mother and fetus at rest and during moderate exercise.[7,75]

Changes in Blood Volume

The total blood volume increases 40% to 50% during normal pregnancy because of rapid expansion of the plasma volume. A disproportionate increase in plasma volume over red cell mass results in so-called physiologic anemia of pregnancy. Physiologic effects of hypervolemia and anemia during pregnancy have several benefits. Decreased blood viscosity (from greater increases in plasma than red cell volume) results in reduced resistance to flow, facilitating placental perfusion and lowering cardiac work. The increase in blood volume (≈ 50% higher than in nonpregnant women) provides some reserve against normal blood loss occurring during parturition. Most of the increased cardiac output is distributed to the placenta to provide nutrients to the fetus, to the kidneys for excretion of maternal and fetal waste products, and to the skin to assist in maternal temperature control.[7]

Respiratory Status

Respiratory system changes during pregnancy help to compensate for physiologic anemia to maintain fetal and maternal homeostasis. Progesterone directly stimulates the respiratory center and increases carbon dioxide sensitivity, resulting in a 30% to 40% increase in tidal volume (TV). The respiratory rate (RR) does not change significantly, but as a result of TV changes, the minute ventilation (i.e., TV × RR) increases 25% to 30%, despite a slight decrease in total lung capacity. A 20% reduction of functional residual capacity due to decreased expiratory reserve volume and residual volume characterizes the relative hyperventilation with compensated respiratory alkalosis. Many of these changes are completed by the end of the first trimester. Their sum is a dramatic 50% increase in alveolar ventilation, increased PaO_2, 30% increase in 1-minute oxygen uptake, and significant decrease in the partial pressure of carbon dioxide. The overall effect is to increase the oxygen-carrying capacity of maternal blood to accommodate fetal and maternal metabolic needs, while facilitating diffusion of carbon dioxide from the fetus. For the wilderness traveler, these changes lead to higher oxygen saturation under hypoxic conditions (e.g., high altitude).

Urinary System

Significant changes in the urinary system account for many complaints and complications of pregnancy (e.g., urinary frequency, incontinence, and increased risk for UTIs). In the first trimester, ureters become dilated, elongated, and more tortuous, presumably under the influence of progesterone. Further dilation of proximal ureters occurs when the uterus reaches the level of the pelvic brim at about 20 weeks' gestation and compresses the ureters, resulting in the first presentations of pyelonephritis. This more often occurs on the right than the left owing to dextrorotation of the uterus by the descending colon. Vesicoureteral reflux occurs secondary to decreased ureterovesical junction competency and contributes to an increased risk for an upper tract infection. This is exacerbated by a progressive decrease in bladder capacity and doubling of intravesicular pressures (from 10 to 20 cm H_2O) during gestation. These factors also contribute to frequent complaints of urinary incontinence in pregnant women.

Integumentary and Musculoskeletal Status

Integumentary and musculoskeletal changes can have significant effects on a pregnant wilderness traveler's well-being. Increased

estrogen leads to proliferation and dilation of small arterioles in the skin to help compensate for the increased need to remove heat generated by the maternal and fetal metabolism. Because of these inherent changes, pregnant women have a limited capacity to respond further to heat stress and are at an increased risk for hyperthermia in hot and humid environments. Estrogen and other pregnancy-associated hormones also increase skin sensitivity to damage by sun exposure, particularly in fair-skinned individuals. Some pregnant women have a predisposition to skin hyperpigmentation in a nonuniform distribution because of excessive melanin deposition in the dermis and epidermis. This is enhanced by sun exposure and often affects the face (melasma), midline abdomen (linea nigra), nipples, axillae, and perineum. It may require a prolonged period for resolution after delivery or may never resolve completely.[75]

Weight gain, weight redistribution, and ligamentous relaxation may pose risks even to well-conditioned pregnant women.[24] Weight gain during pregnancy is approximately 9 to 16 kg (20 to 35 lb). Some weight gain is important during pregnancy to avoid a catabolic state and may be more important to highly conditioned athletes that enter pregnancy with limited fat stores. Increased weight stresses the skeleton and ligaments and may accumulate more rapidly than conditioning can handle. Much of the weight gain is contributed by uterine and fetal growth, resulting in forward displacement of the center of gravity. This is usually accompanied by progressive lower spine lordosis and increased strain on spinal ligaments, disks, and paravertebral muscles. When lumbar lordosis is exaggerated, traction and compression on the sciatic nerves can cause significant pain and weakness in the buttocks and lower extremities. Lower spine changes are frequently followed by compensatory flexion of the cervical spine. This can place traction on the median and ulnar nerves, resulting in upper extremity pain, paresthesias, and weakness.[49]

Challenges of weight gain are accompanied by dramatic changes in ligamentous support throughout the body. Under the influence of relaxin and other hormones, ligaments become more compliant and hydrophilic. Benefits of this include relaxation in the sacroiliac joints and symphysis pubis to facilitate delivery, but hormonal effects on other ligaments can lead to complications. For example, fluid retention by the wrist's flexor retinaculum can cause median nerve compression. This results in carpal tunnel syndrome, a common complaint of pregnancy. This may be more than just a nuisance to the wilderness traveler because pain and hand weakness can compromise activities that require hand strength and endurance (e.g., rock climbing, canoeing). Pelvic girdle instability, accompanied by weight gain, can cause a shift in the center of gravity and spinal lordosis leading to gait and balance disturbances interfering with enjoyment of many wilderness activities such as hiking or skiing. These changes also lead to an increase in the severity of trauma accompanying falls. Maternal trauma remains one of the leading causes of fetal death, typically due to placental abruption or preterm labor.[52,71] The anterior cruciate ligament is especially prone to severe trauma; injury is three to four times more likely in women, and the ligament is especially susceptible to trauma in the active pregnant woman.[214] Difficult terrain poses a risk to pregnant wilderness travelers.

Changes in Immune Status: Response to Infection and Vaccines

Pregnancy results in a number of changes in the maternal immune system. Evidence suggests that there is a reduction in cell-mediated immunity during pregnancy. Pregnancy results in increased susceptibility (or predisposition to more severe disease) to a number of infections in which the cell-mediated immune response is important (e.g., malaria, typhoid, amebiasis, coccidioidomycosis, leishmaniasis, filariasis, leptospirosis, leprosy, trypanosomiasis, listeriosis, and tuberculosis).[127,135,147,171] Determine the risk for these infections when the itinerary is being reviewed. In contrast, infections in which the humoral system is the most important response show no increase in susceptibility to infection. B-cell numbers and function do not appear to be reduced during pregnancy.

Immunizations During Pregnancy and Lactation. Women should be vaccinated before pregnancy. Risks and benefits of immunizations during pregnancy must be weighed against the maternal risk for illness, likelihood of adverse fetal outcomes if the mother becomes ill, and risks associated with vaccines. Risks for immunizations during pregnancy are largely theoretical.[124] When the risk for disease exposure is high, benefits of vaccinating pregnant women usually outweigh potential risks.[1,79,87,90,158,173,197,206,221]

Breastfeeding is not a contraindication to most vaccinations, with the possible exception of yellow fever (YF) vaccine. Three cases of YF vaccine–associated neurologic disease have been documented in breastfed infants whose mothers received the vaccine.[58] It is not clear if transmission occurred via breast milk. Breastfeeding mothers should be advised not to travel to a zone endemic for YF if such travel will require administration of YF vaccine. For a woman trying to conceive, it is recommended that she wait for 1 month after receiving a live virus vaccine (e.g., measles-mumps-rubella, varicella, YF) to become pregnant. If a woman receives a vaccine and later finds out that she is pregnant, there is no indication for termination of the pregnancy.[1]

Ideally, avoid vaccinations during the first trimester because of uncertain effects on the developing fetus. Serologic studies for hepatitis A and B, varicella, measles, and rubella may be checked to assess the potential risk for infection. In general during pregnancy, inactivated vaccines are safe but live vaccines are contraindicated. Tetanus and diphtheria toxoids and influenza vaccine are routinely given during pregnancy. Hepatitis A and B, Japanese encephalitis, meningococcal, rabies, and typhoid fever (inactivated) vaccines may also be administered during pregnancy if there is risk for exposure to these infections.

YF vaccine safety during pregnancy is unknown, but the vaccine has been administered to hundreds of pregnant women without increased risk versus the general population.[124,218] There is concern for decreased seroconversion rates if vaccination is given later in pregnancy. If the risk for YF infection is low but proof of immunization is required, a medical waiver can be given. If the risk for YF is high and travel unavoidable, administer the vaccine. A small study of pregnant women inadvertently given YF vaccine did not find adverse fetal or maternal outcomes.[197] As of June 2016, YF vaccine recommendations will change to advising that one dose of YF vaccine will provide lifetime immunity.[58] Prudence recommends that YF vaccine be given to all women of reproductive age prior to pregnancy who might travel to a zone endemic for YF during their lifetime. This would avoid the theoretical concerns associated with YF vaccine administration during pregnancy. All vaccines are listed as category C under the FDA pregnancy categories (Table 92-5).[1]

MEDICATIONS DURING PREGNANCY

Food and Drug Administration Guidelines

The FDA has developed a set of guidelines to categorize drugs, vaccines, and toxoids with regard to developmental toxicity and adverse fetal outcome. Assessments are based on the degree to which available information has ruled out a risk to the fetus balanced against potential benefits to pregnant woman (Box 92-6). Most medications fall under FDA category C. Few double-blind studies have been done in pregnant women to categorize drugs.

Other Resources for Information on Medications During Pregnancy

Physicians advising pregnant women should have ready access to references related to medication use during pregnancy. The text *Drugs in Pregnancy and Lactation*[53] includes reproductive literature reviews relevant to drugs and immunizations. Each medication is categorized by FDA risk classifications. There are Internet resources with information on the teratogenic risk of particular medications or vaccines. Table 92-6 lists some of the medications commonly used by pregnant women during travel.

TABLE 92-5 CDC Recommendations for Vaccination During Pregnancy*

Vaccination of Pregnant Women Is Recommended		
Hepatitis B	Recombinant or plasma-derived	Recommended for women at risk of infection.
Influenza	Inactivated whole virus or subunit	All women who are pregnant in the second and third trimesters during the flu season (*Northern Hemisphere*: October to May; *Southern Hemisphere*: April to September; *tropics*: year round) and women at high risk for pulmonary complications regardless of trimester.
Diphtheria-tetanus	Toxoid	If indicated, such as lack of primary series, or no booster within past 10 years.
Diphtheria-tetanus-pertussis (TDaP)	Toxoid-acellular	TDaP should be given during each pregnancy, preferably during the third trimester at 27 to 36 weeks to maximize maternal antibody response and passive antibody transfer to infant. However, it may be given at any time.
Hepatitis A	Inactivated virus	Data on safety in pregnancy are not available. Because hepatitis A vaccine is produced from inactivated hepatitis A virus, theoretical risk of vaccination should be weighed against risk of disease. Consider immune globulin rather than vaccine.
Pregnancy Is a Precaution, and Under Normal Circumstances Vaccination Should Be Deferred; Vaccine Should Only Be Given When Benefits Outweigh Risks		
Japanese encephalitis	Inactivated virus	Data on safety in pregnancy are not available. Pregnant women who must travel to an area where risk is high should be vaccinated when theoretical risks are outweighed by risk of disease.
Meningococcal meningitis	Polysaccharide	Meningococcal conjugate vaccine (MCV4) is preferred for adults. However, there are no data on safety and immunogenicity in pregnant women. Polyvalent meningococcal meningitis vaccine (MPSV4) can be administered during pregnancy if the woman is entering an epidemic area. Indications for prophylaxis are not altered by pregnancy; vaccine recommended in unusual outbreak situations.
Pneumococcal	Polysaccharide	Safety of pneumococcal (PPV23) vaccine during the first trimester has not been evaluated, although no adverse events have been reported after inadvertent vaccination during pregnancy. Women with chronic diseases, smokers, and immunosuppressed women should consider vaccination.
Polio, inactivated	Inactivated virus	Indicated for susceptible pregnant women traveling in endemic areas or in other high-risk situations.
Rabies	Inactivated virus	Indications for postexposure prophylaxis not altered by pregnancy. If risk of exposure to rabies is substantial, preexposure prophylaxis may also be indicated.
Typhoid (ViCPS)	Polysaccharide	If indicated for travel to endemic areas.
Typhoid (Ty21a)	Live bacterial	Data on safety in pregnancy are not available; theoretical risk because live-attenuated.
Yellow fever	Live attenuated virus	Use caution. Safety of yellow fever vaccination in pregnancy has not been studied in a large prospective trial. Pregnant women who must travel to areas where risk of yellow fever infection is high should be vaccinated and their infants should be monitored after birth for evidence of congenital infection and other possible adverse effects resulting from yellow fever vaccination. Pregnancy may interfere with the immune response to yellow fever vaccine. Consider serologic testing to document a protective immune response to the vaccine. Avoid in breastfeeding mothers unless travel to high endemic region is unavoidable.†
Pregnancy Is a Contraindication to Vaccination; Vaccine Should Not Be Administered to Pregnant Women		
Tuberculosis (BCG)	Attenuated mycobacterial	Contraindicated because of theoretical risk of disseminated disease. Skin testing for tuberculosis exposure before and after travel is preferable when risk of possible exposure is high.
Measles-mumps-rubella	Live attenuated virus	Contraindicated. Vaccination of susceptible women should be part of postpartum care. Unvaccinated women should delay travel to countries where measles is endemic until after delivery. Unvaccinated pregnant women with a documented exposure to measles should receive immunoglobulin within 6 days to prevent illness.
Human papillomavirus	Recombinant quadrivalent	Contraindicated. Vaccine has not been causally associated with adverse outcomes of pregnancy. However, additional information is needed for further recommendations.
Varicella	Live attenuated virus	Contraindicated. Vaccination of susceptible women should be considered postpartum. Unvaccinated pregnant women should consider postponing travel until after delivery, when the vaccine can be given safely.
Vaccine/Immunobiologic		**Use**
Immune globulins, pooled or hyperimmune	Immune globulin or specific globulin preparations	If indicated for preexposure or postexposure use. No known risk to fetus.

*Adapted from Vaccines and immunizations: Guidelines for vaccinating pregnant women; and Travel and other vaccines, CDC health information for international travel: cdc.gov/vaccines/pubs/preg-guide.htm.
†See Brunette GW, editor: CDC health information for international travel 2016, New York, 2016, Oxford University Press.

BOX 92-6 U.S. Food and Drug Administration Use-in-Pregnancy Classifications

Category A: Adequate and well-controlled studies in women show no risk to the fetus.
Category B: No evidence of risk in humans. Either studies in animals show risk, but human findings do not, or, in the absence of human studies, animal findings are negative.
Category C: Risk cannot be ruled out. No adequate and well-controlled studies in humans, or animal studies are either positive for fetal risk or lacking as well. Drugs should be given only if the potential benefit justifies the potential risk to the fetus.
Category D: There is positive evidence of human fetal risk. Nevertheless, potential benefits may outweigh the potential risks.
Category X: Contraindicated in pregnancy. Studies in animals or humans, investigations, or postmarketing reports have shown that fetal risk far outweighs any potential benefit to the patient.

INFECTIOUS DISEASE RISK

Pregnancy causes immune system adaptations. Pregnant women have been found to have increased severity of infections when they suffer influenza, hepatitis E viral infection, or herpes simplex virus infection.[127] Pregnancy leads to both increased susceptibility to and severity of malaria from *Plasmodium falciparum,* and increased susceptibility to listeriosis.

Food-Borne and Waterborne Disease

The main concern with traveler's diarrhea during pregnancy is dehydration that can compromise placental blood flow and adversely affect the fetus. Reduced gastric acidity during pregnancy may predispose to GI illness. Boiling water is the most effective and safest method of disinfection. Iodination of water is not recommended, because of risk of fetal goiter. Other options are chlorination, a filter containing three elements (i.e., microfiltration, activated charcoal, and iodine resin), or ultraviolet light exposure (e.g., SteriPEN). Iodine resins transfer iodine to microorganisms that come into contact with the resin but leave little

TABLE 92-6 Medication Use During Pregnancy and Lactation

Medication	Category	Issues During Pregnancy	Issues During Lactation
Analgesics/Antipyretics		*Try nonpharmaceutical methods first to treat pain such as rest, ice, heat, massage.*	
Acetaminophen	B	Safe in low doses short term.	Compatible
Aspirin	C/D	Avoid first and last trimester. Has been associated with premature closure of ductus and excessive bleeding. Low-dose aspirin (60-80 mg) may be used for preeclampsia.	Use caution
Nonsteroidal antiinflammatory (Ibuprofen, Naproxen)	B/D	Should not be used in first and last trimesters owing to effects on premature closure of ductus and effects on clotting. Not teratogenic.	Compatible
Codeine	C/D	Use cautiously as may cause respiratory depression and withdrawal symptoms in fetus if used near term.	Compatible
Hydrocodone	C/D	Use cautiously as may cause respiratory depression in infant if used near term.	Use caution
Antibiotics for URI, UTI, GI, Skin, Other		*Use antibiotics only if strong evidence of bacterial infection.*	
Amoxicillin, amoxicillin + clavulanic acid (Augmentin), amoxicillin + sulbactam (Unasyn)	B	Safe. Use for treatment of otitis media, sinusitis, streptococcal pharyngitis.	Safe
Azithromycin	B	Safe. Use for bronchitis, pneumonia, gastroenteritis (*Campylobacter, Shigella, Salmonella, Escherichia coli).*	Use caution
Cephalosporins	B	Safe. Use for otitis, streptococcal infections, sinusitis, pharyngitis.	Use caution. Can be used to treat mastitis.
Clindamycin PO or Clindamycin vaginal cream	B	Safe. Use for bacterial vaginosis (BV) orally or locally in second or third trimester; avoid in first trimester.	Compatible
Ciprofloxacin, other quinolones	C	Controversial. Sometimes used short term in severe infections and/or long term in life-threatening infections (e.g., anthrax). May be used if potential benefit justifies risk to fetus.	Compatible
Dicloxacillin	B	Safe. Use for skin infections.	Safe. Used to treat mastitis.
Doxycycline, tetracycline	D	May cause permanent discoloration of the teeth during tooth development, including the last half of pregnancy, infancy, and childhood until 8 years of age.	Avoid
Erythromycin (base or state)	B	Safe. Use for bacterial causes of URI.	Compatible
Nitrofurantoin	B	Drug of choice for UTI in pregnancy.	Use caution
Penicillin	B	Safe.	Safe
Sulfonamides	B/D	Safe. However, not recommended in third trimester owing to risk for hyperbilirubinemia and kernicterus.	Avoid
Trimethoprim	C	Avoid	Use caution
Gastrointestinal			
Antidiarrheal		*Replacing fluid lost is key.*	
Atropine sulfate diphenoxylate hydrochloride (Lomotil)	C	Use only if severe symptoms.	Avoid
Loperamide (Imodium)	C	Use only if severe symptoms.	Compatible

TABLE 92-6 Medication Use During Pregnancy and Lactation—cont'd

Medication	Category	Issues During Pregnancy	Issues During Lactation
Nausea/vomiting, esophageal reflux		*Encourage supportive measures first rather than medications: crackers upon arising, frequent small meals, protein meal at bedtime.*	
Antacids	B	May use sparingly for symptoms as needed.	Safe
Bismuth subsalicylate (Pepto Bismol)	C/D	Avoid as contains bismuth and salicylate.	Use caution
Cimetidine, ranitidine, omeprazole	B/C	Safe. Study during the first trimester found it is not associated with an increase in congenital malformations.	Use caution
Ondansetron (Zofran)	B	Use for hyperemesis gravidarum.	Use caution
Metoclopramide (Reglan)	B	Safe in small doses.	Use caution
Dimenhydrinate (Dramamine)	B	Safe for severe nausea.	Use caution
Phenothiazines (Compazine)	C	Often clinically used for nausea and vomiting of pregnancy despite class rating.	Avoid
Promethazine (Phenergan)	C	Often clinically used for nausea and vomiting of pregnancy despite class rating.	Avoid
Acupressure (Sea-Bands)		Safe.	Safe
Emetrol (fluid replacement)	B	Safe. Oral solution.	Safe
Ginger	C	Safe.	Use caution
Meclizine	B	Safe for treatment of severe nausea and vomiting.	Compatible
Pyridoxine (B_6)	A	Safe. Used for nausea.	Compatible
Constipation		*Increase fiber and fluid in diet first.*	
Bisacodyl	C	Safe to use occasionally.	Use caution
Milk of magnesia	B	Safe in small amounts.	Safe
Psyllium hydrophilic mucilloid	C	Safe.	Compatible
Hemorrhoids		Increase fiber and fluid in diet.	
Anusol HC suppositories	C	Safe.	Use caution
Antihistamines and Related Respiratory			
URI, congestion, cough		*Symptomatic treatment: steam, rest, fluids.*	
Chlorpheniramine	B	Use cautiously for severe symptoms.	Use caution
Cetirizine (Zyrtec)	B	Safe. Nonsedating but use cautiously.	Use caution
Diphenhydramine (Benadryl)	B	Safe. Use cautiously.	Use caution
Loratadine (Claritin)	B	Safe. Nonsedating but use cautiously.	Compatible
Dextromethorphan	C	Probably safe. Use in small amounts.	Compatible
Guaifenesin	C	Probably safe. Use only if needed.	Use caution
Pseudoephedrine (Sudafed)	C	Avoid in first trimester. Use cautiously.	Compatible
Saline nasal spray	A	Safe.	Safe
Topical nasal decongestants			
Oxymetazoline (Afrin)		Safe. Do not use for more than 3 days.	Safe
Asthma, allergy			
Inhaled bronchodilators (Albuterol)	C	Safe for use of wheezing during pregnancy.	Unknown
Inhaled steroids (Fluticasone)	C	Use if indicated.	Safe
Nasal steroids (Fluticasone)	C	Use if indicated.	Safe
Antimalarials			
Artemether-lumefantrine (Coartem)	C	Used in second and third trimesters for treatment of severe malaria.	Use caution. Excreted in breast milk. Infant still needs own chemoprophylaxis.
Mefloquine (Lariam)	C	Avoid during first trimester unless unavoidable travel to high-risk area. Safe in second and third trimesters for high-risk travel.	Use caution. Excreted in breast milk. Infant still needs chemoprophylaxis.
Chloroquine	C	Avoid in first trimester unless traveling to high-risk area.	Use caution. Excreted in milk in small amounts. Infant still needs chemoprophylaxis.
Atovaquone, proguanil (Malarone)	C	Avoid in first trimester.	Use caution. Safe if infant is > 11 kg (24 lb) or if benefit for mother outweighs possible risk.
Doxycycline	D	Contraindicated for malaria prophylaxis. May be considered for treatment of severe infections.	Avoid
Primaquine	C	Do not administer during pregnancy because of the possibility the fetus may be G6PD deficient. If a causal cure with primaquine is indicated, continue to suppress with chloroquine (or other chemoprophylaxis) until delivery.	Use caution
Proguanil	C	Not associated with teratogenicity. Not effective as a single agent.	Use caution

Continued

TABLE 92-6 Medication Use During Pregnancy and Lactation—cont'd

Medication	Category	Issues During Pregnancy	Issues During Lactation
Insect Repellent			
DEET		Safe. Use sparingly as directed.	Compatible
Antiparasitics			
Albendazole	C	Teratogenic in animal studies. Avoid during first trimester. Treat after delivery if possible. May be indicated for serious infections.	Use caution
Metronidazole	B	Contraindicated during first trimester. Use in second and third trimesters only if clearly indicated.	Use caution. Single dose: hold breastfeeding 12-24 hr.
Antivirals			
Acyclovir	B	Use when indicated.	Compatible
Altitude Sickness			
Acetazolamide (Diamox)	C	Do not use during first trimester. Use only if benefit outweighs risk.	Use caution
Dexamethasone (Decadron)	C	May use if needed for treatment for altitude illness.	Avoid
Calcium Channel Blockers (Nifedipine)	C	Use only to treat severe symptoms of pulmonary edema.	Use caution
Water Disinfection		*Use chemical (halogenation), mechanical (filtration), or energy (boiling, UV).*	
Iodine	D	Avoid. May lead to goiter and fetal hypothyroidism.	Avoid

Data from Briggs G, Freeman R, Yaffe S: *Drugs in pregnancy and lactation*, Baltimore, 2010, Lippincott Williams & Wilkins; Micromedex Online; American Academy of Pediatrics, 2010; and Lexi-Comp Online UptoDate.
GI, gastrointestinal; G6PD, glucose-6-phosphate dehydrogenase; URI, upper respiratory infection; UTI, urinary tract infection.

iodine dissolved in the water. Meat should be well cooked and all dairy products (including cheeses) pasteurized to decrease the risk for toxoplasmosis, listeriosis, and other food-borne pathogens.

Treatment of GI illness during pregnancy should emphasize oral rehydration. Pharmacologic measures are limited. First-line treatment should include vitamin B_6 or vitamin B_6 plus doxylamine. Treatment with ginger may be considered as a nonpharmacologic option.[27] Ondansetron (category B) is an antiemetic commonly used to treat nausea and vomiting of pregnancy, and is a very effective drug to treat emesis associated with gastroenteritis. Products containing bismuth and salicylate (e.g., Pepto-Bismol) are associated with the risks of congenital malformations (bismuth) and fetal bleeding (salicylate). To control frequency of bowel movements with severe diarrhea, consider use of the antimotility drugs loperamide or diphenoxylate (category B). Antimicrobial choices are limited. Fluoroquinolones (category C) are not recommended, although data from inadvertent exposure during pregnancy do not show an association with adverse outcomes. Adverse effects have been shown in animals but not in humans. Azithromycin (FDA category B) is safe in pregnancy. Cefixime and other cephalosporins are safe during pregnancy, but their effectiveness is unclear.[53]

Vector-Borne Disease: Malaria

Most studies on malaria during pregnancy have been performed in endemic areas. These studies have demonstrated that pregnant women have increased susceptibility to *P. falciparum* infection during pregnancy compared with nonpregnant women. Pregnancy also increases the clinical severity of P. falciparum malaria in women, both with and without preexisting immunity.[160] Preferential sequestration of parasitized red blood cells in the placenta and suppression of selected components of the immune system during pregnancy can result in IUGR, premature delivery, anemia, fetal loss, maternal death, or congenital malaria.[76] Maternal and perinatal mortality rates markedly increase with infection.

Pregnant wilderness travelers need to scrutinize their itinerary for risk to themselves and their fetus. If a woman is pregnant or plans to become pregnant and cannot defer travel to a high-risk area, appropriate chemoprophylaxis and maximal personal protective measures are essential.[57,61,89,184] Mefloquine-resistant strains of *P. falciparum* are increasing worldwide. In these geographic areas, there is no ideal safe option for prophylaxis, and travel should be strongly discouraged.

Personal Protective Measures. Pregnant women should use a combination of physical and chemical barriers (Figure 92-5). Permethrin (or deltamethrin) may be used to treat clothing, and *N,N*-diethyl-*meta*-toluamide (DEET) in a concentration of 30% to 35% may be used on exposed skin. DEET crosses the placenta in small amounts but has not been associated with adverse fetal effects when used as directed. Picaridin 20% and lemon eucalyptus 20% (p-menthane-3,8-diol) are effective insect repellents when applied to skin. Clothing pretreated with permethrin is available.[57]

Pregnancy may lead to "increased attractiveness" to mosquitoes. This may relate to physiologic changes during pregnancy (e.g., greater body heat and surface area) that provide a greater host signal for the mosquito. Human behavioral factors (e.g., more frequent trips outside the tent to urinate) may give mosquitoes a prolonged opportunity to attack.[139]

Chemoprophylaxis. Options for chemoprophylaxis and their uses and contraindications during pregnancy and lactation are listed in Table 92-6. For travel to chloroquine-sensitive malaria areas, chloroquine can be prescribed. Chloroquine has been used for decades for prophylaxis and treatment of chloroquine-sensitive malaria without adverse fetal or maternal effects. For travel to chloroquine-resistant *P. falciparum* areas, travel should be deferred during pregnancy if possible. If travel is unavoidable, mefloquine is the only available antimalarial currently recommended. Limited studies in the second and third trimesters have not found increased rates of stillbirth or congenital malformations. Postmarketing surveillance suggests that first-trimester use is also safe.[165] Doxycycline and primaquine are contraindicated in pregnancy. Atovaquone-proguanil is not currently recommended for prophylaxis during pregnancy due to insufficient data. If a pregnant traveler is unable to take mefloquine chemoprophylaxis, the CDC Malaria Hotline (1-855-856-4713), answered during Eastern Standard Time business hours, should be consulted for guidance. Each pregnant woman should carefully consider the impact of acquiring a severe case of malaria that may result in a poor fetal outcome.[166,184] If a pregnant woman

FIGURE 92-5 Personal protective measures during pregnancy. *(Courtesy Susan Anderson.)*

develops malaria and it is after hours, the CDC Emergency Operations Center (1-770-488-7100) can be used to speak with a CDC malaria branch expert. Initial treatment guidelines are available on the CDC website cdc.gov/malaria/diagnosis_treatment/clinicians3.html.

Hepatitis E

Hepatitis E is a major cause of hepatitis outbreaks in India, Nepal, China, Pakistan, Africa, and countries of the former Soviet Union, and cases are also reported from Central America and Southeast Asia. Viral transmission occurs through fecal-oral exposure. Most outbreaks result from fecal contamination of drinking water. In nonpregnant women, severe disease occurs in less than 1% of individuals. Hepatitis E infection acquired during pregnancy, however, has a mortality rate of 15% to 25%.[64,161] Third-trimester hepatitis E infection is associated with fetal complications and death. Causes of increased severity during pregnancy are not known. A vaccine is being tested in clinical trials.[205] Passive immunization with immune globulin is not effective in preventing hepatitis E infection.[109] Ideally, pregnant women should not travel to an area with a high risk of hepatitis E until after delivery.

Zika Virus

Zika virus infection has rapidly emerged as a significant public health issue. Because of its association with neonatal microcephaly, infection with this virus has important ramifications for pregnant women.[105a,151a] The virus is believed to be transmitted primarily by *Aedes* species of mosquitoes, particularly *Aedes africanus, A. aegypti,* and *A. albopictus.*[64d] The four key symptoms of acute infection are fever, conjunctivitis, arthralgias, and maculopapular rash.[64b] Only 20% of infected patients develop these self-limited and nonspecific symptoms, which typically last a week. Death is extremely rare. Consumer testing for infection is not commercially available. Reverse transcriptase polymerase chain reaction (RT-PCR) and IgM antibody assays can be performed at the Centers for Disease Control and Prevention (CDC) if infection is suspected.[64c] Diagnosed or suspected Zika virus infection should be reported to the appropriate state health officials. Treatment is supportive. Given that dengue and chikungunya viruses can be present as co-infections, nonsteroidal antiinflammatory drugs should be avoided to prevent hemorrhagic complications.[64b]

Maternal-to-fetal intrauterine transmission has been implicated, as Zika virus RNA has been detected in amniotic fluid of fetuses with microcephaly.[165a] Mouse models support this hypothesis. Given the risk for neonatal microcephaly, all pregnant women who have traveled to an endemic region within 2 weeks of development of two or more of the following symptoms—fever, maculopapular rash, arthralgia, conjunctivitis—should be tested.[64b,64c] Testing persons possibly exposed should also be offered within 2 to 12 weeks, even if they are asymptomatic, and in particular whenever an ultrasound examination shows fetal microcephaly or intracranial calcifications. Serial ultrasound examinations should be completed if a pregnant woman tests positive for Zika virus infection. As of the writing of this chapter, there is no vaccine. Therefore, prevention is essential. Because the virus can be sexually transmitted, pregnant women should abstain from sexual intercourse or use proper protection against sexually transmitted disease with any partner who might have been exposed or infected.[64a]

SPORTS AND WILDERNESS ADVENTURE RISKS DURING PREGNANCY

Exercise During Pregnancy

Exercise during pregnancy is recommended for most women. Potential benefits and possible risks of particular exercises have been reviewed.[7,54,149] Unless there are other medical or pregnancy-related contraindications (e.g., risk for premature labor, incompetent cervix, multiple gestation, bleeding), exercise and recreational training should be encouraged throughout pregnancy. Precautions should be taken to avoid prolonged exposure to extremes of temperature, dehydration, hypoglycemia, prolonged anaerobic conditions, and excessive skeletal stress.

Even well-conditioned athletes experience limits on strenuous activity because of hemodynamic changes of pregnancy. Exceeding this limit could have deleterious effects on the fetal status because of decreased uterine perfusion, increased uterine contractions, maternal acidosis, and hypoglycemia. Mild to moderate exercise is not associated with increased pregnancy loss. Running and other endurance sports may divert uterine blood flow and should be done with care as pregnancy progresses.

The ACOG provides the following recommendations for exercise during pregnancy:[7,24]

- Maintain the maternal heart rate at less than 140 beats/min during exercise
- Limit strenuous activity to less than 15 minutes
- Avoid a core temperature higher than 38°C (100.4°F)
- Do not exercise in the supine position after the fourth month

Altitude and Pregnancy

The current literature regarding pregnancy and altitude has been obtained from research involving permanent residents of high altitude.[83,115,120] Studies of high-altitude residents indicate that pregnancy and altitude act together to increase ventilation. Arterial oxygen saturation in the pregnant woman is higher due to increases in ventilation.[154] In general, hypoxic conditions compromise uteroplacental circulation and cause placental hypoxia and IUGR. Women of ethnic groups with multiple generations living at extreme altitude (≈ 4300 m [14,000 feet]) display relatively increased uterine artery blood flow and higher birth weights than those found in recent immigrants (e.g., ethnic

Tibetan versus immigrant Han Chinese women on the Tibetan plateau).[56,121,122,194,216,225] A study in women residing in Colorado found that uterine artery blood flow was lower at high altitude (3100 m [10,000 feet]) than at low altitude (1600 m [5200 feet]), which could decrease fetal oxygen delivery.[224] Placental changes due to altitude exposure have not been conclusively studied in short-term travelers.[5]

Pregnancy-induced hypertension and preeclampsia are more common in women living at high altitude.[120] Infant birth weights are lower at high altitude compared with weights of infants born at sea level. Low oxygen tension and pressure changes result in IUGR and an increased risk for premature labor in women who spend most of their pregnancy above 2500 m (8200 feet).[5] Studies done on pregnancy at high altitude have demonstrated that chronic hypoxia plays a key role in causing IUGR and preeclampsia. Genetic factors have been identified that may relate to an underlying susceptibility to complications of pregnancy and fetal life.[154] Although exercise during pregnancy has been shown to be safe and is recommended for all healthy women, little is known about the combined effects of high altitude and exercise during pregnancy. Maternal hyperventilation and an elevated blood hemoglobin concentration maintain the resting arterial oxygen content at or above sea level values. During exercise, arterial hemoglobin saturation falls, which decreases the oxygen content. Uterine blood flow is likely to decrease further during exercise in proportion to the intensity and duration of exercise. A combined reduction in arterial oxygen content and uterine artery flow suggests that fetal oxygen delivery is compromised during exercise at altitude.[83] If the maternal skeletal muscles and the uteroplacental circulation are competing for the blood supply, exercise has the potential to cause fetal hypoxia or preterm labor at high altitude.[114] More studies are needed to evaluate the combined effects of altitude and exercise on pregnancy in short-term sojourners. Due to a paucity of experimental data, recommendations regarding exercise during pregnancy at elevations higher than 1600 m (5200 feet) are based on the synthesis of available information regarding the independent effects of high altitude and exercise on uteroplacental oxygen delivery.[83] For a nonsmoking woman with an otherwise normal pregnancy who is traveling to altitudes up to 2500 m (8200 feet) in the second half of pregnancy, there is little risk for fetal complications.[110] There are no data on safety at higher elevations. One study of pregnant sojourners at a moderate altitude of less than 2500 m (8200 feet) found that the incidence of AMS during pregnancy did not differ from that in nonpregnant women.[164] As for high-altitude residents, increased incidence of preeclampsia, gestational hypertension, and placental abruption in women who stay at higher altitudes for periods of weeks to months has been reported. Infants of women found to have preeclampsia were at increased risk for IUGR.[153]

Altitude alone does not determine fetal oxygen stress. Diseases that decrease the maternal (and fetal) PaO_2 and arterial oxygen saturation (e.g., HAPE, lung disease, smoking, and other disorders of oxygen transport) can place the fetus at greater risk.

A medical commission from the International Climbing and Mountaineering Federation reviewed the research to date on women and altitude and published a consensus paper[115] and official recommendations at their website (theuiaa.org).[116]

Recommendations for Pregnant Women Traveling to a High Altitude

First trimester: Short stays (hours to days) at altitudes up to 2500 m (8200 feet) without heavy exercise.
- Healthy pregnant women in the first trimester with good access to care may go to altitudes of 1600 m (5200 feet) to 2500 m (8200 feet). Plan to allow 2 to 3 days to acclimatize.
- Women at an increased risk for spontaneous abortion should avoid altitude exposure during the first trimester.
- Women with risk factors for preeclampsia or placental abruption, or who are carrying fetuses at risk for IUGR, should not go to a high altitude, even for short stays.

Later trimesters: Short stays (hours to days) at altitudes up to 2500 m (8200 feet) without heavy exercise pose little risk to the pregnancy or of fetal complications during the second half of pregnancy.

Contraindications for going to altitude after 20 weeks of pregnancy include:
- Chronic hypertension or other factors that increase the risk for preeclampsia
- Preeclampsia
- Impaired placental function (e.g., ultrasound diagnosis of partial abruption, clots)
- IUGR
- Maternal cardiac or pulmonary disease
- Anemia
- Smoking

Any trimester: Exercise
- Mild to moderate exercise: Plan at least 2 to 3 days for acclimatization before exercising at an altitude higher than 2500 m (8200 feet).
- Strenuous exercise: Plan at least 2 weeks for full acclimatization before strenuous exercise and avoid heavy exertion at higher altitudes.
- Most would advise against travel to altitude after 36 weeks because of lack of access to optimal care.

Any trimester: Longer stays at high altitude (2500 m [8200 feet])
- There is increased risk for preeclampsia, placental abruption, and IUGR.[130,154,175,177]
- All women should be monitored for signs and symptoms of preeclampsia, placental pathology, and fetal IUGR.
- Prenatal visits should include blood pressure monitoring, urine protein check, and Doppler ultrasound monitoring of the uterine artery for waveform and volumetric flow.
- For "prenatal self-checks," women should be taught how to take their own blood pressure, screen for urine protein and glucose, and assess for other early symptoms of preeclampsia.
- Women at risk should be identified and referred for advanced health care services immediately.
- Ideally, maternal artery and fetal umbilical arterial waveforms and growth after 20 weeks should be followed in high-risk women.

Acute Mountain Sickness

Considerations about acute mountain sickness (AMS) in pregnancy include:
- AMS incidence does not differ between pregnant and nonpregnant women.[164]
- There are few data on treatment of AMS during pregnancy.
- Strict guidelines for acclimatization should be followed as outlined above.
- Acetazolamide and other sulfonamides are contraindicated during the first trimester due to studies demonstrating teratogenicity in animals and are not recommended after 36 weeks due to increased risk for neonatal jaundice.[59]
- If a pregnant woman has symptoms of AMS, theoretical risks of medication must be weighed against symptoms.
- Descent and oxygen therapy are the preferred treatment.
- Use of acetazolamide or dexamethasone may be considered on an individual basis.

There are no studies on skiing while pregnant, although for a normal healthy pregnancy, there is likely little risk during the first trimester. Access to care is the most important issue in case of an emergency. Women skiing later in pregnancy are at higher risk due to increased weight, change in their center of gravity, and increased joint laxity that may predispose to falls, with subsequent placental disruption, ligament ruptures, or other devastating consequences. Short-term travel to a favorite mountain escape with adequate resources is probably safe for a pregnant adventurer with a normal pregnancy. More research is needed to evaluate risks of intense exercise at altitude during pregnancy.[35,36,83,115]

Water Sports During Pregnancy

Swimming and snorkeling are safe during pregnancy and considered to be an excellent form of exercise for pregnant women.[119] Scuba diving is potentially hazardous. The fetus is at risk from nitrogen bubbles in the fetal-placental circulation during decompression on ascent. Most authorities consider pregnancy a contraindication to diving.[48,59,70,200]

Diving is compromised by increased abdominal girth, difficulty breathing due to engorgement of mucous membranes of

the nose and oropharynx, and increased buoyancy secondary to fat deposition. Higher levels of body fat also increase the risk for decompression sickness because nitrogen tends to be retained in these tissues. Dyspnea may be exaggerated and lead to panic even in experienced divers.

As with exertion at high altitude, pregnant women may have limited ability to maintain anaerobic metabolism for prolonged periods because of fetal needs. Pregnant women should also limit prolonged nondiving immersion in cold water that might lead to hypoventilation and hypothermia. Effects of scuba diving on pregnancy have been reviewed in detail.[59] Advice for a woman who finds out she was pregnant during the time she was diving is to not terminate the pregnancy. There are case reports of normal pregnancies despite continued diving. If a pregnant woman insists on diving, it is recommended that she not dive below a depth of 18 m (60 feet) and only remain underwater for half the recommended Navy dive table times.[70] CDC recommendations advise against diving in pregnancy owing to increased risk of air embolism.[58]

Waterskiing, jet skiing, and other water sports that might force water into the vagina and cervix and increase the risk for miscarriage or peritonitis are not recommended activities during pregnancy.[142]

Heat and Pregnancy

Safe limits for exposure to heat during pregnancy have not been established. Acclimation to environments characterized by high temperatures, particularly with high humidity, may be especially difficult for pregnant women and may pose a fetal risk. Hyperthermia has been shown to be teratogenic in various animal models. A higher incidence of birth defects, particularly neural tube defects, has been found among offspring of women who experienced first-trimester hyperthermia by environmental exposure or febrile illness.[151] Later in pregnancy, the fetus depends on maternal abilities to eliminate excess heat. Elevated ambient temperature decreases ability of the pregnant woman to dissipate heat. Elevated humidity decreases the contribution of perspiration to heat loss. Together, these factors increase the risk for an elevated maternal core temperature that further raises the fetal metabolic activity and heat generation. Hyperthermia, particularly with dehydration and loss of electrolytes, increases the risk for premature labor.[37,182,212] Fetal stress, due to decreased uterine perfusion secondary to compensatory peripheral vasodilation and depletion of intravascular volume, further increases the likelihood of preterm labor. Pregnant women exposed to hot climates should pay particular attention to remaining well hydrated.

Data regarding effects of exercise on core temperature are limited. To date, hyperthermia associated with exercise has not been found to be teratogenic in humans. It is recommended that pregnant women avoid hot tubs and saunas.[199,201]

Exposure to Venomous Animal Bites and Stings

Venomous animal bites and stings during pregnancy may have serious effects on the fetus and mother. Snakebite in pregnant women has caused reported fetal death rates ranging from 20% to 40% since 1966.[55] There have been no formal epidemiologic studies on the effect of antivenom on fetal development. Although a large percentage of fetal deaths occurred in mothers who received antivenom, deaths may have been related to the severity of the bite rather than to the therapy. Risks of untreated significant maternal venom poisoning outweigh any theoretical concerns about antivenom risks to the unborn child. "What is good for the mother is good for the fetus."[55]

Envenomation during pregnancy should be reported to a poison control center and to the pharmaceutical company that produces the antivenom so that information on medical management and fetal outcomes can be evaluated and lead to evidence-based recommendations. More research is needed to evaluate the risk-to-benefit profiles of snake, spider, and scorpion antivenoms on pregnant women, embryos, and fetuses.

Remote Wilderness Travel During Pregnancy

Prolonged wilderness excursions during pregnancy, particularly those extending into the late second and third trimesters, should include preparations for ongoing assessment and emergency delivery. Routine antepartum care usually includes visits to a health care provider at least monthly until 26 to 28 weeks, every 2 weeks thereafter until 36 weeks, and then weekly until delivery. Beyond the due date, more frequent visits and fetal monitoring are often recommended. Routine visits focus on uterine activity, vaginal discharge, abdominopelvic pain, bleeding, headaches, symptoms of UTI, current medications, and fetal activity.[75]

A basic antepartum examination includes measurements of blood pressure, weight, and uterine size (height of the uterine fundus above symphysis) and subjective assessments of peripheral edema and reflexes. Urine is tested at each visit with a multitest strip that provides estimates of glycosuria, proteinuria, pH, and presence of nitrites. For wilderness travelers, elevated pH and presence of nitrites may be associated with a UTI. In Rh-negative women with Rh-positive partners, Rh antibody screening is often repeated at 26 to 28 weeks, before administration of Rh immune globulin for prophylaxis against third-trimester sensitization. If an Rh antibody screen cannot be performed, Rh immune globulin should be administered empirically. Maternal hemoglobin and hematocrit are frequently measured in each trimester to assess the need for iron supplementation. If hemoglobin testing cannot be performed, consider empirical supplemental iron during pregnancy unless the woman has a contraindication (e.g., hemochromatosis). All pregnant women should take prenatal vitamins.[75]

PRENATAL CARE IN THE WILDERNESS

Basic supplies for pregnant wilderness travelers include a diary to record progress; reminders of scheduled testing and complications; a tape measure, stethoscope, and sphygmomanometer; urine test strips; and supplies of prenatal vitamins and iron. Other supplies may include a glucometer with test strips, calcium supplements, and basic medications for the most common pregnancy complaints. These include an oral antiemetic (e.g., orally dissolving ondansetron tablets [Zofran ODT]) or suppository (e.g. promethazine or prochlorperazine) for nausea and vomiting, acetaminophen for headaches and pain, stool softener for constipation, and antibiotics for UTIs and vaginitis. In addition to basic medical supplies, pregnant women should have changes in clothing size and possibly shoe size.

Ideally, delivery in the wilderness should not be planned. If delivery in the wilderness is a possibility, special preparations need to be made (Box 92-7), including plans for emergency evacuation and infant resuscitation if needed.

COMPLICATIONS DURING PREGNANCY

Miscarriage

Women who are pregnant or become pregnant for the first time while in the wilderness are at high risk for complications. About 15% to 25% of all pregnancies abort spontaneously during the first trimester, and this number may exceed 60% to 70% in the true primigravida.[181] Reasons may be related to immunologic naiveté to paternal antigens expressed by the fetal tissues. In contrast, isolated miscarriages in women who have successfully carried pregnancies often result from chromosomal abnormalities. Impending first-trimester miscarriages are usually preceded by embryonic demise and accompanied by reduction or loss of early pregnancy-related symptoms (e.g., breast tenderness and nausea). Bleeding and uterine contractions eventually occur and accompany expulsion of products of conception. Under most circumstances, hemorrhage during miscarriage is self-limited and not life-threatening, but at times can be heavy. Risk factors for significant hemorrhage include fetal death not preceding the event, miscarriage late in the first trimester or during the second trimester, or prolonged or incomplete expulsion.[162] Half of women with first-trimester vaginal bleeding will continue to have viable pregnancies. However, this is difficult to assess in the wilderness.[188] Spontaneous abortion after the first trimester is much riskier but less common. It also can result from chromosomal abnormalities or fetal anomalies but is more likely to be caused by chorioamnionitis, UTI, severe abnormalities of placentation, poorly controlled maternal medical conditions, or cervical incompetence.

BOX 92-7 Supplies for Management of Wilderness Delivery

Standard Supplies
Clean towels
Surgical sponges
Surgical gloves
Speculum
Umbilical cord clamps
Suction bulb
Suture kit
Scalpel
Scissors
Syringes and needles
Local anesthetic
Injectable oxytocin
Injectable and oral methylergonovine
Oral analgesics (e.g., ibuprofen, acetaminophen with codeine)
Oral broad-spectrum antibiotic
Sanitary napkins
Neonatal mask and suction
Self-inflating bag/valve/mask resuscitator (Ambu bag)
Reusable uterine balloon tamponade device to control postpartum hemorrhage

Optional Supplies
Injectable magnesium sulfate
Intravenous fluids and administration supplies
Injectable narcotic
Naloxone
Misoprostol
Prostaglandin $F_{2\alpha}$
Injectable antibiotic

Acute and significant blood loss in a physiologically hostile environment can compromise the endurance of the most highly trained individual. Under wilderness conditions, control of significant maternal hemorrhage accompanying miscarriage may be difficult unless provisions, facilities, and medical supplies are available. Uterine curettage is most often used to complete evacuation of the uterus when medical facilities are available. Once empty, uterine involution, spontaneous or aided by uterine massage, is usually sufficient to impede bleeding from the implantation site. In the absence of the ability to perform curettage, treatment with methylergonovine (0.2 mg orally or intramuscularly) can enhance uterine contractions, accelerate expulsion of products of conception, and promote uterine involution to maintain hemostasis while plans for evacuation are being made. Methylergonovine should not be used in patients with hypertensive disorders, underlying vascular disease, and certain cardiac abnormalities unless the benefits clearly outweigh the risks of acute generalized vasoconstriction. As an alternative, the prostaglandin F_{2a} drug carboprost tromethamine (250 mcg intramuscularly) or misoprostol (400 to 600 mcg orally or sublingually) can be administered to stop uterine bleeding with less risk for cardiovascular compromise. Dosing depends on the indication and whether it is given orally, sublingually, or vaginally (misoprostol.org/File/dosage_guidelines.pdf).[95]

Ectopic Pregnancy

Far more dangerous than miscarriage, ectopic pregnancy must always be considered a life-threatening emergency that requires immediate medical attention.[20] Ectopic pregnancy refers to implantation at any location outside the uterine cavity, most often (>95%) within the fallopian tube. Hemorrhage resulting from ectopic pregnancy is still the leading cause of first-trimester maternal death. Ectopic pregnancy incidence has tripled over the past 30 years and now exceeds 1 in every 100 pregnancies. This increase is directly proportional to the increased incidence of acute and chronic PID. The most common predisposing risk factors include a history of infections, multiple sex partners, early age at onset of sexual activity, delayed childbearing, and previous IUD use. Independent risk factors are a history of abdominal and tubal surgery, including previous tubal sterilization procedures, endometriosis, diethylstilbestrol exposure, and pregnancy by assisted reproductive interventions. Regardless of the cause, prior ectopic pregnancy increases the risk for another ectopic pregnancy approximately 10-fold. A woman with a history of ectopic pregnancy should not intentionally plan to conceive again in the wilderness and should have intrauterine pregnancy confirmed ultrasonographically before departure.

Most women with a tubal ectopic pregnancy become symptomatic before 12 weeks' gestation and present with complaints of abdominal pain and altered menses. Early pregnancy symptoms may be minimal or absent. Pain often begins unilaterally with sudden onset and is usually severe and distinguishable by its persistence and intensity from intermittent cramping pain accompanying miscarriage. Clinical findings include tender adnexal mass, nontender cervix, small to slightly enlarged nontender uterus, and absence of high-grade fever. Low-grade temperature elevation to 38°C (100.4°F) may occur in as many as 20% of women with ectopic pregnancy. When intraperitoneal hemorrhage accompanies tube rupture, pain becomes diffuse, with peritoneal signs of tenderness, guarding, and rebound. Shoulder pain from diaphragmatic irritation may be present. Pelvic examination at this point usually elicits discomfort with movement of the cervix and uterus. Fullness of the cul-de-sac posterior to the uterus and abdominal distention suggest significant intraperitoneal blood loss. See Chapter 109 for details on ultrasonographic assessment of pregnant patients under austere conditions. In the pregnant patient with acute abdominal pain, ultrasonographic evidence of abdominal free fluid indicates the presence of an ectopic pregnancy until proven otherwise.

Vaginal bleeding accompanying an ectopic pregnancy usually follows a variable period of amenorrhea. It often begins with minimal flow of blood darker than that seen during miscarriage and results from inadequate progestational support of the decidualized endometrium. Uterine cramping may ensue, with passage of organized clot and tissue in the form of a decidual cast resembling products of conception, leading to a mistaken diagnosis of spontaneous abortion. Cessation of pain is typical with completion of a miscarriage. In an ectopic pregnancy, pain typically continues despite passage of a decidual cast. With rupture of an ectopic pregnancy, heavier, bright-red bleeding may occur vaginally. If accompanied by significant intraperitoneal hemorrhage, this may rapidly result in hemodynamic decompensation that can only be controlled surgically. Differential diagnosis of ectopic pregnancy includes normal intrauterine pregnancy with a corpus luteal cyst or hemorrhagic corpus luteum, threatened or incomplete abortion, PID, adnexal torsion (usually associated with adnexal enlargement from a benign or neoplastic process), endometriosis, UTI or ureteral stone, degenerating fibroid, and appendicitis. Although simultaneous intrauterine and ectopic pregnancies were once considered extremely rare, the incidence is now estimated at 1 in 6000 in the general population and higher than 1 in 100 among recipients of assisted reproductive techniques. Diagnosis of ectopic pregnancy is considered presumptively in any woman with a positive pregnancy test, abnormal bleeding, and abdominal pain. In a full-service medical care facility, the first step in management is to assess serum hCG levels and ascertain location of the pregnancy. Intrauterine pregnancy can usually be confirmed by transvaginal ultrasonography once the serum hCG level exceeds 1000 mIU/mL, corresponding to 3 to 4 weeks after conception or 5 to 7 weeks from the last normal menstrual period. Absence of a visualized intrauterine pregnancy at hCG levels of 1000 to 1500 mIU/mL or greater suggests ectopic pregnancy. However, some normal intrauterine pregnancies may appear later on ultrasound. In an urban setting, if the fetus is not visualized and the patient is asymptomatic, it may be reasonable to monitor with serial hCG levels and ultrasonograms. However, in a wilderness setting that precludes the ability to perform ultrasonography and quantitative determinations of hCG, plans for evacuation must be made at the first suspicion of the diagnosis of ectopic pregnancy.[20,75]

Later Pregnancy Complications

Complications that cause bleeding at 20 weeks' gestation or later cannot be optimally managed in most wilderness settings

BOX 92-8 Later Complications of Pregnancy Requiring Evacuation

Placenta previa
Placental abruption
Preterm labor
Premature rupture of membranes
Chorioamnionitis
Preeclampsia, eclampsia, HELLP syndrome (hemolysis, elevated liver function enzymes, and low platelets)

(Box 92-8). Plans should be made for immediate evacuation. Second- and third-trimester bleeding could simply be the result of cervical effacement, labor, cervical polyps, coital trauma, or vaginitis, but it could also be much more serious (e.g., placenta previa or placental abruption).[75,168] Historical information and physical findings may suggest a cause, but definitive care is required to rule out potentially life-threatening diagnoses.

Placenta Previa. Placenta previa results from placental implantation in the lower uterine segment over or near the internal cervical os. It occurs in approximately 1 of 200 births. The risk increases with age and parity, cigarette smoking, multiple gestations, submucosal fibroids, history of multiple dilation and curettage procedures, and prior cesarean delivery. The classic presentation of placenta previa is painless, sudden, heavy, and bright-red vaginal bleeding.[187] It may occur with exertional activity, straining on the toilet, or intercourse but also occurs at rest with no obvious precipitating factor. No internal vaginal examination should be done, because this may worsen the bleeding.[168]

Placental Abruption. Placental abruption is defined as separation of the placenta from the maternal interface before delivery. One of the most common causes is trauma. Risk factors include hypertensive disorders (e.g., preeclampsia, chronic hypertension), other chronic diseases with vascular compromise (e.g., diabetes, renal disease, certain autoimmune disorders), coagulation disorders (presence of lupus anticoagulants or anticardiolipin antibodies, proteins S and C deficiencies, factor V Leiden, antithrombin III deficiency), trauma, chorioamnionitis, advanced maternal age, and multiparity. Placental abruption is highly variable in presentation, depending on the location and extent of separation and hemorrhage. About 80% of placental abruptions result in visible bleeding accompanying the onset of other symptoms. Unlike placenta previa, abruption is usually accompanied by a sudden onset of sharp pain. The pain may be focal and continuous, intermittently intensifying with frequent uterine contractions and irritability that usually accompany and can extend placental separation.[75]

Premature Labor. Despite advances in obstetric and neonatal care in the past 50 years, rates of preterm delivery, defined as delivery before 37 completed weeks' gestation, have not changed. Rates range from 8% to 10% of all pregnancies in the United States. Premature labor is still the leading cause of perinatal complications and death. Only half of women who experience preterm labor, defined as regular uterine contractions resulting in progressive cervical change (as assessed by effacement, dilation, and softening) actually progress to preterm delivery. Symptoms of preterm labor include mild and menstrual-like painful uterine contractions, intermittent low back pain or pressure, pelvic pressure, increase in vaginal discharge resulting from effacement with compression of endocervical glands or leaking of amniotic fluid, and bloody "show." Common risk factors for preterm labor and delivery include premature rupture of membranes, subclinical or overt chorioamnionitis, UTI, preeclampsia, multiple gestation, hydramnios, dehydration, constipation, chronic stress, and incompetent cervix.[18,75] The pregnant wilderness traveler is at risk for several of these factors (e.g. UTI, dehydration) and should strive to reduce their occurrence.

Thorough evaluation and management of preterm labor cannot be done in most wilderness settings. Empirical measures can be taken, however, based on symptoms and palpation of uterine contractions while awaiting evacuation or preparation for delivery (if evacuation is delayed or impossible). If vaginal bleeding is present, pelvic examination should be avoided unless placenta previa has been previously excluded and sterile supplies are available. If done by an experienced person, cervical examination should determine dilation, effacement, and consistency, as well as station and presentation of the baby. Once it has been concluded that the woman is in preterm labor and evacuation is required, do not repeat examinations unless delivery appears imminent. If she clearly has ruptured membranes, note the characteristics (clear, bloody, meconium stained) of the fluid but do not perform an internal vaginal examination, to minimize the risk for introducing infection. Plans should be made for evacuation at any initial signs of premature labor. If premature labor cannot be stopped before evacuation, guidelines for management of delivery are described below.

Preeclampsia. The diagnosis of preeclampsia is based on the triad of hypertension, proteinuria, and edema.[13] Hypertension is defined as systolic blood pressure of 140 mm Hg or higher or diastolic blood pressure of 90 mm Hg or higher measured on two separate occasions 6 or more hours apart or persistent elevations above baseline. Proteinuria is defined as 0.3 g or more of protein in a 24-hour urine collection, which usually corresponds with "1+" (30 mg/dL) or greater on a urine dipstick test. Edema is considered significant for a diagnosis of preeclampsia only if it is generalized or if the woman has had a sudden weight gain of 2.27 kg (5 lb) or more in a week. Diagnosis of preeclampsia requires the presence of hypertension with proteinuria or the presence of edema, or both. Women meeting these criteria have at least mild preeclampsia. If preeclampsia is suspected, plans should be made for immediate evacuation from the wilderness setting.

Diagnostic criteria for severe preeclampsia require only one of the following: systolic blood pressure of 160 mm Hg or higher or diastolic blood pressure of 110 mm Hg or higher on two occasions at least 6 hours apart; proteinuria (5 mg/24 hours or higher); oliguria (400 mL/24 hours or less); persistent epigastric pain; pulmonary edema or cyanosis; impaired liver function of unclear cause; thrombocytopenia (100,000 platelets/mL of blood or less[21]); and eclampsia (grand mal seizures). Most cases of severe preeclampsia are associated with IUGR or abnormalities of fetal umbilical (increased resistance) arterial flow consistent with relative placental insufficiency and decreased resistance in maternal middle cerebral arterial flow. Eclampsia is a major cause of maternal and fetal complications and death worldwide, occurring in 1 in 2000 pregnancies in the United States. Although difficult to anticipate, presence of visual disturbances, severe headache, irritability, epigastric or right upper quadrant pain, nausea and vomiting, and cerebral dysfunction must be considered predictors of eclampsia. If a woman has early signs of preeclampsia, she should be evacuated because she may progress to severe eclampsia with high rates of morbidity and possible death.[13] Field management should include bed rest until evacuation can be arranged.

EMERGENCY DELIVERY

Although a delivery should never be planned for a wilderness expedition, unexpected delivery may occur. A pregnant woman traveling after 20 weeks' gestation should consider emergency provisions and plans. The travel location, duration of stay, and distance dictate the extent of these plans. Consider the distance to medical care facilities, convenience of evacuation routes, ease of communication, and availability of evacuation support. Any woman planning a wilderness excursion should review detailed emergency plans with her physician and expedition partners. Some considerations are reviewed briefly below.

If a woman goes into labor unexpectedly on a trip, the health care provider or person with the most childbirth experience that is willing to assist in the delivery should be identified as the team leader and "midwife." Participatory roles for other members of the party should be defined in cooperation with the pregnant woman. Requests for privacy and intimacy should be respected to the extent possible.

By necessity and practicality, delivery in the wilderness dictates a laissez-faire approach. Excessive intervention (e.g., repeated cervical examinations, artificial rupture of membranes, augmentation of uterine contractions by oxytocin or nipple

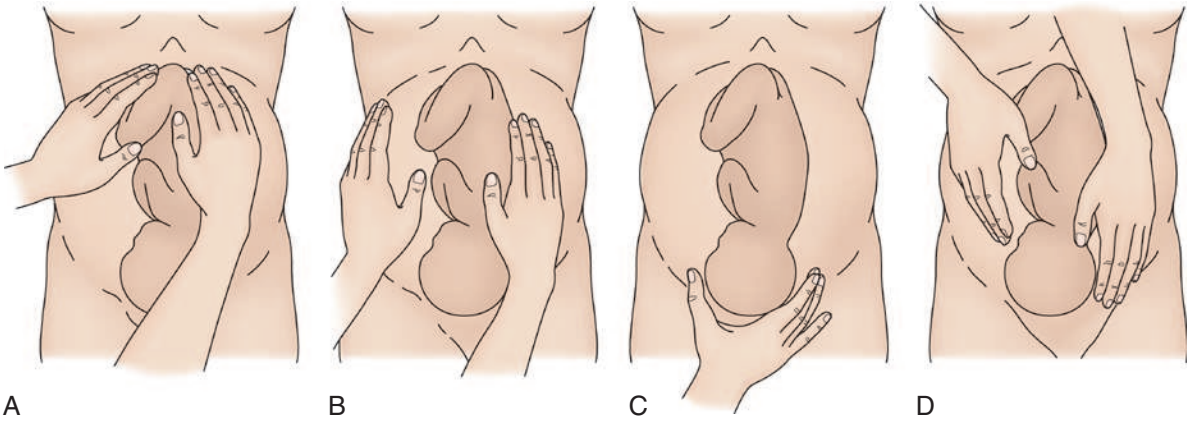

FIGURE 92-6 Ascertaining fetal position by Leopold's maneuvers. **A,** Assess part of fetus in upper uterus. **B,** Ascertain location of fetal back. **C,** Identify presenting part. **D,** Determine descent of presenting part.

stimulation, manual cervical dilation) is neither warranted nor appropriate because delivery cannot be expedited for concerns of fetal distress, and such intervention may increase maternal and fetal risks. Prepare a clean, comfortable, and quiet site for the delivery. If clean and sterile supplies and medications are available, these should be brought to this location and inventoried by the team leader (see Box 92-7). Make clean towels, clothing, bedding, soap, and clean water readily accessible.

The fetal position should be determined. In late third-trimester pregnancies, this can be accomplished by external abdominal palpation using Leopold's maneuvers (Figure 92-6).[13] In preterm pregnancies, this may first require internal digital examination, but determining the fetal position is extremely important because the risk for malpresentation (i.e., breech, transverse, or compound lie) is inversely proportional to the gestational age, as is the disparity between the fetal head and abdominal circumferences. Digital examination should not be done in a wilderness setting unless sterility can be ensured because of the risk of introducing infection. At term, the incidence of breech presentation is about 3%, whereas it may exceed 25% before 30 weeks' gestation. If the woman reports fetal activity, or if this is visible or palpable on abdominal examination, evaluation of the fetal heart rate can be assessed. Fetal activity frequently diminishes with the onset of labor. If the woman or examiner cannot detect fetal activity, assess viability by auscultation. A stethoscope or the ear can be positioned over the location of the baby's back and shoulder. Auscultation with a stethoscope bell placed on the abdomen with minimal pressure is usually more sensitive than using the stethoscope's diaphragm. The normal fetal heart rate at term falls between 120 and 160 beats/min. In most wilderness situations, once viability is confirmed, further auscultation is probably unnecessary and may even provoke anxiety because of inherent difficulties of fetal heart rate detection with unamplified methods, subtle changes in fetal position, descent of the presenting part, and increasing discomfort of labor as it progresses.

In early stages of labor or with spontaneous rupture of membranes in the absence of regular uterine contractions, rest, fluid intake, and frequent light meals should be encouraged. Activity should be restricted until the fetal head is engaged, because too much activity prior to this point might result in umbilical cord prolapse and fetal distress. Prophylactic antibiotics should be started, especially when there has been preterm premature rupture of membranes, or rupture of membranes prior to 37 weeks' gestation. Antibiotic regimen recommendations are as follows:

- Rupture ≥12 hours without signs of infection or labor: Amoxicillin 3 g/day in three divided doses for 5 to 7 days (Note: Do not use amoxicillin/clavulanate because of the increased incidence of necrotizing enterocolitis in neonates).
- Rupture ≥12 hours in labor without signs of infection: Ampicillin 2 g IV for one dose, and then 1 g every 4 hours until delivery. No further antibiotics.
- Rupture of membranes (no time requirement) with signs of infection with/without labor: Ampicillin 2 g IV every 6 hours and metronidazole 500 mg IV every 8 hours and gentamycin 3-5 mg/kg daily. Continue IV antibiotics for 48 hours after fever resolves, and then continue amoxicillin 3 g/day PO in three divided doses and metronidazole 500 mg PO every 12 hours for a total of 10 days of treatment.[73a]

Digital cervical examination is not necessary and is contraindicated with amniotic membrane rupture because of the risk of infection. As labor becomes more active, as gauged by increased frequency, regularity, strength of uterine contractions, pelvic pressure, and discomfort level, the safest approach is to limit oral intake to clear liquids only. The GI tract becomes quiescent with active labor. Because vomiting is not unusual, especially during the "transition" phase of labor, clear liquids minimize discomfort and decrease the risk for aspiration. Intermittent ambulation may also decrease discomfort associated with contractions and can be continued, if the woman desires, until she feels the need to push. During this time, she should also be reminded to empty her bladder because she may not be able to differentiate the sensation of needing to void from that of pressure from the presenting fetal part. A full bladder not only adds to the discomfort of labor but also can impede descent of the baby into the pelvis and prolong parturition.

Although some women become irritable as labor intensifies before complete dilation and do not want to be touched, others appreciate low-back or extremity massage between contractions. Breathing and relaxation techniques to distract, maintain composure, and preserve energy that will be required during the second stage of labor are also beneficial. During labor, no oral pain medication should be given. Parenteral intravenous narcotics, although acceptable, should be administered sparingly unless naloxone is available to manage fetal depression that may result.

When the woman begins to feel involuntary efforts to push with contractions, cervical examination should be performed with a clean or sterile glove or freshly washed hands. At the same time that cervical dilation and effacement are assessed, the presenting fetal body part should be identified and its station determined in relation to the ischial spine. If the cervix is completely dilated and effaced so that no cervical tissue is palpable between the presenting part and the vaginal wall, the first stage of labor is complete and the woman can begin pushing with contractions. If the cervix is not completely dilated, encourage the woman not to push with contractions so that she does not become exhausted or risk entrapping the cervix between the presenting part and pelvis. Cervical entrapment can lead to cervical edema and thickening. It is more commonly due to cephalopelvic disproportion. If membranes have ruptured, note the presence or absence of meconium. If membranes have not ruptured, they should not be ruptured intentionally, particularly if the baby is premature or in a breech presentation.

Once the cervix is completely dilated, the desire to push may become involuntary, and pain is less of an issue until the moment of delivery. Pushing is done only with uterine contractions. At the onset of a contraction, the woman takes in a deep breath and then exhales. Then she takes in and holds another deep breath, bearing down without releasing air as if straining to have

a bowel movement. Most contractions are long enough to permit two or three attempts at this maneuver. Proper pushing is evident by expansion of the introitus and rectum during the effort and should not be accompanied by tensing of the extremities. Once the contraction is over, she should expel any held air and begin restful breathing, trying to relax completely to conserve energy and recover for the next contraction. The woman may push in any position in which she feels comfortable. However, she should avoid lying flat on her back because uterine compression of the inferior vena cava can lead to maternal hypotension and decreased uterine perfusion. Common positions include semirecumbent, with the back and head elevated and legs drawn up or supported at the knees during contractions; lateral recumbent, with the superior leg flexed and supported during contractions; squatting; sitting; kneeling on all fours; and standing while being supported from behind around the torso. These positions can also be used for the actual delivery, as long as the attendant has adequate access. Once the presenting part reaches, distends, and remains at the vaginal introitus between contractions, final preparations are made for delivery. A delivery position should be selected that allows control of the presenting part, protection of the perineum, and room to accomplish completion of the birth with as little trauma to the baby as possible. Delivery should be performed during a contraction.[75]

COMPLICATED DELIVERIES

Vertex Delivery

The most common fetal presentation is the cephalic (or vertex) presentation, with the fetal head facing the perineum (occiput anterior) (Figure 92-7). When the perineum begins to distend with a contraction, instruct the woman to bear down. Intentional cutting of an episiotomy in a wilderness setting is not recommended. Spontaneous lacerations are more likely to occur along less vascular tissue planes and less likely to extend into the rectum. Support the perineum between the rectum and the introitus using the index finger and thumb of the nondominant hand. Maintain the fetal head in flexion until the crown has just begun to clear the symphysis. Instruct the woman to stop pushing while the attendant exerts steady inward and upward pressure at the perineum against the fetal chin, thereby extending the head and completing its delivery while protecting the perineum. Once delivered, the fetal head will usually rotate laterally to align itself with the shoulders. Clean the infant's mouth and nose by bulb aspiration or simple swabbing with a clean gauze or cloth. This step is especially important when meconium is present to prevent aspiration of this fluid when the baby is free to take its first breaths. Once the oropharynx is cleaned, palpate the fetal neck to rule out the presence of a nuchal cord. If present, one or more loops of umbilical cord are often loose enough to be slipped over the baby's head before completion of the delivery. If they cannot be slipped over the head but are not tight, the baby can frequently be delivered through the loops. If the cord is tightly applied around the neck, the attendant should doubly clamp or tie a section of one loop, cut between the clamps, and then deliver the baby. Fashioning clamps may require creativity, depending on your resources. One could use fishing line, rope, a shoestring, or organic matter if absolutely necessary.

In the final stages of delivery, the woman resumes pushing while steady downward (toward the maternal sacrum) traction is applied with hands cupping both sides of the fetal head. When the anterior shoulder has cleared the symphysis, the perineum should again be supported while the head is elevated and the posterior shoulder delivered. The rest of the baby's body usually follows without effort. The baby is held below the perineum (to prevent loss of blood to the placenta from the baby) while the oropharynx is again cleaned and the baby dried. Usually, rubbing the baby dry is sufficient to stimulate breathing and crying. The umbilical cord should be doubly clamped or tied and then severed. The baby should be thoroughly dried and wrapped in clean, dry, and warm fabric with its head covered and given to the mother if she desires. If the baby does not cry within 10 to 15 seconds after delivery, has obvious airway obstruction, or is premature, the umbilical cord should be cut immediately and resuscitative efforts begun.

Shoulder Dystocia

If there is difficulty delivering the anterior shoulder (shoulder dystocia) by the method outlined, immediate steps should be taken to accomplish this. True shoulder dystocia occurs in less than 1% of deliveries and is rare in uncomplicated labors, but is a substantial cause of fetal and maternal distress or complications. Shoulder dystocia is often anticipated when the fetal head snaps back tightly and fails to rotate after its delivery. If available, other individuals can assist. Throughout the steps necessary to accomplish delivery, excessive traction on the fetal head is avoided because it may stretch the brachial plexus, resulting in Erb's or Klumpke's palsy. First, position the woman so that the buttocks are elevated to allow at least 12 inches of free space beneath the perineum to maneuver. Flex both legs upward to the chest (McRobert's maneuver) while the woman is supported in a semirecumbent position. Attempt delivery again by downward traction on the fetal head.[75]

If the shoulder is still impacted against the symphysis, apply pressure with the fist or heel of the hand just above the symphysis in the midline. This may reduce dystocia sufficiently to accomplish the delivery. Assistants should not push on the uterine fundus, because this can further impact the shoulder. If these maneuvers fail, an episiotomy should be cut to admit several fingers or the hand beneath the posterior shoulder. Once

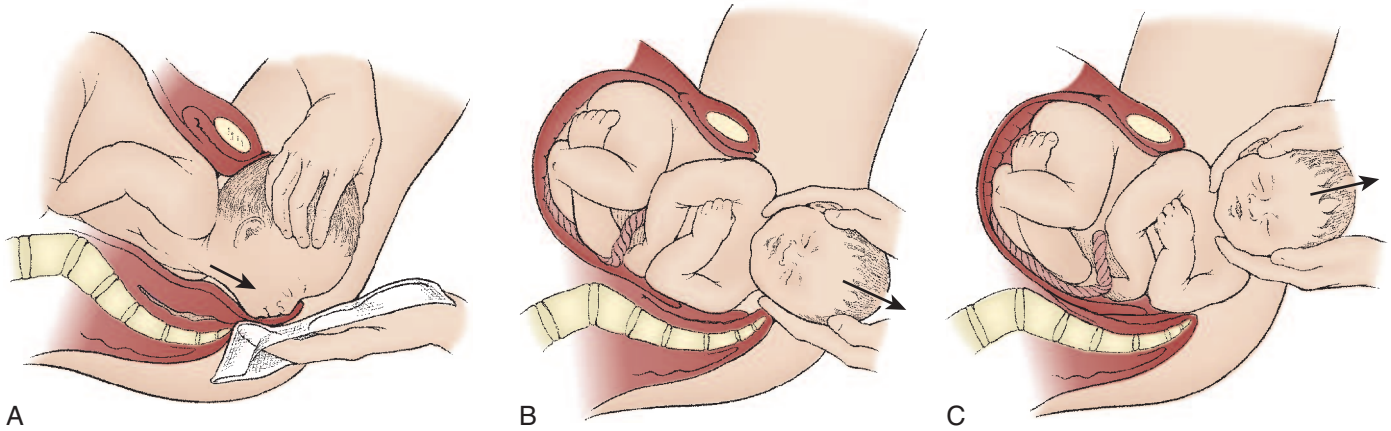

FIGURE 92-7 Management of vaginal vertex delivery. **A,** Control delivery of fetal head by upward pressure on the chin with countertraction on the occiput until the symphysis is cleared. **B,** Delivery of anterior shoulder by downward traction on the fetal head. **C,** Delivery of posterior shoulder by upward traction on the fetal head. *(Modified from Pritchard JA, MacDonald PC:* Williams obstetrics, *ed 16, New York,1980, Appleton Century Crofts.)*

the hand has been inserted, rotate the baby by applying pressure to the shoulder and scapula (Wood's maneuver). The corkscrew rotation will deliver the posterior shoulder as it turns anteriorly, the anterior shoulder will dislodge, and the baby can be delivered without further difficulty. If this rotational maneuver fails, the posterior arm is delivered by grasping it along the forearm and sweeping it across the chest and out the vagina. This technique may fracture the humerus or clavicle but may prevent infant death because of inability to complete a delivery. Once the posterior arm is out, the anterior shoulder can usually be displaced downward, or the baby can then be rotated, allowing completion of the delivery. This approach is preferable to intentionally fracturing the clavicle, which can be technically difficult and does not provide as much room for the delivery.

If the baby is in a vertex presentation but facing the symphysis (occiput posterior), the labor is often more prolonged and uncomfortable, particularly in the woman's lower back. The delivery is basically accomplished as described, except the final maneuvers to deliver the fetal head are extension first, then flexion. Perineal and introital trauma is a greater risk with an occiput posterior delivery. Management of this fetal presentation by the wilderness birth attendant should be a minor challenge compared with delivery of a breech baby.

Breech Delivery

Because most wilderness deliveries are "unexpected" and more likely to be premature, the baby will also more likely be in a breech lie (Figure 92-8). Other than chance and prematurity, the greatest risk factors for a baby to be in a breech presentation are unsuspected congenital fetal anomalies, chromosomal abnormalities, and maternal uterine abnormalities. Each of these adds a new level of challenge to the birth attendant. Under the best of circumstances, delivery of a breech versus a vertex presentation carries a threefold to fourfold greater risk for morbidity resulting from prematurity, congenital abnormalities, and trauma at delivery. Delivery trauma often results from the relatively larger fetal head and smaller body circumference of a premature infant. This disproportion can lead to head entrapment and is especially difficult when the fetal body has negotiated an incompletely dilated cervix.

Breech babies come in many forms: frank breech (hips flexed, knees extended, buttocks presenting), complete breech (both hips and both knees flexed, buttocks and feet presenting), incomplete breech (one hip flexed, one hip partially extended, knees flexed, buttocks and feet presenting), and footling breech (hips and knees extended, feet presenting). Regardless of the form, the approach in a wilderness setting demands patience. No effort should be made to deliver a breech baby until the presenting part is visible at the introitus and the cervix is completely dilated. Membranes should not be artificially ruptured in breech presentations. As the amniotic sac balloons into the birth canal, it helps to dilate the cervix completely. This facilitates descent of the baby through a lubricated smooth surface against which the body can freely move and cushions the umbilical cord against compression in the birth canal.

When the cervix is completely dilated, instruct the woman to push. Regardless of the type of breech presentation, the safest course is to allow the body to be extruded to at least the level of the umbilicus by maternal efforts alone. This increases the chance that the fetal head has begun to pass through the pelvic inlet. For a baby in a frank or complete breech lie, deliver the posterior leg by gently grasping the thigh and flexing the leg at the knee as it is rotated medially and toward the introitus. Rotate the baby to face the ground with the baby's back toward the

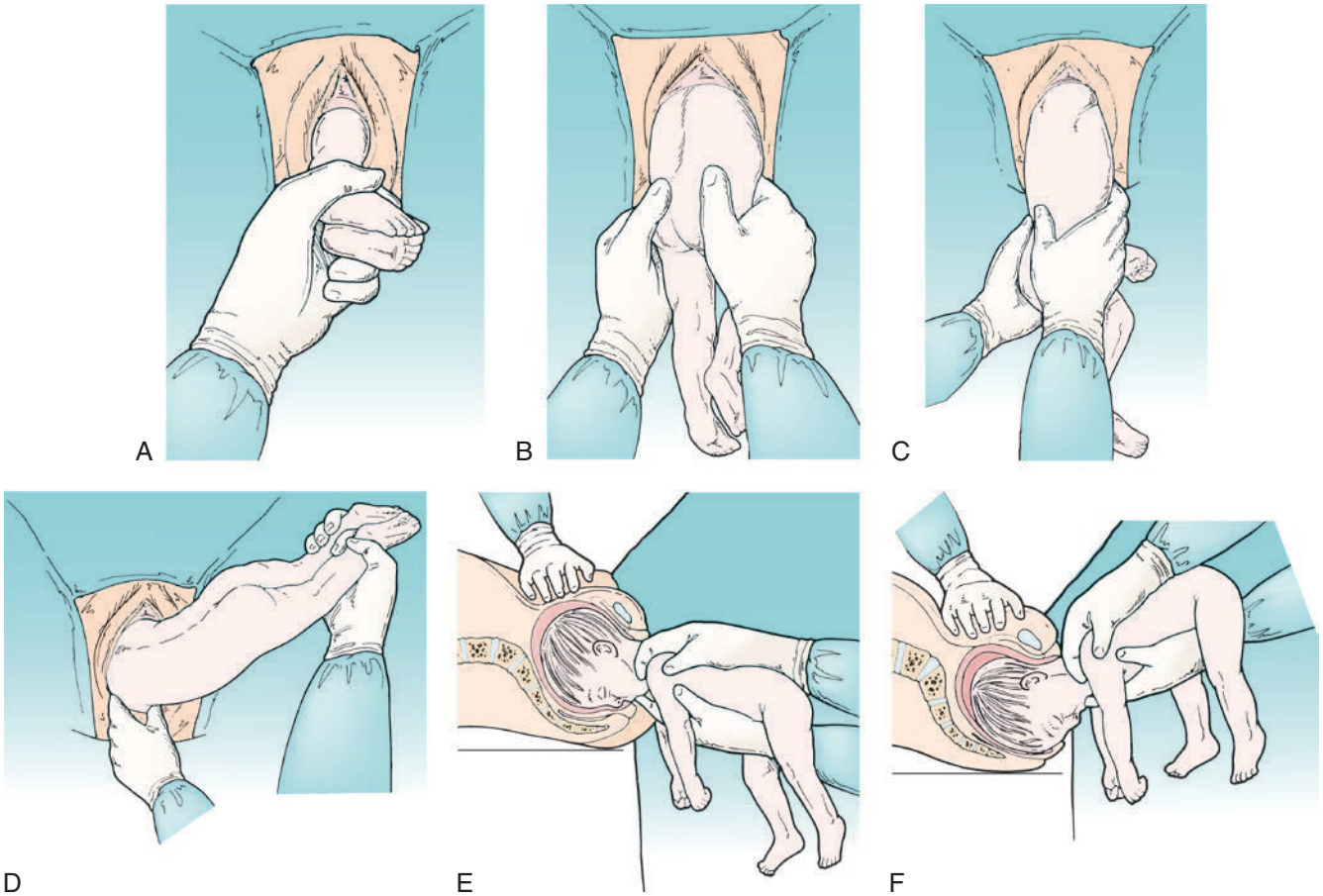

FIGURE 92-8 Management of vaginal breech delivery. **A,** Downward traction at ankles until buttocks clear the introitus. **B,** Traction on pelvic girdle until an axilla becomes visible. **C,** Delivery of posterior shoulder and arm. **D,** Delivery of anterior shoulder and arm with downward traction. **E,** Cradling baby on a forearm, a finger is inserted into mouth or against chin. **F,** Delivery completed by outward traction while maintaining fetal head in a flexed position. *(Modified from Pritchard JA, MacDonald PC:* Williams obstetrics, *ed 16, New York, 1980, Appleton Century Crofts.)*

sky. Rotate the baby another 45 degrees in the same direction to facilitate delivery of the other leg using the technique described for the first leg. Legs and buttocks can be wrapped in a clean towel to provide a firmer grip and decrease infant trauma. Subsequent delivery is the same as for a footling breech presentation. Grasp the upper legs on each side, with the index fingers crossing the infant's pelvic girdle and both thumbs positioned just above the crease of the buttocks. Use gentle side-to-side rotational motion over an arc of 90 degrees outward and downward, and apply traction while the mother pushes, until the upper portion of a scapula is visible at the introitus. With the baby's body rotated 45 degrees toward the opposite side, use flexion and medial rotation across the chest to deliver the arm. Rotate the baby to the opposite side in the same position, and deliver the other arm. If assistants are present, they should help the woman into the McRobert's position with hyperflexion at the hips to maximize space between the symphysis and sacrum.[75]

Maintaining the baby in the same plane as the vagina, the birth attendant reaches palm up between the baby's legs and into the vagina, supporting the baby's entire body on the forearm while placing the second and fourth fingers over the infant's maxillae and placing the middle finger into the mouth or on the chin. The other hand is positioned over the infant's upper back so that those fingers are overlying each shoulder. If there is sufficient room, the middle fingers can be applied to the fetal occiput. Then with the woman pushing, flex the baby's head downward and complete the delivery. Firm suprapubic pressure can help to maintain the head in flexion. During this final stage, do not elevate the baby's body more than 45 degrees above the plane of the vagina to avoid hyperextension of the head. If the fetal head cannot be delivered because the cervix is incompletely dilated, cut the cervix at the 2- and 10-o'clock positions (Dührssen's incisions) to provide sufficient room to complete the delivery. Once delivered, if the baby breathes and cries spontaneously or with minimal stimulation, delay cutting the umbilical cord while the baby is dried. This allows some of the blood retained in the placenta from umbilical vein compression (common with breech deliveries) to return to the baby. If infant response is limited, immediately clamp and cut the umbilical cord and start neonatal resuscitation.

NEONATAL RESUSCITATION

The first steps in neonatal resuscitation are to dry the baby thoroughly, keep the baby warm, and clear the nose and mouth of excess fluid. Assess the respiratory effort and heart rate (by auscultation or palpation at the base of the umbilical cord). If the baby is breathing spontaneously with a pulse greater than 100 beats/min, keep the baby warm and observe. If the pulse falls below 100 beats/min and the respiratory effort is poor, the next step is to improve ventilation. If further stimulation of the baby by rubbing with a towel or flicking the heels fails to elicit improvement in respiratory effort and pulse, the next step is to provide ventilatory support. This ideally is via application of positive-pressure ventilation with a neonatal mask and Ambu bag (preferably with oxygen). If available, perform gentle (15 to 30 cm H_2O) and rapid (40 to 60 breaths/min) ventilation for 30 seconds and then reassess heart rate. If no equipment is available, place the resuscitator's mouth over the infant's nose and mouth, and deliver rapid shallow breaths at a rate of 30 to 40 breaths/min. If this restores the heart rate and respiratory effort, observe the baby for deterioration in status and repeat the maneuvers as necessary until support is available.[28]

If the baby's heart rate falls below 60 beats/min, full infant cardiopulmonary resuscitation (CPR) should be started. Cardiac compression is performed by (1) placing both thumbs on the sternum just above the xiphoid and facing the fetal head, (2) gently stabilizing this position with the other fingers around the chest, and (3) supplying compressions to a depth of 0.5 to 0.75 inches (1.2 to 1.9 cm) at a rate of about 90 per minute. Care should be taken not to deliver compression to the baby's ribs. Continue ventilation simultaneously as described. If the heart rate after 30 seconds of chest compressions is 80 to 100 beats/min, continue the resuscitation with ventilatory support only. If the heart rate is more than 100 beats/min, discontinue CPR and observe. If the heart rate is still less than 80 beats/min, continue CPR. See the latest neonatal and pediatric resuscitation guidelines from the American Heart Association and American Academy of Pediatrics (aap.org/nrp/) or the World Health Organization.

DELIVERY OF PLACENTA

After the baby is delivered and stabilized, redirect attention to the mother. The first step is to assess the status of placental separation. The heel of the nondominant hand is placed just above the symphysis to hold the uterus in position, and then the fingers are cupped to apply pressure to the uterine fundus while providing gentle, steady downward traction on the umbilical cord. If this maneuver does not promote placental separation, as indicated by a gush of bleeding, lengthening of the cord, and descent of the placenta into the vagina, interrupt these efforts until these signs ensue. When the placenta does descend, instruct the mother to once again push to complete the third stage of labor. By rotating the placenta several times once it has passed through the introitus, complete extrusion of the attached chorioamnionic membranes usually results. If there are signs of placental separation but resistance to extraction, place a hand in the vagina and into the cervix. If the placenta is filling the cervix, it should be grasped and gently extracted. If the placenta does not separate spontaneously or is adherent to the uterine wall (placenta accreta), no effort should be made to separate it manually in a wilderness setting because this could precipitate uncontrollable hemorrhage.[111] Excessive traction on the umbilical cord also could result in uterine inversion, causing vasomotor collapse and hemodynamic decompensation.[12,18]

Once placental expulsion has occurred, gently massage the uterus through the abdominal wall to promote contraction and involution. Usually this is sufficient to control hemorrhage from the placental bed. If this is ineffective, it may be necessary to explore the uterus manually for a retained placenta while compressing the fundus externally until it contracts. Additional measures to aid uterine involution and control bleeding include nipple massage to promote endogenous release of oxytocin and one of the following: administration of oxytocin (10 units/mL intramuscularly); methylergonovine, an ergot derivative (0.2 mg intramuscularly or orally every 2 to 4 hours); prostaglandin F_2 carboprost tromethamine (250 mcg intramuscularly); or misoprostol. The optimal dose and route of administration of misoprostol are unclear. Doses of 200 to 1000 mcg have been administered via oral, sublingual, and rectal routes, or using a combination of routes. If none of these measures is successful, and if bleeding from a laceration has been eliminated as a source, the uterus can be packed with clean sponges or towels until additional medical assistance arrives.[12] Use of a reusable intrauterine balloon tamponade device consisting of a condom-covered Foley catheter attached to a syringe has been associated with marked decreases in maternal death from postpartum bleeding in austere environments.[163] Once the placenta is removed and uterine bleeding controlled, assess and repair maternal injury. The most common sites of lacerations are the perineum, periurethral tissues surrounding the external meatus, lower vagina, and cervix. Significant cervical lacerations in unhurried deliveries are rare unless uncontrollable pushing has occurred before complete dilation. Other lacerations from a spontaneous delivery usually occur along tissue planes that do not disrupt vital areas. They will heal naturally or can be repaired later. Significant bleeding at any of these sites can usually be easily controlled by direct pressure. If available, application of ice packs to the perineum for the first 12 to 24 hours after delivery provides relief.

RESOURCES FOR OBSTETRICS IN REMOTE SETTINGS

Médecins Sans Frontières has published a downloadable manual on "Obstetrics in Remote Settings." This manual is intended for nonobstetricians working in remote settings where medical resources are lacking and reviews much of the information described above related to pregnancy, delivery in remote situations, possible complications, infant resuscitation, and postpartum care. It has excellent diagrams for persons interested in

more details (http://refbooks.msf.org/msf_docs/en/obstetrics/obstetrics_en.pdf).

Goals are to protect the mother's life, limit the functional sequelae of pregnancy, and deliver the child in the best possible condition. The manual is not meant to teach advanced diagnosis and management, but to present basic concepts most likely to assist those practicing in difficult conditions. For the wilderness provider, the manual is a good review of warning signs to consider during pregnancy, delivery, and postpartum periods.

BREASTFEEDING

Unless the baby is too premature or too unstable to nurse, breastfeeding should be encouraged as soon as possible after birth. Benefits include promotion of uterine contractions that control hemorrhage at the placental insertion site; encouragement of maternal-newborn bonding; provision of safe, easily digestible, and balanced nutritional support for the baby; and transmission of antibodies (immunoglobulin A) that protect the enteric mucosa against invasion by colonizing bacteria.[9]

During the first 24 hours after delivery, frequent brief feedings (every 2 to 3 hours; 5 minutes on each breast, alternating first breast) are recommended. Although only a small amount of breast fluid (colostrum) is present initially, it contains electrolytes, minerals, and a high concentration of protein and protective immunoglobulin A antibodies. Increase the length of time spent breastfeeding and the intervals between feedings as milk production is established over the next 2 to 3 days. Feeding schedules are typically 10- to 15-minute periods on each breast 8 to 12 times per day. It should be made clear to the mother that babies are not restricted to this regimen.

Instruct breastfeeding women to drink plenty of fluids (2 L/day); increase their caloric intake by 500 to 600 kcal/day, including a total protein intake of 60 to 70 g/day; and consume foods rich in calcium (1200 mg/day).

Breastfeeding Practicalities

Several conditions can interfere with breastfeeding or cause maternal frustration. Breast engorgement 48 to 72 hours after delivery, signifying the onset of milk production accompanied by lymphatic obstruction, can cause pain and low-grade fever, interfere with the baby latching on, and inhibit milk letdown. Frequent feedings and warm compresses just before nursing help to stimulate milk letdown. Cool compresses after nursing, a supportive nursing bra, and acetaminophen usually provide symptomatic relief until milk production and newborn consumption are in equilibrium and lymphatic obstruction is resolving. Engorgement usually resolves within 24 to 48 hours.

Sore and cracked nipples are a frequent complaint of women nursing for the first time. Short, frequent feedings with several rotations between breasts at each sitting can be beneficial. After each feeding, gently cleanse with water and apply a small amount of milk expressed from the breast and spread around the areola to dry to help protect the nipples. Lanolin formulations designed for breastfeeding women can be used as well. Place dry absorbent nursing pads over the nipples between feedings. If contact with clothing or even the nursing pads creates discomfort, breast shells can be used to prevent surface contact. Occasionally, nipple shields can be beneficial for the mother, as well as for the infant who has difficulty latching onto the breast.

Mastitis occurs in 2% to 3% of lactating women and should not be confused with breast engorgement. Mastitis rarely occurs until at least 3 to 4 weeks postpartum.[145] Unlike breast engorgement, mastitis is usually unilateral and accompanied by localized pain, erythema, brawny edema, fever, and malaise. It is more common among women who report painful and cracked nipples and who participate in vigorous exercise- and work-related upper body activities. Encourage these women to empty their breasts by nursing or pumping before these activities and to wear a properly fitting and supportive bra as preventive measures. Women who develop mastitis should continue to nurse from the affected breast and may benefit from warm compresses and pumping between nursing. They should be placed on a course of antibiotics (e.g., dicloxacillin 500 mg or cephalexin 500 mg four times daily) for 10 to 14 days, with coverage for *Staphylococcus* and *Streptococcus* species and *Escherichia coli,* the most common bacterial isolates from affected breasts. Failure to improve or worsening while on this regimen, as determined by consolidation, widening of erythema and induration, and abscess formation, occurs in 10% to 15% of women. Incision and drainage may be required.[145] Consider treatment for antibiotic-resistant organisms (e.g., methicillin-resistant *Staphylococcus aureus*).

For the breastfeeding mother who is traveling without her infant, a breast pump can be used to maintain milk production and prevent engorgement and mastitis. Manual, battery-powered, and electric breast pumps are available.[67]

Medications During Breastfeeding

Physicians treating breastfeeding mothers should have access to relevant and accurate sources providing data on medication safety during pregnancy and breastfeeding.[53,67,93]

Useful References on Medication During Breastfeeding

The Committee on Drugs of the American Academy of Pediatrics publishes a list of drugs and chemicals transferred into human milk. The list is updated on a regular basis. The statement may be found online at aap.org. *Medications and Mother's Milk*, by Thomas Hale, is an excellent reference that provides an alphabetical list of medications with references at the end of each review.[101] This source calculates a theoretical infant dose of medication that a breastfed infant might receive. An article entitled "Breastfeeding Travelers: Precautions and Recommendations" is also an excellent review on this topic.[67]

Because no randomized controlled trials exist on the safety of medications during lactation, any medication given to a lactating woman should be carefully considered. Most routinely prescribed drugs are safe to use during lactation. Short-acting drugs administered after a feeding have the least opportunity to be excreted into milk. Few drugs are absolutely contraindicated while breastfeeding. With important exceptions, most categories of medications are safe for mothers to take without discontinuing breastfeeding. Most medications have no effect on the milk supply or on infant health (see Table 92-6). Lactating mothers may safely receive nearly all vaccinations because most strains of live viral vaccines are not known to be transmitted in breast milk. The exceptions are attenuated rubella virus and YF vaccines. Infants are usually not infected by the vaccine strain of rubella. There are reports that women who are vaccinated for YF and then breastfeed an infant may increase the risk of neurologic disease in the infant, as discussed earlier.[58]

WILDERNESS HEALTH ISSUES FOR WOMEN OVER 50 YEARS OF AGE

Women are traveling to remote areas of the world at all stages of life. One of the fastest-growing subgroups in adventure travel is made up of older adventuresses, or women over 50 years of age. Older women may begin to have more personal freedom as their children leave home, as relationships change through death or divorce, and/or as there may be more flexibility in their professional lives as they acquire seniority and more financial stability. The oldest traveler to contact the CDC traveler's health team was 99 years old. There are many reasons to push physical and emotional boundaries, including planning a trip as escape from an intense professional or personal life, recovering from an illness, learning a new sport (e.g., mountain climbing or kayaking), volunteering their skills, or further exploring of the world. For a woman recovering from breast cancer or a personal loss, the ability to summit a mountain or to participate in another new arena of exploration can build confidence and self-esteem. The opportunity to travel with partners or friends, with their adult children, or "solo" for the first time, is empowering. A wealth of data support the benefits of physical and intellectual activity and exploration to prevent and ameliorate disease as a person ages.[136,174] Chapter 93 addresses the topic of elder wilderness travelers. Box 92-9 is a useful checklist for older female explorers to consider.

BOX 92-9 Checklist for the Older Adventurers

- Review itinerary
- Review past medical history and medications carefully
- Address concerns related to medical history and plan preventive measures as indicated
- Immunizations
  - Risk versus benefit
  - Issues related to immunogenicity of vaccines in the older adult
- Chemoprophylaxis
- Environmental
  - Heat, cold, performance data in the older individuals
- Menopausal issues
  - Estrogen replacement therapy
  - Osteoporosis prevention
  - Incontinence, urinary tract infection, constipation, other
- Sexually transmitted infection prevention
- Medical kit
- Safety and security issues
- Pre–wilderness travel evaluation: electrocardiogram, mammogram, Pap smear
- Medical and evacuation insurance

Twenty years from now you will be more disappointed by the things that you didn't do than by the ones you did do. So throw off the bowlines. Sail away from the safe harbor. Catch the trade winds in your sails. Explore. Dream. Discover.
Mark Twain

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Complete references used in this text are available online at expertconsult.inkling.com.

CHAPTER 93

Older Adults in the Wilderness

CHRISTOPHER R. CARPENTER AND NOUSHAFARIN TALEGHANI

DEFINITION OF OLDER ADULT

Despite rapid advances in understanding the molecular and physiologic attributes of aging, no consensus exists on when a person becomes "old." Every person ages chronologically, but the phenotypic expression of biologic aging is highly variable between persons. Individuals routinely defy preconceptions of aging by appearing younger or older than their chronologic age. Aging is associated with a measurable physiologic decline in most organ systems, however (Table 93-1). The key concept is that exacerbations of chronic illnesses, which increase with aging, are the main risk for the elderly wilderness adventurer, not age alone.[31] One recommendation is to classify people according to chronologic age: (1) *athletic old* (younger than 55 years), (2) *young old* (55 to 75 years of age), and (3) *old old* (older than 75 years of age).[131] By focusing only on chronologic age, however, one fails to recognize the nonuniform functional changes that take place during the passage of years or the residual effects of remote illnesses and injuries. A more accurate and comprehensive classification system consisting of three separate components is preferred: (1) *chronologic,* describing a simple time-based classification of years; (2) *pathologic,* describing morphologic and anatomic changes associated with disease or degenerative processes; and (3) *functional,* describing changes in function resulting from impairment.

The functional classification of individuals is based on an idealized bell-shaped distribution curve that places participants in one of five categories labeled alphabetically: (A) high-performance persons, (B) healthy vigorous persons, (C) healthy deconditioned persons, (D) persons with risk factors, and (E) persons who are manifestly ill. Specific aerobic capacity, defined as the maximal physical work capacity, can be derived from graded exercise testing. Other specific functional characteristics can be determined from testing physical modalities in a human performance laboratory, cardiac rehabilitation center, or physical or occupational therapy unit. This classification is useful for matching an individual with various wilderness activities according to physical and environmental demands.

Individuals who plan to participate in wilderness ventures probably have already been through a form of natural selection. For example, a person who aspires to participate in an expedition to Mt Everest will probably have already participated in a similar activity and will have proved his or her capacity to function at an extreme level of performance. This person would most likely be in participant group A or B. An individual who is healthy but has not recently been involved in vigorous activities and become "deconditioned" may be in group C. The motivation may be a desire to reaffirm youth or vigor in some form of exciting or hazardous activity. These individuals deserve the scrutiny of alert organizers, with perhaps an assessment before the venture in order to consider risk factors or occult health problems.

Particular attention should be directed toward any individual at risk of illness or injury (group D), even though manifested evidence of disease may not be apparent. For example, cardiovascular risk factors identified upon interview and examination, such as smoking, a fat-laden diet, and high blood pressure, may warrant a detailed medical examination to determine the level of functional capacity considered safe for that individual. An examination may disclose the presence of diseases, asymptomatic or symptomatic. Group E includes persons with definite manifestations of illness. Supervised outdoor activities can still be of value for such persons and have on occasion been used as a form of physical therapy and rehabilitation for persons with various illnesses, including cardiovascular disease. Persons in this category should be treated as individuals for their assessment and require a high degree of medical evaluation and supervision.

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TABLE 93-1 Age-Related Biologic Changes and Their Functional Consequences

Organ System	Age-Related Anatomic Changes	Age-Related Physiologic Changes	Age-Related Functional Consequences
General	Decreased organ and muscle mass	Decreased organ function; decreased oxygen consumption	Decreased flexibility, endurance, and maximal performance
Cardiovascular	Fibrosis of arterial media; thickening of arterial intima; sclerosis of arterial valves (especially aortic and mitral); elongation and tortuosity of aorta	Decreased maximal heart rate of 6-10 beats/min per decade; decreased β-adrenergic responses; increased left ventricular ejection fraction; decreased arterial compliance	Decreased cardiac output of 20% to 30% by age 70 years; decreased maximal physical work capacity; orthostatic hypotension; decreased endurance; syncope; shortness of breath
Lungs	Decreased lung elasticity; decreased activity of cilia; reduced cough reflex	Decreased vital capacity of approximately 30 mL/yr after age 30 years; microaspiration	Shortness of breath; cough; aspiration pneumonia
Kidneys	Increased number of abnormal glomeruli	Decreased glomerular filtration rate; decreased renal blood flow; decreased urine concentration; compensatory reduction in muscle mass, neutralizing creatinine elevation; proteinuria	Delayed response to salt or fluid restriction; nocturia
Genitourinary	Prostatic enlargement; vaginal/urethral mucosal atrophy	Urinary retention (increased residual volume); bacteriuria; atrophic vaginitis	Nocturia; tenesmus; incontinence; urinary tract infection
Gastrointestinal	Atrophic mucosa; atrophic taste buds; anorectal incompetence	Decreased salivary flow; decreased gastric hydrochloric acid; decreased hepatic function; decreased motility	Regurgitation with aspiration; food intolerances; constipation; incontinence; modified appetite, food intake, and motility
Hematologic/immune	Bone marrow fibrosis; metaplasia	Decreased bone marrow reserve; decreased T-cell function; antibody dysfunction	False-negative immunologic skin tests; false-positive laboratory immune tests (e.g., rheumatoid factor and antinuclear antibody)
Musculoskeletal	Decreased height, weight, lean body mass, muscle, and bone density; sarcopenia	Loss of skeletal calcium; reduced elasticity in connective tissue; decreased viscosity of synovial fluid	Loss of cartilaginous surfaces; hypertrophic changes in joints; increased ratio of fat to muscle mass; osteoporosis; failure to thrive; loss of muscle mass and strength of 20% by age 65 years
Endocrine	Osteoporosis; vertebral collapse; changes in fluid volumes	Altered glucose homeostasis; decreased thyroid and testosterone hormone, renin, aldosterone production, and vitamin D absorption; increased antidiuretic hormone	Hyperglycemic response to stress; diabetes mellitus; hyponatremia; hyperkalemia; osteopenia; osteoporosis; impotence
Nervous	Reduced brain mass; decreased cortical cell count	Decreased brain catechol and dopamine synthesis; impaired thermal regulation	Decreased nerve conduction; impaired cerebral and cognitive functions; dementia; depression; forgetfulness; sleep changes; loss of agility; impaired balance; falls; hypothermia, hyperthermia; sensory impairment, including taste, smell, vision, hearing, and touch
Eyes	Decreased translucency of lens; decreased size of pupil; increased intraocular pressure; macular degeneration; arcus senilis	Decreased accommodation; need for increased illumination; susceptibility to glare	Decreased vision, including color and night vision; impaired accommodation; presbyopia
Ears	Loss of auditory neurons; atrophy of cochlear hair cells	Decreased hearing, especially tones higher than 2000 Hz; decreased directional discrimination; vestibular dysfunction	Loss of hearing; loss of click pitch hearing and constant discrimination; balance impairment with falls
Skin	Flattening, atrophy, and attenuation in dermal collagen, rete pegs, and cytoplasm of basal keratinocytes	Decreased skin thickness; risk for dermoepidermal separation; loss of elasticity	Decreased resistance to tearing

WHY AND HOW SOME OLDER ADULTS VENTURE INTO THE WILDERNESS

In addition to an unprecedented post–World War II population explosion, 20th century advances in medical science and hygiene dramatically altered the age composition of the persons who make up Western civilization. In 1900 the median age in the United States was 23 years, increasing to 30 years in 1950, 33 years in 1990, and 36 years in 2000. Senior citizens over age 65 years in the United States increased from 35 million (12.4% of the general population) in the year 2000 to 71 million (19.6%) in 2030. The "old-old" represent the fastest-growing segment of society; octogenarians numbered 9.3 million (3.3%) in 2000 and will reach 19.5 million (5.4%) by 2030.[24]

Many aging adults adopt active and adventurous lifestyles and activities, using time and disposable income that were not available when they were younger. For example, the number of adults over age 50 who reported mountaineering accidents increased five-fold between 1980 and 2010, during a period when the overall population of that age group increased from 26% to 32%.[113] Wilderness fatalities in older adults have been reported in diverse outdoor activities ranging from caving[134] to hiking.[45] Personal reasons given by elders for venturing into the wilderness are enjoyment of nature, physical fitness, tension reduction, tranquility and solitude away from noise and crowds, experiences with friends, enhancement of skill and competency, and excitement or even the thrill of risk-taking.[107]

For elders, the physical and environmental demands of certain activities may be excessive. The physical workload of a wilderness venture depends on its nature and characteristics of its component parts. For example, is the venture a walk or a climb? What is the nature of the terrain? What is the altitude? What is the ambient temperature? It is prudent for elders to examine plans for prospective wilderness ventures and to select activities consistent with their personal capacity, skill, and tolerance. Wilderness activities can be classified according to their physical, technical, and environmental characteristics. The skill, judgment, and capacity of all participants, elders included, can be matched with the characteristics of the venture to determine whether individual capacity is adequate for the demands.

CLASSIFYING "FITNESS FOR ADVENTURE" BY AGE, HEALTH, AND FUNCTIONAL STATUS

Active older adults seeking wilderness adventures generally are more fit, vigorous, and health conscious than the general population. Not surprisingly, wilderness medicine research implies that older adults exposed to environmental challenges are often at less risk (or at least not at increased risk) in high-altitude situations[68,98,119,124] and tropical regions.[127] However, some older adults are at medical risk when exposed to new environmental challenges. Classifying wilderness ventures according to demands required by the activity is helpful. A useful classification includes (1) extreme-performance ventures, (2) high-performance ventures, (3) recreational activities, and (4) therapeutic activities (Table 93-2). The physiologic attributes of the elderly adventurer can be qualitatively categorized (Table 93-3). In conjunction with the activity classification and objective assessment of underlying disease and physiologic capacity learned via the history and physical examination (Box 93-1), experts can categorize the individual adventurer risk prior to wilderness exposure (Table 93-4).

As an example of this classification scheme, a 58-year-old who has coronary artery disease and angina with a stent in place is symptomatic during a graded exercise test. This individual would be functionally classified as

Chronologic: 58 years of age
Pathologic: stented coronary artery disease
Functional: symptomatic (angina) 6 metabolic equivalent of task (6-MET) maximal physical work capacity

This person is manifestly ill and is considered class E. Such pre–wilderness exposure classifications by clinicians provide a basis for recommendations about the risk of extreme environment exposure and optimal management of underlying medical conditions. Clinicians experienced in wilderness medicine and travel medicine can use this classification scheme in conjunction with an individual patient's preferences, goals of care, and anticipated destinations to provide efficient preexposure preventive planning, advice, and prescribing (Box 93-2).

ENVIRONMENTAL STRESSES AND OLDER ADULTS

Environmental variables encountered in the great diversity of outdoor wilderness activities may produce significant physiologic stresses. These variables include extremes of heat and cold, high altitude, water immersion, tropical humidity, desert aridity, and ultraviolet exposure. The common denominator in nearly all wilderness ventures is physical activity, often at extreme levels. To compound the complexity of physical activity influenced by environmental stress, the physician may care for a senior afflicted with subclinical or manifesting disease. When the physiologic demands from environmental stresses are added to the increased and prevalent degenerative conditions and diseases associated

TABLE 93-2 Classification of Wilderness Ventures

Class	General Description	Examples
1	Extreme-performance ventures	High-altitude mountaineering, such as a Mt Everest climb or other Himalayan trekking
2	High-performance ventures	Remote hunting activities, particularly at high altitude or under stresses of heat, dust, or cold Jungle trekking
3	Recreational activities	Trail walking is generally considered recreational, but because of endurance demands and environmental risks, it may present physiologic hazards Other activities that may fit this classification: Alpine hiking National park trail walking Forest-based orienteering
4	Therapeutic activities	For more than a century, physical activity has been recommended for certain individuals with cardiovascular disease and other physical limitations to improve their functional capacity

TABLE 93-3 Classification of Participants in Wilderness Ventures

Group	General Description	Examples
A	Individuals with demonstrated ability to engage in high-performance activities	Athletes in training Mountaineers continually active and in training Workers involved with heavy physical tasks
B	Healthy, vigorous individuals	Athletes Active hunting guides
C	Healthy, deconditioned individuals	Young to middle-aged, healthy business and professional people who are moderately active
D	Individuals with risk factors	Individuals at risk because of age, lifestyle, smoking, excessive alcohol consumption, or factors not under their control; most elders are in this group
E	Individuals who are manifestly ill	People at any age with chronic illness or physical limitations, such as heart disease, diabetes, or neuromuscular or orthopedic problems

BOX 93-1 Components of the Medical Examination

1. **Personal characteristics,** which provide a profile of the subject regarding age; gender; education; occupation; status as volunteer or recruit; history of a recent or remote similar venture; use of tobacco, alcohol, drugs, or steroids; history of psychological or interpersonal problems, especially during wilderness ventures; and history of participation in athletics.
2. **Historical features,** such as illness, with particular emphasis on cardiovascular, pulmonary, musculoskeletal, and neurologic problems; problems associated with a previous venture; intolerance to altitude, heat, or cold; psychological problems; accidents; and pertinent family history.
3. **Medical examination,** including examination of heart rate, blood pressure, precise cardiac examination (including auscultation); examination of peripheral pulses and carotid arteries; auscultation of the chest; abdominal palpation with rectal examination; musculoskeletal system with range of motion of joints and back; and height and weight.
4. **Physiologic examination,** which is only rarely required, depends largely on the nature of the venture and may range from simple simulation of the planned activity to functional aerobic testing for $\dot{V}O_{2max}$ using a treadmill, cycle, or step ergometry. Functional testing with electrocardiographic monitoring is frequently used for diagnostic testing and for predicting cardiovascular response to exercise. Testing by running for speed or endurance and evaluation of dynamic strength and agility are rarely used but are interesting during skill assessment. Testing for hypoxic ventilatory response may be primarily of research interest but nonetheless should be considered if precision is needed for elders going to high altitude.
5. **Psychological interviews** largely depend on the skill and technique of the examiner and should attempt to uncover a history of previous difficulties with group interaction and team activities, or fears related to physical and environmental stress.

BOX 93-2 Older Adult Checklist Prior to and During Wilderness Exposure

- Seek medical advice before trip and avoid travel if unstable medical condition exists
- Obtain requisite age-appropriate immunizations for regions traveled
- Exercise months before major trips to ensure physical fitness for potentially harsh environmental exposures
- For remote locales, purchase travel insurance
- Do research on airline travel restrictions on medications and medical devices; request necessary documentation from physician
- Consult physician or pharmacist regarding regular medications and:
  - Potential interactions with medications used to treat travel-related infectious illnesses or high-altitude sickness
  - Respiratory depressant effects
  - Medication effects on cognition, acclimatization, thermoregulation, and exercise tolerance.
  - Appropriate storage of medications
  - Review time zone changes and medication schedule
- Bring extra doses of medications and carry emergency supply separate from main travel equipment; travel with companions who you inform of existing medical conditions and the location of key medications and medical equipment
- Permit time for acclimatization to temperature and altitude
- Schedule time for nutrition and hydration
- Wear MedicAlert bracelet at all times

with aging, the risk for illness and injury is increased. The complete package of age, conditioning, environment, nature of the activity, and experience must be considered when an elder is advised or treated in the wilderness.

ALTITUDE

Increasing personal wealth and renewed interest in outdoor activities have led increasing numbers of adventurers of all ages to explore mountain climbing, trekking, and skiing. In 1999 an estimated 100 million tourists worldwide visited high altitudes, 15% of whom were over age 60 years.[16] Increasing altitudes decrease atmospheric pressure and the partial pressure of oxygen such that at 5500 m (18,000 feet) of altitude, atmospheric pressure is half that of sea level. Although the elderly demonstrate reduced ventilatory and heart rate responses compared with younger individuals,[81] the respiratory system adapts within 2 days, and the heart rate and metabolic responses adapt within 1 week.[16] The hypoxic ventilatory response is an essential defense mechanism against high-altitude hypoxia; dopamine is the neurotransmitter responsible for the carotid body chemoreceptor response to hypoxia. Older adults demonstrate decreased dopamine receptor sensitivity during short-term adaptation to altitude.[126]

Exposures to the relative hypoxia of high altitude are a risk in all age groups for high-altitude pulmonary edema (HAPE) and high-altitude cerebral edema (HACE), discussed more fully in Chapters 1, 2, and 3.[60,108] Aging reduces physiologic components of the gas exchange process that maintain oxygenation, such as

TABLE 93-4 Construction of the Medical Examination of Prospective Participants in Wilderness Ventures

Classification of Characteristics of Participants	Classification of Venture			
	1. Extreme Performance	2. High Performance	3. Recreational	4. Therapeutic
A. Demonstrated high performance	2, 3, **5***	2, 3, **5**	2	†
B. Healthy, vigorous	2, 3, 4, **5**	2, 3, **5**	**2**	**2**
C. Healthy, "deconditioned"	1, 2, 3, **4, 5**	2, 3, **4, 5**	2, **4**	2, **3, 4**
D. Risk factors	1, 2, **3, 4, 5**	1, 2, **3, 4, 5**	2, **3, 4,** 5	2, **3, 4, 5**
E. Illness	†	†	1, 2, **3, 4, 5**	1, 2, **3, 4,** 5

Category of components (from Box 93-1):
1. Personal data
2. Historical data
3. Medical findings
4. Physiologic assessment
5. Psychological evaluation

*A reason for classifying wilderness ventures and participants is to help design an examination that assesses the most important data, depending on the physical status of the individual and the nature of the venture. All categories listed in Box 93-1 should be considered in the examination, but those shown here in **bold** numbers are of prime importance and should be emphasized.
†Individualized assessment indicated.
Data from Decentennial state population changes by age, Stat Bull Metrop Insur Co 73:30, 1992; and Erb BD: Determining medical suitability for wilderness ventures. In Domej W, Schobersberger W, Waanders R, Berghold F, editors: Jahrbuch 2005, Innsbruck, Austria, 2005, Austrian Society for Alpine and High Altitude Medicine.

vital capacity and hypoxic ventilatory drive.[60] Older persons are known to have a lower arterial partial pressure of oxygen (Po_2) because of thickening of the pulmonary alveolar-capillary membrane.[81] The risk for altitude sickness among elders is increased by a poor physical condition, alcohol intake, preexisting pulmonary disease, medication, and excessive activity within the first 12 hours after arriving at altitude. Alcohol tolerance is variable, so total abstinence during a wilderness venture is recommended. It is prudent to avoid sedatives and hypnotics at high altitude.

The physical manifestations and optimal management of HAPE and HACE in older adults are not clearly understood. This is in part because older adults are often excluded from altitude studies that include younger, more vigorous subjects. For example, studies evaluating the sharpened Romberg test as a screen for acute mountain sickness extended only to age 65 years,[76] and randomized trials of ibuprofen[53,91] and acetazolamide[12] excluded older adults. However, as summarized below, most high-altitude illness studies suggest that older adults are not at increased risk for HAPE or HACE.[68,98,119,124]

Honigman studied the general population at moderate altitude (2000 to 3000 m [6500 to 9750 feet]) at ski resorts in Colorado. Predictors of mountain sickness included chronic residence at an altitude greater than 1000 m (3250 feet) before a high-altitude venture, underlying lung problems, previous history of acute mountain sickness ($p < 0.05$), and, surprisingly, age younger than 60 years.[68] One hypothesis for identification of older age as a protective factor against mountain sickness is self-selection among the small group of elderly individuals who are exposed to altitude and activity; wilderness medicine enthusiasts likely represent a healthier subset of all older adults. Another possibility is that elders require more time to ascend and thus are more diligent with regard to acclimatization.

Roach and colleagues studied 97 older men and women (ages 59 to 83 years) over a 5-day period in Vail, Colorado at a moderate elevation of 2500 m (8200 feet). They concluded that it was generally safe for older men and women with underlying, asymptomatic cardiovascular and lung disease to make short sojourns to moderate altitudes. In particular, they suggested that hypertension was not a contraindication for travel to moderate altitudes, although blood pressure should be closely monitored and antihypertensive medication continued as prescribed. Of note, their subjects had a short stopover at a lower altitude, and the authors acknowledge that selection bias may have played a role in this particular study.[119]

Although older adults do not appear to be at increased risk for illness related to high altitude, they are more likely to require emergency evacuation when it occurs.[83] Therefore, prior to embarking on wilderness adventures with high-altitude exposures, prudent and specific considerations for individuals with preexisting pulmonary,[94,4] cardiovascular,[4] neurologic,[7] ocular,[96] endocrine,[15] and other conditions[102] are required. For example, safety of high-altitude trekking in high-functioning, physically fit individuals after coronary artery bypass surgery has been the subject of debate, without any clear consensus.[8,50,70,118] In fact, in the 1930s, hypobarism was used as a stress test to diagnose occult coronary artery disease.[86] The question for the physician screening an asymptomatic individual prior to high-altitude exposure must therefore be to accurately label the patient's cardiovascular status (and coronary circulation) as "normal." An electrocardiogram alone has a positive predictive value of 0.0001% for such individuals and should not be the sole marker of a "normal heart"; instead, preventive prealtitude cardiac screening should include a careful history of the usual activity level, symptoms with this activity, and education about appropriate ascent rates and acclimatization.[84,118]

The cerebral effects of high altitude include headache, acute mountain sickness, cerebral edema, and cerebral vasospasm. This last effect may manifest as transient ischemic attacks or transient global amnesia.[139] High-altitude exposure may impair memory, perception, cognitive flexibility, and psychomotor responsiveness, which can lead to poor decision making and preventable tragedies in patients.[120] These effects are magnified by fragmented sleep.[137] Disorientation and confusion related to HACE are not uncommon in younger populations initially exposed to high altitude[6]; 33% of acutely ill community-dwelling older adults (albeit not those who trek mountains) frequently demonstrate cognitive impairment if formally tested.[20] Therefore, as noted later in this chapter, it is important to have a sea-level objective cognitive baseline test for comparison when symptoms arise at high altitude.[65] Altered mental status in older adults can also occur on descent, as reported in the case of an experienced 85-year-old mountaineer with thiazide-related hyponatremia and hyperactive delirium.[29]

Acetazolamide is the drug of choice for prophylaxis against periodic breathing[61] and acute mountain sickness. When prescribing for the elderly, drug-drug and drug-disease interactions are important to consider (Table 93-5).[95,108] Elders may experience side effects, such as weakness, nausea, and paresthesias, with large doses of acetazolamide; therefore, caution is encouraged. In addition, acetazolamide compromises exercise capacity during early acclimatization in older persons.[12] Characteristics of elders who are vulnerable to altitude illness are listed in Box 93-3. Age-appropriate preventive measures for high-altitude illness are suggested in Box 93-4.

COLD

Cold exposure (discussed more fully in Chapters 7 to 11) is poorly tolerated in older adults. Unfortunately, the Wilderness Medical Society practice guidelines for hypothermia and frostbite do not evaluate age-related risk factors for cold injuries.[100,143] The complex mechanisms that control body temperatures in elders are not as responsive as in younger people due to age-related changes in multiple organ systems, as well as the effects of certain medications (Box 93-5).[30] Research suggests that age may not influence thermosensitivity upon immersion into cold water.[54] With aging, the metabolic rate is diminished. When associated with age-related reduction in muscle mass, the shivering response is blunted and there is reduced capacity for heat generation. In addition, the peripheral vasoconstrictive response to cold is diminished. Systolic hypertension through stimulation of the sympathetic nervous system is exaggerated in a cold environment.

BOX 93-3 Characteristics of Elders Vulnerable to Altitude Illness

1. Abrupt ascent in altitude from near sea level to 3000 m (9750 feet) or higher, without an extra night for acclimatization for every additional 600 to 900 m (1950 to 2900 feet) of continuing ascent
2. History of previous episode of altitude sickness
3. Preexisting lung disease characterized by decreased capacity and decreased hypoxic ventilatory response
4. Preexisting cardiovascular disease
5. Metabolic abnormalities associated with diabetes and renal disease
6. Medication that influences respiratory drive
7. Low physical functional capacity
8. Obesity

BOX 93-4 Prevention of Altitude Sickness in Elders

1. Avoid strenuous physical activity at altitude if there is a history of acute mountain sickness.
2. Limit the intensity of physical activity in the presence of cardiovascular disease.
3. Limit physical activity in the presence of pulmonary disease, especially if there is decreased vital capacity.
4. Avoid significant physical activity for at least 12 hours after arrival at an altitude of 2500 m (8100 feet) or more above sea level, and delay physical activity for an additional 24 hours for every gain of 600 to 900 m (1950 to 2900 feet) in altitude.
5. Be aware of all medications and their effects on hypoxic ventilatory drive.
6. Use carbonic anhydrase inhibitors (acetazolamide) according to recommendations of the venture leaders, considering the altitude, medical history, and other medications.

TABLE 93-5 Issues Related to Dosages of Medications Used for Prevention and Treatment of Altitude-Related Illness in Aging Adults

Medications	Renal Insufficiency	Hepatic Insufficiency	Other Major Dosage Issues
Acetazolamide	Avoid with GFR < 10 mL/min, metabolic acidosis, hypokalemia, hypercalcemia, or recurrent nephrolithiasis	Acetazolamide contraindicated	Avoid in patients receiving long-term aspirin or with FEV_1 < 25% predicted; caution with sulfa allergy; avoid concurrent use of topiramate, potassium-wasting diuretics, and ophthalmic carbonic anhydrase inhibitors
Dexamethasone	No contraindications	No contraindications	Expect ↑blood glucose in diabetics; avoid in patients at risk of peptic ulcer or upper GI bleeding; caution in patients at risk for amebiasis or strongyloidiasis
Nifedipine	No contraindications	Best to avoid; if necessary, administer at reduced dose (10 mg twice daily) of sustained-release version	Caution in patients at increased risk of GI bleeding or with gastroesophageal reflux; caution in patients taking medications metabolized by CytP450 3A4 and 1A2 pathways; caution using concurrently with other antihypertensive medications
Tadalafil	If GFR 30-50 mL/min give 5 mg/day; if GFR < 30 mL/min, give no more than 5 mg	Child's class A and B maximum 10 mg/day; Child's class C, do not use tadalafil	Increase risk of gastroesophageal reflux; avoid concurrent use of nitrates or α-blockers; caution in patients taking medications metabolized by CytP450 3A4 pathway
Sildenafil	Dose adjustment if GFR > 30 mL/min	Dose reduction recommended starting at 25 mg 3 times a day; avoid use in patients with known esophageal or gastric varices	Avoid in patients with known varices; avoid concurrent use of nitrates or α-blockers; caution in patients taking medications metabolized by CytP450 3A4 pathway
Salmeterol	No contraindications	Best to avoid	Potential for adverse effects in patients with arrhythmia-prone coronary artery disease; avoid concurrent use of β-blockers, monoamine oxidase inhibitors, or tricyclic antidepressants

FEV_1, forced expiratory ventilation; GFR, glomerular filtration rate; GI, gastrointestinal.
Adapted from Luks AM, Swenson ER: Medication and dosage considerations in the prophylaxis and treatment of high-altitude illness, Chest 133:744-755, 2008.

The cardiac workload is increased; consequently, in the presence of coronary artery disease, angina is frequently precipitated by exertion and cold. Four avoidance factors for persons with coronary artery disease, the "four *E*s of angina," are *exertion, emotion, eating* excessively, and *exposure* to cold.

Exhaustion added to hypoglycemia and dehydration compounds the problem of impaired metabolic function, making the elder individual more vulnerable to the effects of cold. Adequate food intake is essential for maintaining body heat and may become critical. Other physical environmental influences, such as wind, humidity, ultraviolet and infrared radiation, and altitude, should be factored into the exposure equation.[115] The wind chill index provides a useful teaching device for reminding explorers about the hazards of combined cold and wind. The classic combination of cold, dampness, wind, and exhaustion may prove fatal, especially in an elder with decreased physical reserves.

Medical conditions such as cardiovascular disease, metabolic diseases such as hypothyroidism and diabetes, compromised nutritional status, and modified thermoregulatory responses resulting from central nervous system disease or medication may influence heat conservation and contribute to hypothermia. Heat loss may also be increased by damp, wet clothing. All persons should be cautioned to carry ample clothing for changes after saturation with moisture.

Peripheral vasoconstriction, the fundamental mechanism for heat conservation, may be enhanced to some small degree by long-term exposure to cold. When an older adult recognizes personal intolerance to cold, he or she may begin a program of gradual increase in exposure to cold. Prevention of cold injury, however, is best achieved through a learning process derived from experience.[123] Elders should never venture unaccompanied into the cold wilderness. Judgment, orientation, and independent responsibility may be impaired in elders who find themselves lost in the cold or in a rescue situation. Some useful preventive measures are suggested in Box 93-6.

BOX 93-5 Causes of Older Adult Vulnerability to Cold Exposure

1. Peripheral vascular disease (impaired vasoconstriction)
2. Hypertension (perhaps cold induced)
3. Heart disease, including coronary artery disease, decreased cardiac output, congestive heart failure
4. Metabolic diseases (diabetes, obesity, hypothyroidism)
5. Hematologic disorders (anemia, dysproteinemias)
6. Pulmonary disease (cold-induced asthma, chronic obstructive pulmonary disease)
7. Drugs and alcohol
8. Medications, particularly β-blockers and tranquilizers

HEAT

Heat-related illnesses range from heat edema to life-threatening heat stroke (see Chapters 12 and 13).[87,90] Acute management of heat-related illness is identical to that for younger populations.[39,142] Tolerance to heat depends on characteristics of the

BOX 93-6 Prevention of Cold Injury in Older Adult Adventurers

1. Avoid exhaustion during wilderness ventures.
2. Limit exposure.
3. Carry and wear adequate clothing, including rain gear.
4. Stay dry and avoid damp undergarments from excessive sweating.
5. Maintain adequate nutrition with high carbohydrate intake and fat. Carry adequate food for the trip.
6. Maintain adequate fluid intake. Do not consume snow or ice.
7. Participate in a physical training program before the expedition.
8. Pay attention to medication effects.
9. Avoid alcohol and illicit drugs.
10. Always maintain access to an adequate shelter.

BOX 93-7 Attributes of Older Adult Vulnerability to Heat Exposure

1. Obesity
2. Decreased physical functional capacity
3. Infrequent heat exposure
4. Altered thermoregulatory center in the hypothalamus or insensitive skin sensors
5. Metabolic and serum electrolyte abnormalities
6. Heart disease, coronary artery disease, pulmonary disease, diabetes, and renal disease
7. Peripheral vascular disease
8. Multiple medications, often in combination: anticholinergics, antipsychotics, tranquilizers, and β-blockers
9. Alcohol

host, including health status, medications taken, frequency and duration of exposure, history of recent acclimatization, and prevalent environmental factors. Elders in a hot wilderness setting may have personal host characteristics, in addition to the environment, that further limit tolerance and safety (Box 93-7). The person's weight; a fractionated body mass; cardiovascular, renal, or pulmonary problems; and the presence of various medications may influence the individual response to heat.

Regulation of body heat may be affected by altered function of the thermoregulatory center located in the anterior preoptic hypothalamic nuclei, by deranged skin sensors, or by medications used to treat various diseases. These include anticholinergics, beta-adrenergic blockers, antipsychotic medications, and major tranquilizers. Side effects influence adaptation of sweat mechanisms to thermal stress. Diuretics may produce hypovolemia with loss of adequate subcutaneous circulation for heat dissipation. Because older adults in general consume more medications than do younger persons, it is very important to approach heat injury from a position of prevention.

The cardiovascular system plays a major role in heat regulation through heat dissipation. Circulatory abnormalities, peripheral vascular disease, hypertension, and reduced cardiac output may modify heat dissipation, resulting in vulnerability to heat injury. The physical work capacity, as measured by maximal oxygen consumption ($\dot{V}O_{2max}$), decreases 5% to 15% per decade after age 25 years. β-adrenergic blockers and calcium channel blockers may also influence cardiac output by modifying the heart rate and myocardial contractility.

To prevent heat-related illness associated with wilderness activities in older adults (Box 93-8), it is sometimes helpful to suggest a regular exercise program in the heat for the purpose of adaptation. A regular program consisting of 60 to 100 minutes of low-intensity exercise per day for 7 to 14 days at tolerable heat levels before the planned exposure should result in significant adaptation in normal individuals. The exercise level should require oxygen consumption of less than 50% of the individual's $\dot{V}O_{2max}$. Experience teaches that a degree of adaptation results from frequent and extended periods of exposure. Acclimatization to heat yields a generally improved response to exercise. Physiologic responses to adaptation include lower heart rate, enhanced tolerance to physical activity, predictable core temperature in response to heat stress, increased sweat rate, and decreased sodium loss through sweating.

Additional environmental factors, such as high humidity, high winds, and infrared and ultraviolet radiation exposure, may modify levels of an individual's tolerance to heat, partly through skin changes. It is valuable to teach individuals to be aware of the environment and associated responses such as warmth, coldness, or dampness in the skin.

BOX 93-8 Prevention of Heat Injuries in Older Adults

1. Assess health status, with particular emphasis on history, cardiovascular status, obesity, and previous history of problems associated with heat exposure.
2. Maintain adequate hydration.
3. Maintain adequate nutritional status: food, fluid, and electrolyte intake.
4. Participate in a proper acclimatization program.

TRAVEL MEDICINE AND OLDER ADULTS

As the population increases, older people have the opportunity to travel for longer periods and to destinations that are quite different from those to which they have become accustomed. Compared with younger populations, elders tend to have more ongoing medical issues and also have certain limitations related to the aging process. However, most of the time, ongoing medical issues do not contraindicate or impede travel. Older adults traveling to exotic locales or more adventurous destinations often choose to use a managed tour so that a tour manager (and often a tour doctor or nurse) conducts much of the logistical planning. Even on managed tours, older adults frequently seek medical advice for gastrointestinal, respiratory, dermatologic, and cardiovascular symptoms.[127,128] Anticipating and preventing medical complications is prudent for older adults exploring far-away locales, especially patients with preexisting medical conditions.[111] Travelers should seek the advice of medical specialists related to their specific medical condition(s), as well as a travel medical physician, prior to embarking on a wilderness or exotic trip. Travelers should also ensure that their medical insurance covers them in a foreign country.

Many elderly travelers require vaccinations and seek guidance from a primary care provider. Physicians routinely confront clinical decisions about which patient to vaccinate, assessing vaccination safety for particular patients, and estimating the level of protective efficacy likely to be offered by a vaccine(s).[3] Aging is associated with alterations in immune responses (Figure 93-1), which may lead to clinically significant changes in safety, immunogenicity, and protective efficacy of certain vaccines.[78] Immune senescence and diminished vaccine efficacy are associated with loss of B-cell activity, although changes in T-cell function are the dominant age-associated cellular dysfunctions in the immune system.[78] In the future, new approaches to augment efficacy of traditional vaccinations, such as viral vectors for antigen delivery, DNA-based vaccines, and toll-like receptor agonists, may improve immunoprotection following vaccination.[138]

Leder and colleagues evaluated existing data regarding the effects of age on responses after immunization to vaccines generally administered before travel. The specific vaccines included hepatitis A, typhoid, yellow fever, encephalitis, and rabies vaccines. Additional vaccines discussed were many routine vaccines frequently administered before travel, including tetanus-diphtheria-toxoid, hepatitis B, pneumococcal, and influenza vaccines. The authors noted diminished serologic responses to hepatitis A and rabies vaccines in older individuals, as well as increased toxic effects following yellow fever vaccination.[82] However, many of the vaccines currently in use—in particular, many of the vaccines given prior to travel—have never been specifically studied in elderly subjects, and many questions remain unanswered. Existing evidence suggests that immune responses are at least in part age dependent. This could translate into a requirement for altered vaccine schedules for elderly persons, such as those used for many vaccines administered to infants. Additional studies need to be conducted to ascertain the schedules. These issues are becoming increasingly important as the number of elderly persons in the population increases and they travel to exotic destinations.

MEDICAL EXAMINATION FOR OLDER ADULTS PLANNING WILDERNESS TRAVEL

There are two important occasions when wilderness medical leaders should consider a health and medical evaluation for older adult adventurers: (1) during the planning phase before the

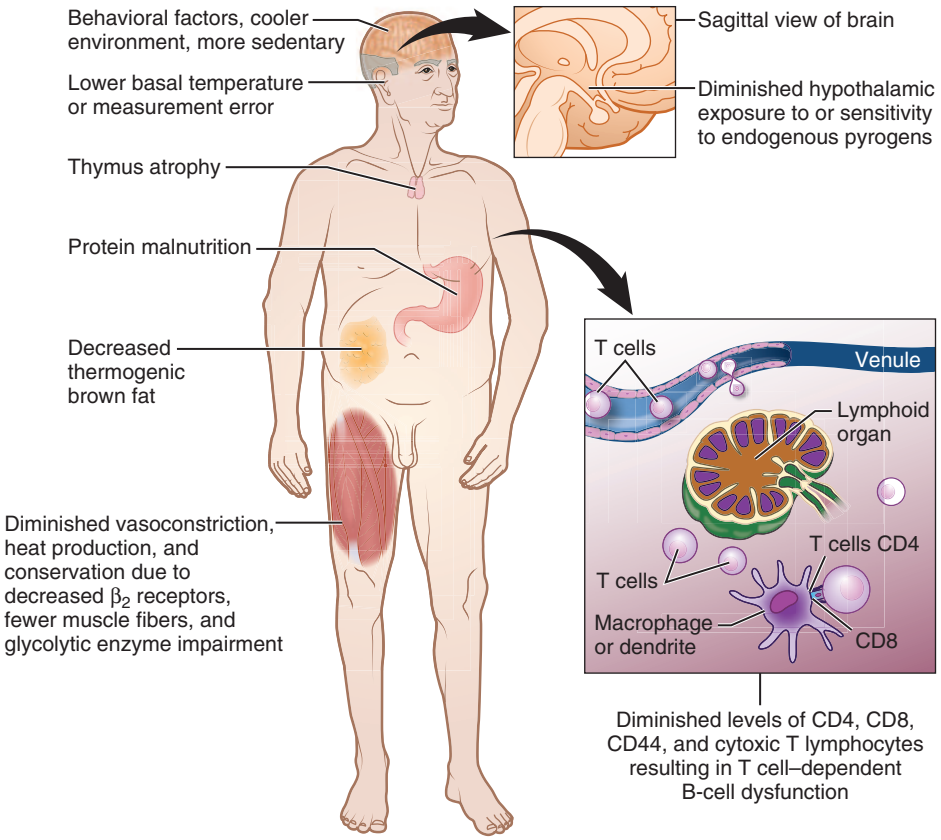


FIGURE 93-1 Factors associated with a diminished older adult response to thermoregulation and immune response. *(From Katz ED, Carpenter CR: Fever and immune function in the elderly: In Meldon SW, Ma OJ, Woolard R, editors:* Geriatric emergency medicine, *New York, 2004, McGraw-Hill, Figure 9-1, p 59.)*

venture and (2) in response to symptoms that occur during or after the venture. Components of the pretrip evaluation are based on the characteristics of the individual and on the nature of the proposed venture. By the time an individual qualifies for designation as an older adult, that person has usually made some arrangements for medical care, examination, and advice. However, as older adults consider venturing into the wilderness, there is often confusion or insecurity about the prospect of what medical issues might become important. A formal prewilderness clinical examination may be helpful to prevent or anticipate medical problems. The content of a medical examination, consisting of any or all of the five categories listed in Box 93-1, matches characteristics of the individual with characteristics of the venture and identifies components of the medical examination that may be needed (see Table 93-4). Wilderness leaders indicate that the most important part of the medical examination before a wilderness adventure is an in-depth interview by an examiner experienced in medical care *and* the nature of the venture, so the most appropriate screening physician may not be the patient's primary care physician. However, if the primary care physician is the only available screening physician, then it is advisable to seek input from persons who have experienced the anticipated environmental hazards and understand the physiology of the older adult's underlying comorbidities. After the interview, appropriate medical, laboratory, radiographic, and physiologic studies may be performed. The remainder of this chapter reviews age-related changes in specific organ systems pertinent to the medical evaluation prior to wilderness adventures.

CARDIOVASCULAR DISEASE

Age-related changes in the cardiovascular system affect the heart rhythm, myocardial pump function, and afterload. With aging, there is a progressive reduction in the number of pacemaker cells in the sinoatrial node, increase in myocyte cell volume per nucleus in both ventricles, increase in peripheral vascular resistance, and increase in aortic impedance from loss of elasticity. Increased levels of circulating catecholamines are associated with aging, especially with stress, but β-adrenergic–induced vasodilation decreases with age. This is important for exercise tolerance in elders.

The presence of pump failure, either systolic or diastolic, may be indicated by recent weight gain, shortness of breath, orthopnea, or ankle edema. The patient with symptomatic heart failure should limit remote wilderness ventures to activities that do not cause excessive shortness of breath, breathing through an open mouth, or excessive fatigue. Peripheral vascular disease, claudication, symptomatic carotid disease, and aortic aneurysm warrant caution with regard to the difficulty of return or evacuation in the event of incapacity.

Cardiac rhythm disturbances range from the nuisance effect of premature systoles to significant rhythm disturbances, such as atrial fibrillation, to potentially life-threatening ventricular arrhythmias. An older adult who is aware of symptoms related to an arrhythmia should seek evaluation by a physician before a wilderness adventure. The evaluation should include history of the onset of symptoms and initiating factors, medications taken, physical examination with emphasis on auscultation of the mitral and aortic valves, electrocardiogram, ambulatory monitoring if there is a history of heart disease or light-headedness, and possibly echocardiogram. For persons with atrial fibrillation, structural heart disease, and an appropriate rate response to exercise, activities consistent with the limitations of the structural heart disease are allowed. Persons with atrial fibrillation requiring anticoagulation should not participate in activities risking physical contact and injury, in particular head trauma.

Valvular pathology, especially aortic and mitral valve issues, may be recognized by auscultation and confirmed by echocardiography. The patient with a prosthetic cardiac valve may be at risk during prolonged adventures with exposure to inclement

weather, infectious diseases among fellow travelers, or diseases among the local populace.

CORONARY ARTERY DISEASE

A heart attack is the ultimate medical emergency and frequently mimics other environmental catastrophes, such as high-altitude illness.[5] In the United States, millions of individuals suffer myocardial infarctions annually, 30% of whom do not survive. Of these, 50% die within the first hour of the onset of chest pain. Because the myocardium depends almost entirely on aerobic metabolism, the workload is reflected in the myocardial oxygen consumption. Delivery of oxygen to the myocardium depends on the coronary blood flow. Hence, integrity of the coronary arteries is essential for a viable response to wilderness stresses. Remoteness and delay in instituting treatment in wilderness settings render myocardial infarction to be of high risk for poor outcome in many cases. If a victim survives the first hour, which may be the time required to initiate a search and rescue, there may be a maximum 85% chance of survival, using urban statistics.[38]

Only one-half of people with myocardial infarction have symptoms beforehand, and acute myocardial infarction can be difficult to recognize,[110] but asking about the history and risk factors during a medical history might help clinicians risk-stratify an older adult's chances of a myocardial infarction before the wilderness adventure. However, exercise testing in asymptomatic patients without risk factors for coronary artery disease is not usually indicated.[71] Subgroups of cardiac patients with preexisting pulmonary hypertension, uncompensated congestive heart failure, unstable angina, recent myocardial infarction, severe anemia, or decreased arterial oxygen saturation are at higher risk than are other cardiac patients.[133] The history should include detailed assessment of risk factors for coronary artery disease. Knowledge of the existence and extent of coronary artery disease will influence recommendations for the nature and level of activity, expected tolerance to environmental stresses, and recommendations as to the degree of remoteness, level of exertion, and environmental factors that the individual should endure in the proposed wilderness adventure. Activity prescriptions target heart rate rather than workload.[105] A series of philosophical discussions dealing with the limitations of wilderness activities in people who have undergone cardiac surgery appeared in a series of letter exchanges and editorials in the *Journal of the American Medical Association*.[8,50,70,118] The conclusion places the decision-making process squarely on the clinical judgment of the cardiologist on a case-by-case basis.[118]

Because there is no absolutely risk-free activity for a person with significant cardiovascular disease, prevention is the fundamental principle for reducing risk. Before vigorous outdoor activity by an older adult, the physician should:

- Understand the individual's wilderness activity plans
- Based upon contemporary geopolitical conditions, weather patterns, and the epidemiologic status of infectious diseases, anticipate exertional and environmental stressors
- Recognize a history of coronary artery disease and other illnesses, and the use of medications
- Be prepared to make specific recommendations regarding physical activity and exposure

There are currently no published guidelines to aid in advising older individuals intending to venture into the wilderness, but the American College of Sports Medicine provides exercise and physical activity recommendations.[26] High-level recommendations suggest that older adults are able to engage in acute aerobic or resistance exercise and experience positive adaptations to exercise training. In addition, individuals vary widely in how they adapt to exercise; the variability is likely related to the individual lifestyle and genetic factors.

HYPERTENSION

Hypertension is an important marker for potential cardiovascular problems.[73] Complications include angina, myocardial infarction, left ventricular hypertrophy, heart failure, stroke (both ischemic and hemorrhagic), and renal failure. The most widely accepted values of blood pressure considered to represent hypertension are systolic pressure above 140 mm Hg or diastolic pressure over 90 mm Hg. Treatment of hypertension prior to a wilderness adventure is recommended. However, common antihypertensive medications are associated with significant side effects that can alter the physiologic adjustment to environmental stressors and interact with common pharmacologic therapies for high-altitude illness and infectious diseases. Diuretics deplete volume and are associated with hypokalemia and hyponatremia. β-adrenergic blockers reduce the adaptive capacities of the heart rate and thermoregulation. Calcium channel blockers are frequently associated with headache, flushing, and edema.

DERMATOLOGIC DISORDERS

Thin Skin

Normal aging of skin leads to atrophy, decreased elasticity, and impaired metabolic and reparative responses. These changes are different from photoaging, which is due to sun exposure. As the epidermis becomes thinner and the dermoepidermal junction flattens, the skin becomes fragile and subject to shear stress.[103] This is why removing an adhesive from an older person's skin can dislodge the epidermis and why bleeding into the space between the dermis and epidermis occurs more frequently, as evidenced by bruising from seemingly mundane contact.

Additional changes that occur in an older individual's skin include delayed wound healing due to thinning of the dermis with decreased vascularity.[55] The ability to deliver heat to the skin for excretion is impaired. Combined with the loss of subdermal fat that decreases insulation, this leads to inability of older persons to conserve heat as well as can younger persons. Sensory perception of the skin decreases, leading to increased risk for injury.

Vitamin D synthesis declines with aging; outdoor activity benefits older adults by reducing the likelihood of inadequate levels of this vitamin.[44] Unfortunately, sun exposure is also associated with risks. Photoaging that is not due to physiologic skin aging produces cosmetically undesirable changes in skin, making it look wrinkled, yellow, and rough. These changes can sometimes be reversed by topical treatments with retinoic acid and refraining from sun exposure. Sunscreen with a high sun protection factor (SPF) should be applied liberally. The Skin Cancer Foundation considers SPF of 15 or higher acceptable ultraviolet B protection for normal everyday activity, and SPF of 30 or higher acceptable for extended or intense outdoor exposure. Such sunscreens also provide some protection against ultraviolet A wavelengths, although the SPF rating refers only to ultraviolet B protection.[88]

Onychomycosis

Onychomycosis is nail infection caused by any fungus, including yeast and nondermatophyte molds. In one study, most patients were noted to have toenail involvement, mostly due to a dermatophyte.[58] Although onychomycosis is usually a cosmetic concern to patients, it can also cause physical discomfort. Toenails are most likely to give hikers problems in the wilderness. Risk factors that have been associated with onychomycosis include older age, tinea pedis, diabetes, and genetic predisposition.[49]

Potassium hydroxide examination of a scraping from under the nail is followed by culture as the general diagnostic approach. Traditional topical therapies are usually ineffective for clearing the primary infection; even oral therapy is associated with a high rate of treatment failure or reoccurrence.[34,56,57] Nevertheless, treatment is often dictated because morbidity associated with the infection, especially with comorbidities such as diabetes, is high. Oral terbinafine is considered first-line therapy because data suggest greater efficacy and fewer side effects.[59] Oral itraconazole is also effective. Onychomycosis should be treated in patients with a history of cellulitis or diabetes or those who are experiencing discomfort. During oral therapy, monitoring liver function is important because these drugs can be hepatotoxic. Newer therapies include laser application, broad-spectrum antifungals such as albaconazole, nail lacquers, or ionophoretic drug delivery, which is a low-level electrical current used to enhance absorption of topical medications.[13,104]

DENTAL ISSUES

Dentures are removable false teeth made of acrylic or metal. They fit snugly over the gums to replace missing teeth. Complete dentures are used when all the teeth are missing; partial dentures are used when some natural teeth remain. A dental bridge spans the gap created by one or more missing teeth. Bridges are constructed of two or more crowns for the teeth on either side of the gap. These false teeth are called pontics, and can be made from gold, alloys, porcelain, or a combination of these materials. The bridges are supported by natural teeth or implants.

Caring for dentures and dental bridges in the wilderness can be challenging. Common denture or bridge problems often stem from poor oral hygiene. To avoid problems such as gum and mouth irritation, stomatitis, or cheilitis, brush and floss often and use proper technique to keep dentures clean. Bridges rely on the health of surrounding teeth, so daily brushing is essential. Mouth infections can occur. Stomatitis is caused by *Candida* and often goes unnoticed until red lesions appear in the mouth. Cheilitis (also called cheilosis) is a painful infection that causes inflammation and cracking at the corners of the mouth, caused by overgrowth of yeast. Yeast can accumulate in moist areas of the mouth if dentures do not fit properly or are not properly cleaned and stored.

In addition to proper oral hygiene and making sure that dentures fit well, it is also important to maintain dentures. This includes not sleeping with dentures, handling them with care, and cleaning them daily. Tips for cleaning dentures in the wilderness include:

- Soak dentures overnight in a denture cleaner (warm water can be used as a substitute if no denture cleaner is available, but hot water that will alter the shape of the denture should not be used)
- Use a soft-bristled brush or special denture-cleaning brush to thoroughly clean dentures every morning before inserting them into the mouth
- Never use powdered household cleaners or bleach on dentures
- Never use toothpaste on dentures because it is too abrasive
- Lacking any proper cleaning solution in the wilderness, use a very small amount of soap and copious water

When dentures are not in the mouth, they should be stored in denture-cleaning solution or warm water. Carrying a small container for dentures when in the wilderness is the best way to keep them clean and safe when not in the mouth. In the event of serious facial injury, the first responder should examine the mouth carefully for fractures of dentures or displaced dental appliances, which could cause respiratory obstruction.

GASTROINTESTINAL DISORDERS

Among the most common gastrointestinal problems affecting older adults are constipation and diverticulitis.[85] Physical activity and a high-fiber diet reduce symptomatic diverticular disease.[1] Constipation is a frequent complaint among 33% of adults over age 60 years in the Western hemisphere.[32] A difference exists between the medical definition and an older adult's perception of constipation and their need for laxatives.[33] Normal frequency of bowel movements ranges from three defecations per day to three per week. Laxatives are used by 15% to 30% of elders on a regular basis. When such individuals find themselves in the wilderness, away from the convenience of their bathrooms, alteration in bowel habits may occur, sometimes to the point of fecal impaction. Diverticulitis may flare at such times, requiring dietary change, stool softeners, and antibiotics.[136] It is prudent to obtain a detailed history of bowel habits and medications before embarking on a wilderness venture. Dietary fruit, fiber, and grain combined with stool softeners for older adults during a wilderness adventure may help prevent fecal impaction, rectal fissures, hemorrhoid bleeding, fecal incontinence, and chafing.

Gastrointestinal disorders noted among older adults may include malignant disease of the colon and pancreas, gastric ulceration that may bleed, especially after nonsteroidal antiinflammatory drug (NSAID) ingestion, and *Helicobacter pylori* infection.[85] A surgical emergency may arise from an incarcerated or strangulated inguinal or ventral hernia.

In elders, diarrhea contracted in Third World countries may be severe, leading to dehydration, gastrointestinal bleeding, or perforation of a hollow organ.[129] Some evidence indicates that older travelers adhere more closely to sanitary water sources and are less likely to report diarrhea.[2] Exacerbations of diverticulitis or acute cholecystitis (with or without pancreatitis), persistent or unusual abdominal pain, vomiting, bleeding, or worsening dehydration are reasons for ending the adventure and initiating evacuation to medical care. When traveling to remote locales, it is prudent for certain expeditions to carry intravenous fluids and consider appropriate antimicrobial prophylaxis or medications for presumptive treatment of infectious diarrhea.

GENITOURINARY DISORDERS

Elders are particularly vulnerable to urinary tract disorders, including infection, obstruction, and ureteral, renal, or bladder stones. Bladder infection in women is common in remote settings because of dehydration and difficulty with hygiene.[66] Incontinence after hysterectomy is frequent, and discomfort from chafing and bladder infection may be present. It is prudent for women to carry medicated skin pads and cotton diapers. Men may incur bladder infection from benign prostatic hypertrophy with obstruction. Anticholinergic medications may induce bladder relaxation with subsequent retention. Terazosin hydrochloride, an α_1-selective adrenoreceptor blocking agent, may improve urine flow in instances of obstruction resulting from benign prostatic hypertrophy by reducing bladder outlet obstruction without affecting bladder contractility. On extended trips in remote areas, it may be prudent to carry a catheter for emergency relief of acute urinary retention.

Dehydration from fluid loss or inadequate oral replacement may precipitate infection. Adequate fluid intake is the key to genitourinary health in the wilderness, so it is particularly important to caution the participant about water quality.

MENOPAUSE

Menopause is a normal phenomenon associated with aging. Rather than occurring as a discrete, definable event, the menopause transition may take place over a period of several years, beginning around 40 years of age or as late as 55 years of age. Also known as the climacteric, this is a time in life when the opportunity for leisure activities may be greatest. Women who participate in wilderness activities must deal with the symptoms and somatic changes of menopause in addition to the physical and environmental stresses of the wilderness.

Symptoms that foretell the onset of menopause include vasomotor flushing, night sweats, insomnia, vaginal dryness, and variations in menstrual cycle and flow. Convention accepts that 12 months of cessation of menses is a confirmation of menopause.

As ovarian production of estrogen declines, the androgen : estrogen ratio changes dramatically. Gonadotropin feedback results in increased follicle-stimulating hormone in a range of up to 30 MIU/mL. Progesterone secretion is variable and may either increase or decrease.[132] Resulting anatomic changes from these hormonal alterations may affect lipid ratios, the coronary arteries, cortical and trabecular bone, and changes in body fat distribution with a shift in fat toward the center of the body. Changes in cognitive functions have also been reported.

In the past, hormonal replacement therapy was often used for menopausal or postmenopausal women or those who underwent surgical hysterectomy, based upon three classic indications: (1) for symptoms related to estrogen deficiency (vasomotor symptoms or genitourinary tissue atrophy); (2) to prevent or treat osteoporosis; and (3) for prevention of cardiovascular morbidity and mortality, all of which may occur in the wilderness setting. Hormone replacement therapy is much more controversial today because compelling research indicates that it significantly increases the risks of coronary artery disease and breast cancer.[25,114]

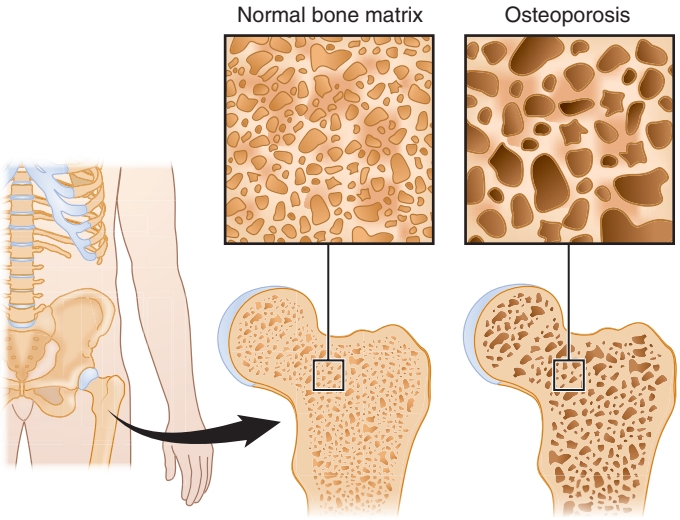


FIGURE 93-2 This artistic rendition of normal and osteoporotic bone demonstrates the striking difference in bone density and histologic microstructure. *(Redrawn from Nucleus Medical Media, Kennesaw, Georgia; with permission from MedlinePlus Medical Encyclopedia: nlm.nih.gov/medlineplus/ency/imagepages/17156.htm.)*

MUSCULOSKELETAL DISORDERS

Musculoskeletal disorders are common among elders. Age-related musculoskeletal system changes include decreases in lean body mass and increases in total body fat, with loss of muscle mass due to decreasing numbers of muscle fibers; this also reduces muscle strength.[23] Another important physiologic change is loss of skeletal bone mass and density (osteoporosis; Figure 93-2). Osteoporosis occurs earlier in women, during the postmenopausal period, but by age 60 years, men and women have equal rates of bone loss. Bone integrity declines with aging. The combination of decreased bone integrity with diminishing bone mass reduces bone strength, increasing skeletal fragility and susceptibility to fractures caused by less kinetic injury than that needed to fracture bones of younger patients.[23] The lifetime risk of fractures in women after age 50 years is 17.5% for hip fractures, 16% for vertebral fractures, and 16% for wrist (Colles) fractures. Men over age 50 years carry a lifetime fracture risk of 6% for hip fractures, 5% for vertebral fractures, and 2.5% for wrist (Colles) fractures.[92]

The aging joint undergoes degenerative changes in its components. Cartilage has very little ability to heal. Injuries to cartilage tend to accumulate with age, leading to irreversible damage and osteophyte formation, developing into hypertrophic osteoarthritic changes in joints of the extremities and spine. Skeletal muscle undergoes age-related changes with loss of muscle mass. Changes in hormones, growth hormone/insulin-like growth factor-1, androgen:estrogen ratio, cytokines and growth factor, interleukin-6, and free radical production may be related to atrophic changes.[52]

Osteoarthritis, the most common form of arthritis, affects millions of U.S. older adults.[48] The prevalence of arthritis and osteoarthritis both increase with age.[52] In the wilderness, joint stress associated with extended hiking, injuries from repetitive motion, falls, and other trauma, when superimposed on the aging body, can induce functional impairments. Limitations in mobility from pain lead to loss of success or even to significant hazards during wilderness ventures.

A detailed musculoskeletal history and physical examination, with emphasis on prior and present symptoms, are of value for any older adult contemplating physical activity, and essential for any older adult planning remote wilderness activities. Treatment of arthritis in a layered stepwise manner begins with rest, acetaminophen, NSAIDs, and topical capsaicin.[52] Older adults must be cautioned about gastric irritation from NSAIDs and their danger in the presence of comorbid conditions and anticoagulant therapy. Intraarticular corticosteroids may help reduce inflammation.

Before and after the onset of symptoms, weight reduction and physical therapy, including progressive resistance training, aerobic conditioning, and spa therapy, may be effective in treatment or when preparing for a wilderness adventure. Corsets, braces, and canes prescribed by the treating specialist should be used, but the layperson is cautioned against self-prescription. A conditioning program before the wilderness adventure may help prevent musculoskeletal problems or may precipitate symptoms that alert the individual to a problem not previously recognized. It is better for symptoms to occur at home and serve as a warning for potential untoward events than for them to occur in a location far from medical care. Because degenerative changes in the lumbar and cervical spine may become symptomatic, it is appropriate to carry a backpack during a conditioning program before a hiking adventure. At least one, and preferably two, hiking sticks are recommended for hiking activities.

Arthroplasty

Age-related musculoskeletal changes lead many individuals to consider arthroplasty, a trend that is increasing around the world with an aging society.[36,69,117] Hip and knee replacement surgery are the most frequent joint replacement surgeries and are cost-effective.[116] However, patients vary in their willingness to undergo joint replacement when weighing anticipated benefits and pain alleviation against postoperative functional recovery and hospitalization.[72] Individuals engaged in high-impact activities such as mountaineering and skiing are generally motivated to resume outdoor activities as soon as possible following arthroplasty. Prosthetic joints have a reduced loading capacity without biologic adaptability. High-impact sports may increase wear, but regular and moderate activity increases the longevity of total hip arthroplasties.

Several considerations merit discussion with patients contemplating wilderness adventures prior to or following hip arthroplasty: First, experts generally agree that low-impact sports, such as level surface walking or bicycling, stair climbing, swimming, and golf, can be resumed within 7 months following surgery without restrictions. Higher-impact activities, such as mountaineering, are less liberally recommended.[135] Second, minimally invasive hip arthroplasty represents one surgical approach to reduce recovery times and safely permit resumption of high-impact activities, although orthopedic studies do not report long-term outcomes.[112,121] Third, patients and surgeons should inform the rehabilitation team of the objective to return to high-impact activities, such as mountain sports, during the postoperative recovery phase. Patients should not anticipate becoming involved in a high-impact activity after joint replacement unless they were engaged in that same activity prior to arthroplasty. Fourth, in planning wilderness adventures following hip or knee replacement, patients should avoid routes with foreseeable hazards, such as ice or slippery slopes that lead to hard falls. Although each postarthroplasty patient's capacity to engage in high-activity sports should be assessed individually, general contraindications to participation in these activities include revision surgery, prior prosthesis dislocation, deep wound infection, prosthesis instability, osteoporosis, significant pain with sports practice, or gluteal muscle insufficiency.[112]

Spinal Stenosis

Spinal stenosis is the clinical syndrome of neurogenic claudication secondary to narrowing of the lumbar spinal cord canal, and manifests as lower back pain with radiation to the legs; this impairs walking.[79] Narrowing can occur in the central spinal canal or in the neural foramina. Pain is exacerbated by lumbar extension and improved with lumbar flexion. Patients are comfortable sitting and less comfortable with prolonged walking. Weakness that limits function is uncommon. The sensitivity of computed tomography scanning or magnetic resonance imaging for lumbar spine stenosis exceeds 70%.[41] Twenty percent of persons over age 60 years have imaging evidence of spinal stenosis with no symptoms.[10,75] Most symptomatic patients managed nonoperatively report no progression over 1 year. Studies evaluating surgical decompression versus nonoperative management do not demonstrate a significant benefit with either approach.[74] Active

postoperative rehabilitation improves functional recovery.[99] No studies have identified the ability to return to wilderness adventure pursuits with operative or nonoperative management of spinal stenosis.

Foot Problems

Bunions, or hallux valgus, are bony joint deformities at the distal base of the first metatarsal. The main sign of a bunion is the big toe pointing toward the other toes on the same foot, which may force the first metatarsal to protrude outward. Symptoms may include pain and swelling over the big toe exacerbated by pressure from wearing shoes; hard, callused, and red skin caused by overlap of the big toe and second toe; sore skin over the top of the bunion; and changes to the shape of the foot, making it difficult to find properly fitting shoes.

Treatment of bunions is generally first with properly fitted shoes, followed by orthotics, followed by surgery as needed.

FALLS AND RESULTING INJURIES

One of the most important sequelae of aging is an increased risk of falls and injuries related to falls. A fall is an unintentional, sudden descent to a lower level. Most geriatric falls occur from standing or when arising from a sitting position. Approximately 27% of independent community-dwelling adults over age 65 fall each year, and the rates of injurious falls are increasing faster than the overall rates of falls in older adults.[51] Falls occur due to a complex interplay of intrinsic factors (balance and gait stability, motor strength, reaction time, visual impairment) and extrinsic factors (environmental hazards, medication side effects). Most falls in community-dwelling adults occur in or around the home, and 20% cause serious injury.[97] Unfortunately, many elderly fall victims do not receive guideline-directed clinical care,[122] likely because of a combination of an inadequate capacity to predict future falls,[18,51] insufficient fall prevention interventions, and incomplete incorporation of implementation science principles into fall injury prevention efforts.[21] Multiple fall risk stratification instruments exist,[18,51] yet most remain without convincing validation. For example, in older adults presenting to an emergency department for evaluation after a fall, two instruments have been derived to risk-stratify individuals for future falls, but neither has been validated. Furthermore, neither instrument identifies individuals at increased risk for future falls; instead, both instruments only identify those at lower risk for future falls.[18] Nonetheless, one of these instruments is depicted in Box 93-9 because it may represent a simple method in the field to assess a future risk of falls in wilderness settings following an accidental standing-level fall.[22]

SENSORY SENESCENCE

Senses serve as a warning system for hazards in the wilderness. The five classic sensory "instruments" of vision, smell, taste, touch, and hearing (including its vestibular function) send signals to the central nervous system during interpretation of the physical environment. With age, sensory organs undergo functional degeneration. Up to 75% of elders have visual and auditory impairments not reported to their physicians. Changes may be subtle. The aging rule is that after age 30 years, there is a 1% loss per year of physiologic function in most organ systems.

BOX 93-9 Carpenter Instrument for Stratification of Six-Month Fall Risk Among Older Adults in the Emergency Department

Presence of nonhealing foot sore?
Any fall in last 12 months?
Inability to cut own toenails?
Self-reported depression?

More than one "yes" response in a community-dwelling older adult indicates an increased risk for falls.

Vision Issues

Acute, subacute, and chronic ophthalmologic issues should be evaluated by an ophthalmologist prior to embarking on a wilderness adventure.[96] Complete healing after eye surgery should be confirmed before the adventurer heads into the wilderness, especially with altitude changes. Visual acuity decreases because of morphologic changes in the lens, choroid, retina, macula, rods and cones, and other neural elements and by an increase in intraocular pressure. Night vision and color vision are notably decreased after age 50 years. Hypoxia, to which the elder's eye may be sensitive, may cause tunnel vision. This can be a valuable body signal, indicating an altitude that may be hazardous for the individual.

The most troublesome ophthalmologic effects of age are glaucoma and changes in refractive power. Increased intraocular pressure may be associated with halos and declining vision. This is a serious medical condition warranting continuing care by an ophthalmologist. Manifestations and treatment of far-sightedness range from purchasing a pair of nonprescription reading glasses to elaborate multipower prescription lenses and surgical correction of lens abnormalities. Negotiating rough terrain may be difficult while wearing bifocals. An older person walking on a wooded trail may be unable to see roots or rocks in his or her path. Trifocals and various lens designs have been tried, but experience suggests that trail glasses should be configured for distance, with separate reading glasses for close-up work such as map reading. Paradoxically, corrective lens use has been associated with an increased fall risk in multiple studies.[37,40,64]

Taste Issues

Some lingual papillae are lost because of age, diminishing the ability to taste. Salivary secretion is reduced. Dentures may cover secondary taste sites. Because olfactory bulbs also undergo atrophy with age, combined taste and olfactory sensory deprivation may account for decreased "pleasure" of trail food taste.

Touch Issues

In addition to assisting in the fine movement needed for technical work, sensitivity of touch against a hostile environment may be lifesaving. For example, conventional wisdom holds that the threshold for feeling a gentle breeze against the cheek is about 5 miles per hour. Impairment of cold awareness, which originates from stimuli at the end bulbs of Krause in the skin, along with age-attenuated metabolic adaptation to cold, can interfere with signals that alert an individual to assume cover from the weather.

Hearing Issues

According to the National Institute on Deafness and other Communication Disease, one-third of the population age 65 to 74 years reports difficulty hearing, a percentage of individuals that increases to 50% by age 75 years. Hearing loss can be debilitating, leading to increased risk of falls and less awareness of danger while driving because one is less aware of surroundings. Hearing loss can also lead to social isolation. Most cases of hearing loss in adults are from damage to the inner ear, with the two most common causes of that damage being aging and chronic exposure to loud noises. Middle and outer ear causes of hearing loss are often reversible and include such causes as impacted cerumen, fluid buildup from infection, or use of certain ototoxic medications. Older adults often have a mix of both types of hearing loss. Acoustic trauma may cause permanent reduction in sensitivity to high-frequency sounds. Failure to hear the "click pitch" of consonants may obscure communications because consonants often are found at the beginning and end of words. Speech in that circumstance may be heard as a continuous drone of vowels.

Problems with sound localization may result in loss of directional hearing. An aging brain cannot process confused sound signals as accurately. Add tinnitus and a hostile environment, and the hearing sense loses its value as an important survival tool. The vestibular apparatus is especially valuable for balance and stability; combined with proprioception, it may provide a "biologic gyroscope" of crucial importance. Increasing age seems to be associated with more frequent episodes of vestibular dysfunction, including vertigo.

Hearing aids dramatically reduce auditory deficits, improving the ability to hear, speak, and resume normal activities. Devices that amplify sound are integral to management of hearing impairment and include hearing aids, portable devices that can be used to amplify the sound coming from speakers at public events, and devices such as cochlear implants. Unfortunately, less than half of the elderly population with hearing impairment uses a hearing aid.[89,130] The first step in providing hearing amplification is to determine if the individual will benefit from hearing aids, based on audiogram results, lifestyle, motivation for use, and the individual's expectations.

A common misconception is that hearing aids restore normal hearing (much as corrective lenses restore sight). Hearing aids improve hearing by 30% to 60% at best. The goal of these devices is not to restore hearing but to significantly improve the ability to communicate and the quality of life. Digital hearing aids and the older analog hearing aids are the most popular hearing devices prescribed by audiologists. Hearing aids are useful for enhancing volume, sound direction, and pitch discrimination. Traditional analog hearing aids have limitations, especially in high-frequency ranges, obscuring click pitch discrimination. Digital devices, some with a range of 500 to 6000 Hz, provide increased clarity and sound quality and can enhance volume, as well as directionality, a valuable warning signal in the wilderness setting. Programmable units can be changed according to needs, such as listening to music and background noise reduction. Unilateral hearing loss can be improved by "cross-over" hearing aids. Less expensive versions available without a prescription include personal sound amplifiers, which are over-the-counter products with fewer features and less functionality than offered by more sophisticated fitted devices. However, personal sound amplifiers are significantly less expensive ($35 to $50 U.S. versus several thousand dollars) and a reasonable solution for individuals with a mild hearing deficit who are not ready for the high cost of a prescription fitted device, and may represent an alternative for wilderness travelers who do not want to risk losing expensive appliances. Travelers with significant hearing loss should consult an audiologist about anticipated outdoor activities to determine the best approach.

In the wilderness setting, a hearing aid user must be cautious to prevent sweat, rain, and other moisture from entering the components. A drying kit containing desiccating crystals is available and should be carried by anyone wearing a hearing aid while in the wilderness.

TREMORS

Tremors are rhythmic, involuntary body movements. Once considered a benign accompaniment of aging, tremors are now recognized as an abnormal and sometimes controllable component of growing older.[47] Essential tremor is the most common movement disorder; it affects up to 20 million individuals in the United States, with worldwide population prevalence estimates ranging from 0.4% to 6.3%.[93] Other forms of tremor include physiologic (low amplitude, high frequency), Parkinson disease, medication-induced, lesional (multiple sclerosis, stroke, cerebellar), dystonic, and psychogenic. Tremors can occur at rest or with activity. Physiologic tremors become more pronounced with stimulants (methylphenidate, dextroamphetamine, caffeine, nicotine, β-agonist inhalers), sleep deprivation, and stress. Ethanol withdrawal can also cause or exacerbate tremors. Action tremors include postural (noted while holding a position against gravity), kinetic (noted with volitional movement), intention (amplitude increases with targeted movement), task-specific, or isometric (noted with muscle contraction against resistance without movement). Tremor should be distinguished from other involuntary movement disorders, including dystonia, chorea, dyskinesia, myoclonus, and asterixis.[47]

Identifying the cause of tremor can be important before or during a wilderness adventure. Before traveling, understanding the cause, likely precipitants, and effective treatments for tremor empowers the screening physician and patient to plan proactively for fine motor tasks that might require companion assistance, medications, and situations to avoid. During the wilderness experience, recognizing the cause and preexisting nature of tremors permits medical personnel to avoid unnecessary evaluations for other causes while understanding available treatments, if necessary. The neurologic examination is essential to distinguish essential tremor from that of Parkinson disease, as well as other forms of movement disorder. Imaging and laboratory tests are generally not required to diagnose the origin of tremor. Bradykinesia, rigidity, masked face, muffled speech, or asymmetric arm swing or stride length while walking suggest Parkinson tremor. Over one million individuals live with Parkinson disease in the United States. The annual incidence for ages 64 to 74 years is 1%, compared with 3.1% for ages 74 to 85 years and 4.3% for persons over age 85 years.[43] Worldwide, there is a tendency for Parkinson disease to develop in individuals over age 60 years, males, and nonsmokers.[42] Differentiating Parkinson disease from essential tremor is quite important because Parkinson disease is an independent risk factor for falls.[51] In addition, Parkinson disease medication management using dopaminergic agents is quite different from that for other forms of tremor.[27] First-line medical management for essential tremor is propranolol or primidone.[47]

NEUROPSYCHIATRIC AND SUBSTANCE ABUSE DISORDERS

Situational stresses are often superimposed on environmental stresses during wilderness ventures. Difficulties with group interaction, changes in rational thought in individuals with organic brain disease, or behavioral upheaval from bipolar states can jeopardize health and safety not only of an individual but of an entire group.

Drug abuse[46] and alcohol use disorders[77] occur in aging adults. Subtle alcoholism may evolve into full-blown withdrawal psychosis during a hypoxic event or during extreme physical exertion. Drug use in elders may not necessarily be "recreational," but withdrawal from ethical drugs may still be quite severe.[35] Leaders of wilderness ventures must recognize the danger of disruptive psychiatric problems and attempt to prevent them by careful screening before the venture.

As people age, a variety of cognitive disorders becomes apparent, including progressive dementia, acute confusional states such as delirium, and cognitive disorders resulting from psychiatric syndromes. Table 93-6 distinguishes delirium from dementia.[62] The cause of dementia is not uniform and includes Alzheimer disease, cerebrovascular disease, Lewy body dementia, and frontotemporal dementia, as well as multiple forms of reversible "pseudodementia" such as vitamin B_{12} deficiency, depression, and hypothyroidism.[9,28] The most common cause of dementia is Alzheimer disease, afflicting 26.6 million individuals worldwide in 2006 and projected to affect 1 in 85 persons by 2050.[14] In the United States, the cost of dementia care was $604 billion in 2010; if these expenses represented the gross domestic

TABLE 93-6 Features Distinguishing Delirium From Dementia

Characteristic	Delirium	Dementia
Onset	Hours to days	Months to years
Course	Waxing and waning	Stable
Inattention	Present	Usually absent
Altered level of consciousness	Usually present	Typically absent
Disorganized thinking	May be present	Typically absent
Sleep-wake cycle	Present	Typically absent
Perceptual disturbances and hallucinations	May be present	Typically absent
Reversible cognitive decline	Usually reversible	Rarely reversible

Han JH, Wilber ST: Altered mental status in older patients in the emergency department, Clin Geriatr Med 29:101-136, 2013.

TABLE 93-7 Distinguishing Features of Different Forms of Dementia and Conditions That Mimic Dementia

Characteristic	Delirium
Alzheimer disease	Early: gradual memory loss with preserved level of consciousness, subtle language errors, worsened visual-spatial perception Midstage: apraxia, disorientation, impaired judgment Late stage: aphasia, apraxia, agnosia, inattention
Vascular dementia	Loss of cognitive function correlated with cerebrovascular events, stepwise deterioration; may present in individuals with "silent" strokes
Lewy body dementia	Mild parkinsonism with unexplained falls, hallucinations and delusions, fluctuating cognition, extreme sensitivity to extrapyramidal side effects of antipsychotic medications
Frontotemporal dementia	Onset often before age 60, language difficulties common, prominent personality changes often with behavior disturbances such as impulsivity or aggression
Depression, major	Anhedonia, hopelessness; diminished self-worth, appetite, and libido
Medications	Benzodiazepines, barbiturates, anticholinergics, other sedative-hypnotics
Traumatic brain injury	Features vary by site of injury; personality and mood changes common
Normal-pressure hydrocephalus	Gait instability, urinary incontinence, psychomotor slowing and apathy

Adapted from Blass DM, Rabins PV: In the clinic: dementia, Ann Intern Med 148:ITC4-1-ITC4-16, 2008, Table 1, p ITC4-5.

product of a nation, the nation would have the world's 18th largest economy.[140]

Table 93-7 differentiates the features of various forms of dementia.[9] Although the impact of various forms has not been formally evaluated in wilderness settings, theoretically, different issues can be anticipated in planning such adventures. Early Alzheimer dementia is characterized by gradual memory loss, language errors, and declining visual-spatial perception, so these individuals could manifest short-term memory deficits by failing to inform the wilderness medicine clinician about pertinent health issues or forgetting key recommendations before or during a wilderness adventure. Vascular dementia manifests as stepwise deterioration correlated with cerebral ischemic events; the specific cognitive deficit varies with the anatomic distribution of the ischemic injury. Lewy body dementia is characterized by Parkinsonism, frequent falls, hallucinations, and fluctuating cognition, all of which could present extreme hazards to a patient and travel companions during a wilderness adventure. Frontotemporal dementia often presents before age 60 years; memory is preserved early in the course of disease but personality changes, such as impulsivity and apathy, become apparent that may be hazardous during a wilderness adventure. By understanding the specific dementia diagnosis, wilderness medicine clinicians, patients, and their travel companions can plan adventures more appropriately, including activities to avoid, anticipated supervision requirements, medications to avoid, and communication requirements for outside clinicians who may need to care for acute illnesses or injury.

Early dementia is often undetected by primary care physicians without focused case finding.[17] In fact, the U.S. Preventive Services Task Force finds insufficient evidence to support routine cognitive screening in primary care settings.[106] However, focused cognitive screening may be important for older individuals planning a wilderness adventure. Cognitive symptoms may be precipitated in vulnerable individuals by physical or environmental stresses of the wilderness.[29] The two usual sources of information concerning the status of a patient are the patient's family and the patient herself or himself. It is rare for a family member to approach the physician with concerns about the cognitive function of a relative; thus, an interview and brief mental status testing using validated instruments should be included in the medical examination.[19] Multiple dementia screening instruments exist, none of which are diagnostic when used alone.[67] Several examples of validated and appropriately brief screening instruments and scoring instructions are provided in Box 93-10, including the informant-based AD8,[19] Short Blessed Test,[19,80] Brief Alzheimer Screen,[19,101] and Clock-Drawing Test.[109] An abnormal dementia screen should prompt referral to a neurocognitive psychologist or neurologist for definitive imaging and evaluation. Delirium screening tests differ from dementia screening tests.[141] Brief delirium screening tests appropriate for office or wilderness use include the Brief Confusion Assessment Method (Figure 93-3).[63] Acute delirium is a neurologic emergency and should prompt immediate evacuation to an appropriate medical facility. A cognitive interview should provide the examiner with insight into prior cognitive skills and personality traits to serve as a baseline. Included should be the nature of the patient's memory at that time, interval since onset of symptoms, nature of onset (slow or sudden), and current state of cognitive function. Initial laboratory testing for persons with abnormal cognitive screening should include a comprehensive metabolic profile, complete blood count, thyroid-stimulating hormone level, and vitamin B_{12} level; additional tests might include the rapid plasma reagin assay, HIV testing, toxicology and heavy metal screens, and erythrocyte sedimentation rate.[9]

PHARMACOLOGY, PHARMACOKINETICS, AND POLYPHARMACY

Older people are major consumers of all categories of medications. The health status and pharmacokinetics of elders influence drug choices, dosages, prospects for adverse reactions, and

BOX 93-10 Brief Dementia Screening Tests

AD8 Dementia Screening Interview

If the patient has an accompanying reliable informant, the informant is asked the following questions:

Has this patient displayed any of the following issues? Remember that a "yes" response indicates that you think there has been a change in the last several years caused by thinking and memory (cognitive) problems.

Problems with judgment (e.g., falls for scams, makes bad financial decisions, buys gifts inappropriate for recipients)?

1. Reduced interest in hobbies or activities?
2. Repeats questions, stories, or statements?
3. Trouble learning how to use a tool, appliance, or gadget (e.g., computer, microwave, remote control)?
4. Forgets correct month or year?
5. Difficulty handling complicated financial affairs (e.g., balancing checkbook, figuring income taxes, paying bills)?
6. Difficulty remembering appointments?
7. Consistent problems with thinking and/or memory?

Each affirmative response is 1 point. If the score is 2 or higher, the risk for cognitive impairment is considered high.

BOX 93-10 Brief Dementia Screening Tests—cont'd

Short Blessed Test

Instructions to the patient: Now, I would like to ask you some questions to check your memory and concentration. Some of them may be easy and some of them may be hard.

	Correct	Incorrect
1. What year is it now?	0	1
2. What month is this?	0	1
3. Please repeat this name and address after me: John Brown, 42 Market Street, Chicago John Brown, 42 Market Street, Chicago John Brown, 42 Market Street, Chicago (underline words repeated correctly in each trial) Trials to learn _____ (if unable to do in 3 trials = C)		
4. Without looking at your watch or clock, tell me what time it is. (If response is vague, prompt for specific response within 1 hour.)	Correct 0	Incorrect 1
5. Count aloud backward from 20 to 1. (Mark correctly sequenced numerals; if patient starts counting forward or forgets the task, repeat instructions and score 1 error.) 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1	0 1 2 Errors	
6. Say the months of the year in reverse order. (If the tester needs to prompt with the last name of the month of the year, 1 error should be scored; mark correctly sequenced months.) D N O S A JL JN MY AP MR F J	0 1 2 Errors	
7. Repeat the name and address you were asked to remember. (John Brown, 42 Market Street, Chicago) _____, _____, _____, _____, _____	0 1 2 3 4 5 Errors	

Item	Errors	Weighting Factor	Final Item Score
1		× 4	
2		× 3	
3		× 3	
4		× 2	
5		× 2	
6		× 2	

Sum Total (range 0 to 28) =

0-4 = normal cognition

5-9 = questionable impairment

≥10 = impairment consistent with dementia

Brief Alzheimer Screen

Instructions to the patient: I would like to ask you some questions that ask you to use your memory. I am going to name three objects. Please wait until I say all three words; then repeat them. Remember what they are because I am going to ask you to name them again in a few minutes. Please repeat these words for me: APPLE TABLE PENNY

(May repeat names 3 times if necessary, repetition not scored.)

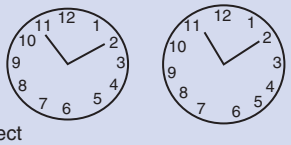
Did the patient correctly repeat all three words?	YES	NO
1. What is the date? (D)	Correct	Incorrect
2. Name as many animals as you can in 30 seconds. (A) _____ (number)		
3. Spell "world" backward. (S)	Number correct 0 1 2 3 4 5	
4. Three-item recall. (R)	Number correct 0 1 2 3	

Brief Alzheimer Screen = (3.03 × R) + (0.67 × A) = (4.75 × D) + (2.01 × S)

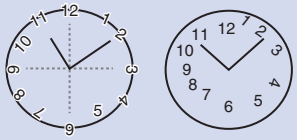
A score of 26 or lower is consistent with dementia.

Clock-Drawing Test

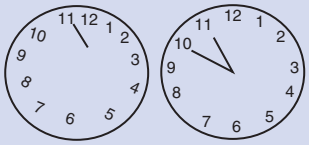
Scores above 2 suggest dementia.



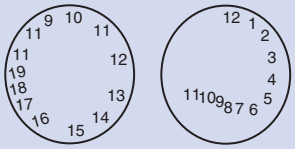
1. Perfect



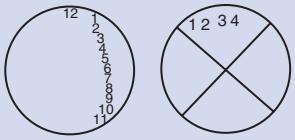
2. Minor visuospatial errors
   Examples
   - Mildly impaired spacing of times
   - Draws times outside circle
   - Turns page while writing numbers so that some numbers appear upside down
   - Draws in lines (spokes) to orient spacing



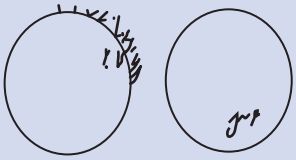
3. Inaccurate representation of 10 after 11 when visuospatial organization is perfect or shows only minor deviations.
   Examples
   - Minute hand points to 10
   - Writes '10 after 11'
   - Unable to make any denotation of time



4. Moderate visuospatial disorganization of times such that accurate denotation of 10 after 11 is impossible.
   Examples
   - Moderately poor spacing
   - Omits numbers
   - Perseveration – repeats circle or continues on past 12 to 13, 14, 15 etc.
   - Right-left reversal – numbers drawn counter clockwise
   - Dysgraphia – unable to write numbers accurately



5. Severe level of disorganization as described in 4.



6. No reasonable representation of a clock
   Exclude severe depression or other psychotic states.
   Examples
   - No attempt at all
   - No semblance of a clock at all
   - Writes a word or name

Adapted from Carpenter CR, Bassett ER, Fischer GM, et al: Four sensitive screening tools to detect cognitive impairment in geriatric emergency department patients: Brief Alzheimer Screen, Short Blessed Test, Ottawa3DY, and the caregiver-completed AD8, Acad Emerg Med 18(4):374-384, 2011; and from http://tinyurl.com/ClockDrawingTest2015.

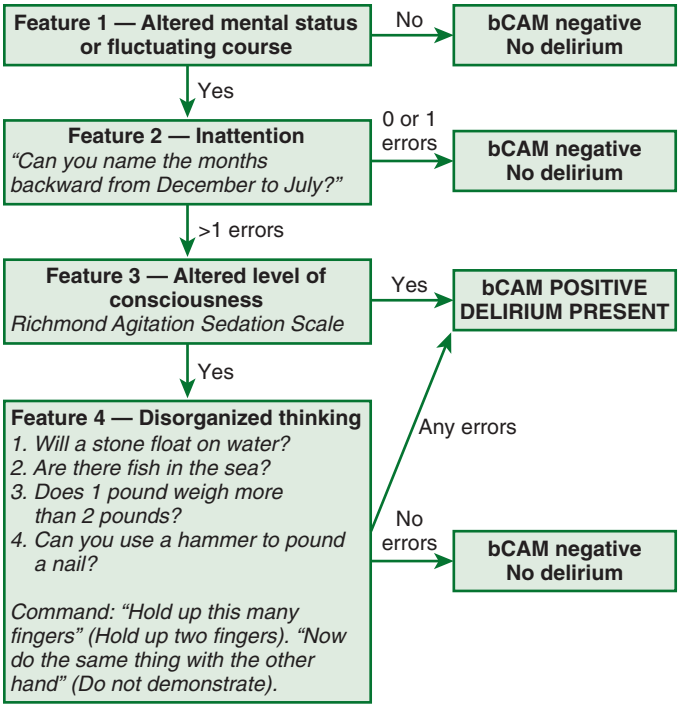


FIGURE 93-3 Brief Confusion Assessment Method and Delirium Triage Screen. *(From Han JH, Wilson A, Vaselevskis EE, et al: Diagnosing delirium in older emergency department patients: validity and reliability of the delirium triage screen and the brief confusion assessment method,* Ann Emerg Med *62:457-465, 2013.)*

therapeutic goals. The physician assessment of older adults before wilderness activities should include a careful review of all medications.[11] Age-related physiologic changes that may influence pharmacokinetics include reduced gastric acid production and altered gastric emptying that affect absorption; reduced splanchnic blood flow that affects first-pass (or presystemic) clearance; reduced body water, serum albumin, body fat, and body mass that affect protein binding; changes in hepatic size and blood flow that affect hepatic clearance; and reduced glomerular filtration rate and renal tubular function that affect renal clearance.[125] As a result, physicians recognize that it is usually prudent to begin with a lower starting dose and lower maintenance dose of certain prescribed medications in older patients.

CONCLUSION

Older adults are exploring wilderness environments with increasing frequency because they enjoy the fellowship, camaraderie, and adventure of these activities. Unfortunately, health risks associated with high-performance activities increase with age because of altered physiologic function, unrecognized impairments, or the cumulative effects of illnesses and their treatment. To reduce risks, appropriately screened older adults should be advised to temper their enthusiasm with the caution derived from the wisdom of experience. Importantly, a healthy respect for risk should not become a fear that precludes beneficial and desirable wilderness experiences. "Old" is not synonymous with "unable." The golden years hold many opportunities for adventure. We concur that the optimist sees sunset as sunrise in reverse.

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Complete references used in this text are available online at expertconsult.inkling.com.

CHAPTER 94

Persons With Disabilities in the Wilderness

SUSAN B. SHEEHY

A blind climber reached the summit of Mt Everest. A group of people, including several people with disabilities, rafted the Middle Fork of the Salmon River in Idaho and camped on its banks. A Wounded Warrior double amputee completed a triathlon in Hawaii. A group of people with tetraplegic spinal cord injuries scuba-dived in Belize. A young paraplegic male scaled El Capitan in Yosemite National Park. People with disabilities who participate in outdoor activities express feelings of significant accomplishment and increased self-confidence. Those who accompany them express deeper understanding of the abilities of people with disabilities, feelings of personal growth, and gratefulness for being able to witness such significant and life-changing accomplishments.

Why would people with disabilities want to participate in wilderness activities? Their reasons are the same as those of able-bodied people. They want to experience the beauty of the wilderness and challenge themselves. They possess the same competitive spirit as do able-bodied people and often work diligently to build endurance, strength, speed, and the skills to transfer to wilderness activities. People with disabilities do not want the wilderness environment altered to meet their accessibility needs. Rather, they want it preserved in its natural state.[47] It is essential to provide information about opportunities for wilderness adventures, including organizations that have programs for people with disabilities and the types of programs they offer, places where disabled persons can obtain appropriate equipment and guides/helpers, preparations needed before a trip, and things to consider during a trip.

The benefits of wilderness adventures for people with disabilities are increased self-efficacy, deeper understanding of

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personal abilities and capabilities, improved functional independence, satisfaction in succeeding at challenges, new opportunities, greater social adjustments, improved physical and psychological health, building like-minded relationships, deeper appreciation for nature, the positive reactions of family members, and spiritual benefits.[63] People with disabilities who participate in wilderness activities experience outcomes that result in positive outlooks on their personal lives, work, and family relationships. *"Study results on integrated wilderness adventure programs indicate that these programs are successful therapies for persons with disabilities with low morale, showing an increase in self-awareness, personal goals, interpersonal relationships, and nature appreciation."*[38]

PEOPLE WITH DISABILITIES IN THE WILDERNESS

Wilderness is defined as a remote geographic location more than 1 hour from definitive medical care.[27] There are numerous wilderness opportunities available to people with disabilities. Many organizations offer equipment, guides, and activities for all ages and most levels of disability regardless of ability to pay. Many people with disabilities take part in activities that were previously thought impossible. Wheelchair users can rock climb and people with tetraplegia are able to swim with sharks. People with amputations can hike and run trails. People with hearing loss can raft rivers, and people with vision loss can climb mountains. These activities require significant knowledge about the disability and possible complications and detailed pretrip planning.

One cannot hike a trail if one cannot reach the trail. However, with adaptive devices, the trail may become accessible. As long as safety is a priority, people with disabilities can take part in many outdoor activities with the help of friends, guides, and adaptive equipment. Wilderness activities for people with disabilities can help to dispel the myths of limitations and reveal realities about abilities of people with disabilities (Figure 94-1).

PREPARATION FOR A WILDERNESS ADVENTURE

Many wilderness activities require no special adaptation for people with disabilities, and others can be adapted to meet special needs. Adaptive equipment should be viewed as assistive devices that help a person supersede physical limitations and/or provide extra safety measures.

FIGURE 94-1 Double amputee hiking a mountain trail. *(Courtesy the Borden Institute, Ft Detrick, Maryland.)*

TABLE 94-1 General Considerations in Planning for a Trip by a Disabled Person

Topic	Considerations
Risk assessment and precautions	Diagnosis-specific potential complications during the trip
Limitations of the condition	Functional; cardiac; respiratory; elimination; psychological
Medical clearance	Physician authorization to participate
Personal care needs	Self-care; requires some assistance; requires complete assistance
Environmental hazards	Hazards specific to the condition
Available resources during the trip (including evacuation plan)	Location of resources; how to gain access to resources; time and distance to resources
Regulations specific to area	Special requirements or permits for use of assistive devices
Weather conditions	Short-term and long-range weather forecast; especially important for climbers, those using motorized vehicles, and those wearing prosthetic devices

As needed for an able-bodied person, it is important to train appropriately and specifically for any physical activity. It is essential to match adaptive devices to the participants' needs, body types, and skill levels. Inappropriate adaptive equipment (fit or type) may result in physical injury or adversely affect physical ability and inhibit performance. People with disabilities and chronic illnesses are at risk for any of the hazards usually associated with an activity, to which are added unique potential complications associated with a disability or illness. Health care providers accompanying people with disabilities in the wilderness must be equipped with the knowledge, ability, and equipment to manage all aspects of complications. In preparation for a safe and successful wilderness experience, plans must include anticipation of potential medical complications, knowledge of treatment protocols, and appropriate supplies, equipment, and medications.

Careful planning for the entire experience is essential and must include assurance that others on the trip are in agreement with and involved in pretrip planning. Anticipate any challenges that are expected or may occur and be prepared to address them, including emergency medications and treatment modalities related to the disability and an evacuation plan. Ensure that the person with the disability participates in planning for the trip to the extent possible, including taking part in a physical conditioning program and having a full understanding of physiologic limitations and risk factors (Table 94-1).

WORLDWIDE WILDERNESS PROGRAMS FOR PERSONS WITH DISABILITIES

Education and adventure groups have expanded their programs to be inclusive of people with functional limitations. There are customized programs that incorporate outdoor activities such as hiking, running, camping, rafting, canoeing, kayaking, caving, scuba diving, hunting, fishing, skiing, bicycling, and rock climbing. The national organization specific to a given disability or sport can be used as a reference point to explore wilderness opportunities, regardless of one's ability level.

In Canada, a nationwide campaign was launched by 250 communities with the goal of promoting public awareness of the fact that people with disabilities can function independently within society.[26] By 1992, more than 600 additional communities joined the effort. The British Mountaineering Council of the United Kingdom lists all the adventure clubs in the UK for climbers, hill

TABLE 94-2 Prevalence of Disability for Selected Age Groups: 2005 and 2010

Category	2005 Number	2005 %	2010 Number	2010 %
All ages	**291,099,000**	**100%**	**303,858,000**	**100**
Disabled	54,425,000	18.7	56,672,000	187
Severely disabled	34,947,000	12.0	38,284,000	12.6
Age ≥ 6 years	**266,752,000**	**100**	**278,222,000**	**100**
Needed personal assistance with an ADL or IADL	10,996,000	4.1	12,349,000	4.4
Age ≥ 15 years	**230,391,000**	**100**	**241,682,000**	**100**
Disabled	49,069,000	21.3	51,454,000	21.3
Severely disabled	32,771,000	14.2	35,683,000	14.8
Vision impairment	7,793,000	3.4	8,077,000	3.3
Severe vision impairment	1,783,000	0.8	2,010,000	0,8
Hearing impairment	7,809,000	3.4	7,572,000	3.1
Severe hearing impairment	993,000	0.4	1,092,000	0.5
Age 21-64 years	**170,349,000**	**100**	**177,295,000**	**100**
Disabled	21,141,000	16.5	29,479,000	16.6
Severely disabled	18,705,000	11.0	20,286,000	11.4
Age ≥ 65 years	**35,028,000**	**100**	**38,599,000**	**100**
Disabled	18,132,000	51.8	19,234,000	49
Severely disabled	12,942,000	36.9	14,138,000	36.6

Adapted from 2010 U.S. Census Report: census.gov.
ADL, Activity of daily living; *IADL*, instrumental activity of daily living

walkers, and mountaineers and indicates which ones are accessible to people with disabilities. There are many other organizations across the United States and in other countries that offer similar services. Outward Bound in the United States (outwardbound.org) offers an 8-day course, "Activate," where persons with disabilities can experience the full range of activities typical of an Outward Bound course for able-bodied people.

PREVALENCE OF DISABILITY IN THE UNITED STATES

Approximately 19% of the U.S. population (56.7 million people) lives with some level of disability. Of these, approximately 38.3 million have severe disabilities.[72] In addition, of the estimated 2 million young men and women who were deployed to Iraq and Afghanistan between 2001 and 2014, there have been more than 60,000 wounded in action (fractures, shrapnel wounds, burns, traumatic brain injuries, spinal cord injuries, loss of vision and/or hearing, amputations, and other injuries resulting in nerve damage and paralysis, leading to permanent disabilities).[18] These young men and women are returning home to heal and reintegrate. Wilderness activities can help to rebuild confidence, inspire undertaking new adventures, and regain a sense of self-worth (Tables 94-2 and 94-3).

TABLE 94-3 Number of People in the United States With Specific Disabilities (U.S. Census, 2012)

Specific Disability	Number of People
Vision loss	8.1 million
Hearing loss	7.6 million
Mobility challenges	30.6 million
Lifting/grasping challenges	19.9 million
Severe depression/anxiety	7.0 million

A BRIEF HISTORY OF DISABILITIES, DISABILITY TERMINOLOGY, AND DISABILITY ETIQUETTE

The definition and descriptions of disabilities have evolved over millennia. The ancient Greeks thought that sick people were inferior.[7] Plato determined that "deformed offspring" should be put away in some mysterious unknown place.[33] Early Christian doctrine spoke to a person being diseased as a means of purification on the road to grace and not to be disgraced or punished.[7] In the 16th century, however, Luther and Calvin preached that people who were mentally retarded or who had other disabilities were possessed by demons.[49] Hobbes wrote that 19th century Darwinism supporters believed that protecting the "unfit" would be a barrier in the process of natural selection of the fittest.[37]

The first mention of disabilities in the United States was in the Military Laws of the United States Army, where the policy for pensions and compensation for disabilities and deaths were defined. *Disabled* was defined as "any degree of personal disability which renders the individual less able to provide for his subsistence … a disability may properly be said to be permanent when it appears to be chronic or of indefinite future duration."[46]

The word *disability* is defined as "an inability to pursue an occupation because of a physical or mental impairment; lack of legal qualifications to do something; disqualification, restriction, or disadvantage; incapacitated by illness or injury; physically or mentally impaired in a way that substantially limits activity, especially in relation to employment or education" (*Merriam-Webster*, 2015). Disabilities were previously defined as physical impairments that occurred as results of accidents, illnesses, and congenital conditions. Currently they are described as multidimensional, to include physical, mental, and emotional conditions that restrict both physical and social activities.

For purposes of this chapter, the Americans with Disabilities Act (ADA) of 2008 (a federal law) definition will be used. The ADA states that a person with a disability is "any person who has a physical or mental impairment that substantially limits one of more major life activities, has a record of such impairment, or is regarded as having such an impairment."[4] Several federal agencies have defined disabilities within the parameters of their targeted programs. The ADA Amendment Act of 2008 defined major life activities as "… caring for one's self, performing manual tasks, seeing, hearing, eating, sleeping, walking, standing, lifting, bending, speaking, reading, learning, concentrating, thinking, communicating, and working" … and further defines a major life activity to include … "the operation of a major bodily function, including but not limited to, functions of the immune system, normal cell growth, digestive, bowel, bladder, neurologic, brain, respiratory, circulatory, endocrine, and reproductive functions."[4]

The World Health Organization summarized its definition of disability with the following, "Disabilities is an umbrella term covering impairments, activity limitations, and participation restrictions. An impairment is a problem in body function or structure; an activity limitation is the difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations. Thus disability is a complex phenomenon reflecting an interaction between features of a person's body and features of the society in which he or she lives."[78]

For the purposes of this chapter, the ADA definition will be foundational: a physical or mental impairment that substantially limits one or more major life activities.[4]

DISABILITY ETIQUETTE

Most people with disabilities are sensitive to terms used to describe their disabilities. Terminology can cause one to place unintentional restrictions on persons with disabilities. Do not use terms such as "disabled person" or "the amputee." S/he is "a person with a disability" and/or "a person with an amputation." People in wheelchairs should not be referred to as "wheelchair bound." Rather, they are "people who use wheelchairs."

BOX 94-1 Barriers to Participation in Wilderness Activities for a Disabled Person

Limited physical abilities
Physiologic limitations
Personal motivation
Cost
Time
Transportation
Adaptive equipment
Willing companions
Knowledgeable coaches and companions and experienced health care person
Program availability
Program accessibility

If you see someone with a disability struggling to complete a task, ask if you may be of help or how you can be of help; do not assume the person wants your help.

BARRIERS THAT RESTRICT PEOPLE WITH DISABILITIES

Barriers that restrict people with disabilities from wilderness activity participation may be personal, attitudinal, physical, or psychological. The person with a disability may lack self-confidence, have low self-esteem, be isolated, have difficulty finding acceptance, and lack the finances and transportation to avail themselves of wilderness programs and equipment (Box 94-1).

WILDERNESS LEGAL AND LEGISLATIVE ISSUES

In 1990, the Americans with Disability Act (ADA) was signed into law.[73] It is considered by many to be the civil rights legislation for people with disabilities that prohibits discrimination based on someone's ability and the person's need for accommodations and accessibility. The bill's primary sponsor was Senator Tom Harkin (D-IA), whose deaf brother was present in the Senate gallery when his brother's speech was simultaneously delivered vocally and in American Sign Language. The Act was further amended in 2008[4] to clarify definitions of disabilities and broaden the scope of the law.

Until the ADA was enacted, the Wilderness Act of 1964,[76] in particular Section 4C, had provisions that essentially prohibited people with disabilities who required motorized assistive devices from gaining access to wilderness environments. "… [T]here should be no temporary road, motor vehicles, motorized equipment or motor boats, no landing of aircraft, no other form of mechanical transport, and no structure or installation within any such area."

The ADA defines people with disabilities[73] as:

1. People with physical or mental impairments that substantially limit one of more of their major life activities
2. Those with a record of such impairments
3. Those being regarded as having such impairment

Disability is recognized by the ADA as a multidimensional and complex entity involving physical, emotional, and mental elements of functioning and includes restrictions in participation in social activities and being able to participate in the environment where one lives, works, and plays. This expanded definition of disability has led to federal funding to increase opportunities for people with disabilities so that they are able to be productive in the workplace and participate in physical activities. It provides for persons with disabilities being able to use necessary assistive devices, such as wheelchairs, respiratory assist devices, and service dogs, in the wilderness.

The National Council on Disabilities prepared a report for the President and the Congress on accessibility for people with disabilities as determined in Section 507(a) of the ADA and the Wilderness Act. "In general—Congress reaffirms that nothing in the Wilderness Act is to be construed as prohibiting the use of a wheelchair in a wilderness area by an individual whose disability requires use of a wheelchair, and consistent with the Wilderness Act, no agency is required to provide any form of special treatment or accommodation, or to construct any facility or modify any conditions of lands within a wilderness area to facilitate such use." It went on to say that the National Park System is not mandated to alter trails, campsites, footbridges, or make other accommodations within the National Parks and that motorized wheelchairs that are designed for indoor use and for use in pedestrian areas may be used in wilderness areas, but that other motorized vehicles, such as all-terrain vehicles, may not be used on lands within the National Wilderness Preservation System.[52]

Prior to the Wilderness Preservation Act and the ADA, the Architectural Barriers Act of 1968 and Section 504 of the Rehabilitation Act of 1973 (amended in 1978) mandated that the National Park Service policy would ensure the highest feasible level of accessibility in all visitor and management buildings and facilities, provided that the nature of both the area and the facility remained intact.

PREPARING PEOPLE WITH DISABILITIES FOR WILDERNESS ADVENTURES

In the spirit of the 1948 London Olympic Games, Sir Ludwig Gutmann from the Stokes Mandeville Hospital arranged for a wheelchair competition. It was met with such enthusiasm that the Stokes Mandeville Games became a regular occurrence and precursor to the current Paralympic Games,[17] which demonstrate the athleticism of people with disabilities.

Over the last several decades, people with disabilities have been encouraged to participate in more activities. There has been a great deal of focus on assisting people to achieve personal goals despite their disabilities, with much emphasis on exercise. The keys to safe wilderness adventures are maximizing functional independence and minimizing health risks. Prior to participating in a wilderness experience, a functional assessment should be completed to plan for the trip and to understand the limitations of the person with a disability. Of particular importance is assessment of the level of independence, ability to transfer or ambulate, level of mobility with and without adaptive equipment, and proficiency in using adaptive equipment.

Fitness programs for people with disabilities typically focus on improving cardiovascular endurance and increasing muscle strength and range of motion. The American College of Sports Medicine has proposed that problem-oriented exercise management be used to develop custom exercise programs for people with a variety of physical challenges and disabilities.[3] Problem-oriented exercise management uses exercise testing to identify physiologic dysfunction in such areas as mobility, strength, and endurance. It provides information to guide training and integrates exercise into medical management plans with attainable goals. A cognitive assessment may also be helpful to estimate the ability for skills acquisition and awareness of safety issues. A number of cognitive assessment tools, such as the Mini-Mental State Examination, are available for practitioner use.

The goals of preparticipation examinations are to assess, educate, and prevent. Appropriate physical screening must take place to rule out contraindications for a given activity and to develop a list of precautions. One should assess the physical capacity to understand and perform physical requirements for a specific activity; educate the participant about exercise preparation and potential medical risks; provide information to both participant and team members about the participant and potential safety risks; take into consideration the effects of medications; weigh the risks, costs, and benefits of a specific activity; and determine the costs associated with training requirements.

There are no standard guidelines that define how many people are required to safely support a person with a disability

BOX 94-2 Equipment and Supplies to Consider Bringing on a Trip

Food
Water disinfection equipment
Diet-specific food
Electrolyte replacements

Gear
Durable medical equipment
Adaptive equipment for specific sports

Activities of Daily Living
Adaptive devices
Toileting supplies: catheters, suppositories, plastic bags with zip closure, wipes, toilet paper, nonlatex gloves

Sleeping
Appropriate padding; warmth, pillows, foam

Head
Hat, cap with visor, sunglasses, goggles, bandana

Upper Body Clothing
Long-sleeve shirts, warm jacket, hoods, scarfs, waterproof jacket, rain poncho

Lower Body Clothing
Extra dresser , long underwear, waterproof pants, bathing suit, wet suit

Hands
Mittens, gloves, hand warmers*

Feet
Socks (liners and heavy weight), foot warmers*

Accessories
Appropriate backpack, first-aid kit, insect repellent, sunscreen, lip gloss, trash bags (heavy-weight black trash bags for insulation), instruction books, emergency phone numbers, cell phone, evacuation plan

Medications and Lotions
Prescription medications (bring extra), antibiotics, eye drops, normal saline (for irrigation), anti-diarrheals, laxatives, analgesics, antacids, topical steroids, sunscreen, antihistamine, epinephrine, calamine lotion

*Do not use hand or foot warmers if there is loss of sensation and heat of the pack cannot be sensed by the user

in the wilderness. It may take as few as one or a team of five or more people, depending upon the person's disability, ability, and strength of each team member. Every situation is unique and therefore requires careful planning and determination of resources. Common sense thorough preplanning is essential.

The first step is to define the nature of the activity, where it will take place, and for how long it will last. One then factors in the season and weather conditions. Determine the accessibility to and within the site and any special equipment that may be necessary. Inquire about the condition of pathways and trails, especially for use by mobility assist devices.

There may be disruption of normal activities of daily living. This may result in frustration and discomfort. Ask the participant if he or she has had prior difficulties with heat or cold. Someone on the trip team must receive and understand all pertinent medical information, including medications, signs and symptoms, possible complications, and treatments. The caregiver should be prepared to make medical decisions and initiate interventions, and determine when medical evacuation is necessary. This necessitates knowledge about the rescue and evacuation process supported by possession of communication devices such as satellite phones or emergency personal radio beacons (Box 94-2).

Answers to these questions will assist trip planners in acting to prevent complications rather than needing to react when a complication occurs. Should a complication occur, they will be fully prepared to intervene (Box 94-3).

BOX 94-3 Questions a Physician Should Be Ready to Respond to as a Person Prepares for a Trip

What are the potential complications of the disability or condition?
Which complications associated with this disability or condition commonly affect this individual?
How is the complication managed at home?
Will the wilderness environment be the cause of possible complications?
How can the complication be prevented?
What specialty equipment is necessary to prevent complications?

With solid planning, team support, and proper equipment, a wilderness experience for a person with a disability can be safe and enjoyable (Box 94-4).

CHECKLIST FOR PREPARATION FOR A TRIP

Participant education: Brief all participants about specifics of the trip. Provide details to the person with a disability.

Pretrip planning: Discuss every aspect of the trip and determine what needs to be accomplished prior to the trip, including physical preparation; obtaining permits, necessary equipment, supplies, assistive devices, and special equipment; and incorporating dietary requirements.

Prevention: Discuss possible complications specific to the participant's condition and plan preventive measures.

Fitness and conditioning prior to departure: Discuss the amount of time required and specific ways to prepare for the physical requirements of the trip.

Hygiene during the trip: Determine methods for toileting and bathing during the trip, to include any special equipment.

Guidance required during the trip: Determine who will be the designated guide for the disabled person and which members of the trip can provide extra assistance as needed.

Expectations: Review trip activities and minimum to maximum expectations of all members of the trip.

Medical clearance: Obtain medical clearance if necessary.

Immunizations: Ensure that routine immunizations are current and obtain those that are specific to the region in which the trip will take place.

Medications: Bring prescription medications, including broad-spectrum antibiotics, eye drops, antidiarrheal and anticonstipation medications, analgesics, antacids, and topical steroids.

Address fears: Address and acknowledge fears, such as concerns about snakes or other animals that might be encountered, heights, claustrophobia.

Protection: Bring supplies to prevent sunburn and protect the traveler from rain, snow, heat, cold, and insect bites. Plan for frequent rest stops within the time and mileage goals to allow for position changes and stretching. Apply sunscreen of the appropriate sun protection factor (SPF) to any exposed body areas. Cover large areas with clothing. Take extra precautions if the person is taking medications that increase sun sensitivity (see Box 94-2).

BOX 94-4 General Guidelines for an Outdoor Experience for People With Disabilities

Check frequently for hypothermia
Maintain adequate hydration by drinking plenty of liquids
Maintain the same eating schedule as that of home
Bring enough medication to last at least 3 days beyond the length of the trip
Bring a family member or personal care attendant if needed
Let other key people who are not coming on the trip know the planned itinerary and overnight locations

National Center on Physical Activity and Disability, Department of Disability and Human Development: General guidelines for an outdoor experience, 2011, Chicago, 2011, College of Applied Health Sciences, University of Illinois: nchpad.org.

FIGURE 94-2 Master Sargent Cedric King, double amputee, training for a long-distance cross-country run. *(Courtesy MSGT Cedric King.)*

SELECTED DISABILITIES WITH WILDERNESS CONSIDERATIONS

PERSONS WITH CHALLENGES TO MOBILITY

There are more than 9.9 million people over the age of 15 years who have upper body mobility limitations, including difficulties with physical tasks. In addition, there are more than 30.6 million people over the age of 15 years who have lower body mobility limitations while walking, transferring, and climbing stairs. There are more than 3.6 million permanent wheelchair users, and 1.6 million permanent crutch, cane, or walker users.[72]

In addition to the source of the immobility, there are common secondary complications of immobility that include shoulder, back, and wrist pain, poor sleep patterns, spasticity, muscle atrophy, low self-esteem, depression, and weight issues. All of these should be considered when preparing for a wilderness adventure. Common wilderness challenges for people with mobility issues are steep grades, uneven terrain, adverse weather conditions, and inability to use assistive devices in certain situations.

PERSONS WITH AMPUTATIONS

There are more than 1.7 million people in the United States living with amputations (Figure 94-2).[79] Eighty-two percent of new amputations occur as a result of vascular system issues in the elderly population. Of these, 97% are lower extremity amputations, with 25% above the knee and 27.6% below the knee.[5] Other amputations occur as the result of trauma or malignant diseases. Amputations are one of the signature injuries of the recent Middle East wars due to mounted (in vehicles) and dismounted (foot patrol) encounters with improvised explosive devices. Approximately 1558 (6%) of the U.S. casualties in the post-9/11 wars resulted in amputations of one or more limbs.[15]

People who undergo amputations are fitted with prosthetic devices early in their recovery periods and discouraged from using wheelchairs except in cases of extreme fatigue or stump wounds. Because of the high volume of young military personnel with amputations, significant research has been focused on better design and function of upper and lower limb prosthetics. Due to rapid advances in technology, people with amputations are able to increasingly become more active and independent and are able to participate in a wide range of activities. Evolution of advanced prosthetics and bionics has enabled people with amputations to grasp, ambulate, run short and long distances, dance, hike, climb, cycle, swim, and do most anything able-bodied people can do (Figures 94-3 and 94-4).

The functional level of a person with an amputation depends upon several factors, including the initial injury, how the remaining part of the limb heals and how much is viable, the potential for rehabilitation, type of prosthetic that is appropriate for the patient, and joint function as it relates to the wound.[16,35] Age, rather than level of amputation, appears to be what influences

FIGURE 94-3 The bebionic hand. *(Courtesy Advanced Arm Dynamics.)*

participation in wilderness activities. The functional level also depends upon the psychological response of the person to the injury, because losing a limb is a very personal loss and adjustment to the loss often takes time. Early engagement in activities often affects the outlook and willingness to continue to participate in such activities.

Prosthetics

Most limb prosthetics have a socket that connects to the residual limb and transmits forces associated with movement. The limb

FIGURE 94-4 Dynamic-response prosthetic foot. *(Courtesy Diest and Associates Prosthetic Centre, Pretoria, South Africa, and Össur, Inc.)*

prosthetic attaches to the body using a suspension mechanism. The type of suspension mechanism depends upon the limb that is affected, the amount of residual of that limb, and for which activities the prosthetic will be used. Prosthetics typically have a pylon, joint, and terminal device. The pylon is a shell that connects the socket to the terminal device. Terminal devices have different functions. For example, lower extremity prosthetics have five basic foot functions: shock absorption; stable weight-bearing surface; anatomic joint function; cosmetic appearance; and adequate strength for the activity.

There have been many new prosthetic knee and foot designs that enable people with amputations to participate in rigorous physical activities. Designs are lightweight and able to deform when bearing a load, returning to their original shape when the load is lightened. There are prosthetics for rock climbing, running, cycling, swimming, and many other activities. If used for hiking or running, one may consider using larger sockets and additional padding.

Preparation of Prosthetics Before a Trip. It is important to preplan the types of prosthetics that will be required for a specific wilderness adventure, ensuring that the person with the amputation has been fitted and has had time to get used to that type of prosthetic. For questions about specific types of prosthetics for various activities, one should consult a prosthetist for expert advice. Be sure to pack tools that may be required for repairs along the way and consider bringing a spare prosthetic in the event of damage to the original one. Keep the prosthetic dry if it is not meant for water sports. Elastomeric skins are available to cover and protect prosthetics.

A good way for someone with an amputation to condition aerobically without high impact to the residual limb is cycling or swimming. There are several different types of swimming prosthetics, making it easier to maintain parallel trunk and shoulders, to propel, and to enter and exit the water. Most below-the-knee swim prosthetics are hollow and fill with water when submerged to decrease buoyancy. A hole drilled in the ankle area allows water to drain upon exit from the water. Upper extremity prosthetics have similar use principles as lower extremity prosthetics. Above-knee swim prosthetics have quick-release lock mechanisms that allow the user to walk on land. Many persons with amputations prefer to swim without a prosthetic device. It is possible to use swim fins with certain water prosthetics.

Check all prosthetic components frequently. Consider a change of training routine prior to the wilderness adventure in order to adapt to a new prosthetic. Ensure that the fit and suspension are good and that the prosthetic has the proper amount of shock-absorbing capacity. If more-rigorous-than-normal activities are required, the person with the amputation should train accordingly. If a new prosthetic device is required, be sure it is used prior to the trip to ensure proper fit and comfort.

Adaptive devices are available for various sports, such as skiing, using a three-track ski or single ski (sit-ski, monoski, or regular ski with two outriggers) that can be used both by amputees and by people with paraplegia. With appropriate training, proper assistance, and adaptive equipment, healthy people with amputations may develop the ability to perform almost any wilderness activity (Figure 94-5).[21]

Discomfort Caused by Prosthetics. Swelling of the distal segment of the residual limb is usually due to a socket that is too tight, causing venous outflow obstruction. If the socket is too loose, swelling will occur to fill the empty space. Protection of the skin under the prosthetic depends upon the specific construction of the prosthetic. Some prosthetics employ a traditional stockinette, some use silicone "socks," and others use a vacuum technique that suspends the stump without the distal part of the stump touching prosthetic material. If blisters or abrasions occur on the stump during the trip, remove the prosthetic and treat the injured area immediately. The prosthetic should not be worn until the blisters and/or abrasions are treated and deemed safe to bear pressure and friction. An alternate form of mobility, such as a wheelchair, must be provided.

Causes of prosthetic discomfort can be poor fit, inadequate suspension, and shock-absorbing qualities less than what are required for a particular sport, any of which can result in blisters, abrasions, pressure sores, edema, and back pain.

FIGURE 94-5 Single-track cross-country skier at Ski for Light, 2005. *(Courtesy Craig Gray.)*

As with any other athlete, be cognizant of hypothermia or hyperthermia and various forms of dehydration. Because of an absent limb, especially a lower limb, temperature control may be challenging, because excessive perspiration may occur on other parts of the body, resulting in hypothermia and dehydration. Replace wet clothing and stump socks with dry apparel, and pay particular attention to fluid intake and systemic hydration.

PERSONS WITH CEREBRAL PALSY

Most people with cerebral palsy have muscle imbalances, difficulty with balance and posture, and vision, speech, and swallowing issues. They are readily prone to dehydration and exhaustion. Many have cognitive disabilities; others have excellent cognition but lack the ability to communicate via speech. If speech recognition or simulation devices are available and accompany the participant on an adventure, ensure that a battery source is available for the duration of the trip.

Trip Preparation

Persons with cerebral palsy require varying levels of assistance depending upon the severity of their condition. It is essential for persons who wish to participate in wilderness activities to prepare for the trip by exercising to strengthen muscles, increase range of motion, and increase endurance levels. Seventy-five percent of people with cerebral palsy are independent with activities of daily living, mobility, and communication.[74] The Cerebral Palsy International Sports and Recreation Association developed a classification system based on functional abilities.[13] The classification system also includes other conditions characterized by nonprogressive brain lesions, such as stroke, brain injuries, and tumors.

Challenges During the Trip

Low-intensity exercises, such as walking, may prove to be much more intense for people with cerebral palsy. They are more likely to injure the shoulders, hands, knees, and ankles.[67] They are also more prone to dehydration and exhaustion due to the excess energy required for simple physical activities and needed to overcome increased tone. Dehydration commonly leads to constipation, electrolyte imbalance, muscle inefficiency, and renal insufficiency. Be particularly cognizant of the need for frequent hydration, and ensure that there are ample fluids available. Pace activities to avoid exhaustion, which may lead to decreased muscle coordination. Select activities that can be adjusted in intensity and pace, such as walking, hiking, backpacking, swimming, and cycling, and take frequent rest stops.

PERSONS WITH MULTIPLE SCLEROSIS

There are approximately 400,000 people in the United States living with multiple sclerosis and approximately 10,000 newly diagnosed cases each year. It most commonly affects people between the ages of 18 and 50 years. Symptoms may be blurred vision, balance issues, weakness in extremities, numbness, tingling, vertigo, spasticity, cognitive impairment, emotional changes and depression, altered gait, and problems with balance, coordination, bladder control, and sexual function The course of the disease is variable, ranging from death within 5 years (5% of people diagnosed) to one "episode" in a lifetime.[55]

Preparation for and Challenges During the Trip

Prior to a wilderness trip, physical conditioning to improve endurance is essential. During the trip, avoid elevated body temperatures and excess humidity, because both have been associated with worsened symptoms of multiple sclerosis. Cold temperatures may cause an increase in spasticity and other symptoms. Mobility and cognition problems may be exacerbated during a trip, so be prepared to provide an alternate mobility modality, such as a wheelchair.

Bladder issues typically involve urinary frequency, retention, and/or incontinence. Be prepared to manage these situations, especially when restrooms are not readily available. Consider urinary devices specifically designed for use during travel, such as the Lady J and Freshette. Additional disposable bowel and bladder management devices can be found at www.traveljohn.com.

PERSONS WITH SPINAL CORD INJURIES

There are approximately 276,000 people in the United States living with spinal cord injuries (SCIs) (Figure 94-6), and 12,500 new cases each year. Seventy-nine percent are males. The average age at injury is 42 years, due to the high number of elder persons who sustain SCIs as a result of a fall. However, the largest percentage is typically young adolescents to young adults.[56]

Injuries range from cervical to thoracic to lumbosacral injuries. People with injuries in the cervical area typically have tetraplegia, affecting the upper extremities, lower extremities, chest, and abdomen (including bowel and bladder). Injuries at level C4 or higher may affect a person's ability to breathe without assistance due to loss of diaphragmatic innervation. Spinal cord injuries in the thoracic and lumbar regions usually result in paraplegia, affecting the abdomen (including bowel and bladder) and lower extremities. If the SCI is complete, there will be no distal motor or sensory function. If the injury is incomplete, there may be some motor and/or sensory function at or below the level of the injury. The extent of recovery depends upon the extent of damage to the spinal cord.

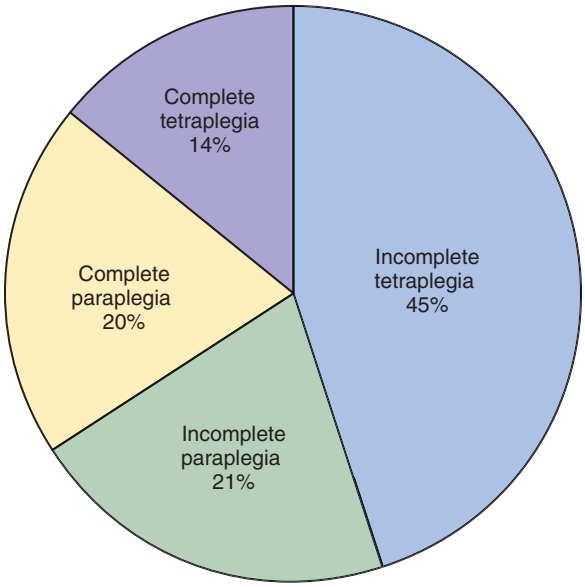

FIGURE 94-6 Types of spinal cord injuries.

Trip Preparation

Because of advances in adaptive equipment and rehabilitation programs, with preplanning, people with spinal cord injuries can now be safely and actively involved in many types of wilderness activities.

If a mobility device will be used, consider how the device will be broken down or compactly packed to allow for transport. If flying, contact the airline to obtain information about size specifications and limitations, and to obtain a "medically necessary" tag so the equipment does not count against the allowed baggage amount. Check with wilderness areas to ensure that mobility devices are permitted. Special permission may be required for use of power wheelchairs or other mobility assist devices. Bring inflatable mattresses, material for extra soft sleep surfaces and padding, and medications that are prescribed, intended for a bowel regimen, and needed for emergency purposes.

Training before the trip should focus on cardiovascular conditioning using such equipment as hand cycles, VitaGlide, or NuStep, strength and endurance training, and familiarity with equipment that will be used during the trip. New equipment should be broken in before the trip. Each member of the team should plan to spend time with the person with the disability prior to the trip so that familiarity and comfort are not issues during the trip. Identify roles and responsibilities and learn about the specific needs of the individual. Pretrip planning includes discussions with the participant about the current skin condition, how the person handles urination and a daily bowel program, and if the person will require a care provider during the trip.

Challenges During the Trip

Secure the paralyzed areas of the person, such as a limb or the upper body, to the equipment to avoid inadvertent injuries, and recheck them frequently. Pad equipment straps, such as climbing harnesses, parachute harnesses, scuba buoyancy-control devices, and other unpadded straps, to avoid pressure injuries. Protect sleep pressure areas and remember to clear stones, twigs, and other debris from sleep areas.

Protect the skin from dryness by applying moisturizer each night, paying particular attention to the hands and fingers. Ensure that gloves are durable and intact, fit well but are not constricting, are soft and smooth on the inside, and are warm and water repellent. Mittens are warmer than gloves but are not as flexible for various purposes. Carry several pairs of gloves, and change them if they become wet. If hands become cold, small hand warmers or heat packs can be used (never directly against the skin) to provide warmth. Pay special attention to the hands; check for dryness, hangnails, cuts, open scrapes, and bruises.

Persons with SCIs may have lost the sensation to cold and may therefore need protection from frostbite. Ensure that clothing and other protective equipment provide warmth and functional usability. It may be necessary for someone with an SCI to wear clothing and shoes or boots of a larger size than usual so that layers of clothing or socks can be worn underneath to provide insulation. Frequent checking of hands, fingers, feet, and toes for warmth and adequate circulation is essential. Remove any wet clothing, socks, and foot gear immediately. Take extra caution around the campfire to prevent burns to areas that lack sensation. Do a complete visual skin inspection at least once a day. Maintain medication routines and remember to pack special dietary foods. Dietary intake should be kept as close to normal as possible to avoid changes in bowel function. Changes in activity, fluid intake, and food intake may cause diarrhea or constipation. If new foods are necessary for the trip, they should be introduced into the diet well in advance of the trip.

Despite one's best efforts, the wilderness activity may disrupt a regular SCI bowel program. Factors that may influence the desire to maintain a regular bowel routine are wearing multiple layers of clothing and not wanting to undress, necessity to pack out all human waste, lack of private space, and being otherwise occupied. Fecal elimination in the wilderness can be well managed with preplanning and practice. Most manual wheelchairs can be adapted to become commodes. The chair seat fabric can be cut to accommodate the size of a toilet seat–sized hole. The edge of the fabric should be stitched or enforced with duct tape to avoid fraying. Velcro is sewn around the edges of the seat where the "cover" will be attached. The hole can be covered by using fabric of the same type and size as the original seat to cover the entire seat base, attached with Velcro tape to cover the hole. A padded cushion is placed on top of the cover. When needed as a commode, the user is transferred off the chair, the padded cushion and "cover" are removed, and the user is returned to the chair prepared to urinate or defecate (Figure 94-7).

Several options can be employed to collect the feces, urine, and wipes. If it is not in an area where waste must be carried out, the commode seat can be placed over a pit or cat hole. If a pit is not permitted, urine and feces can be collected in a large plastic bag under the chair. The bag can be draped over a bucket for stability. Light-weight absorbent kitty litter can be placed in bags prior to the trip to absorb odor and liquids. Carry biodegradable toilet paper, wipes, and sanitary products. Anything not biodegradable must be packed out. If the participant uses a power wheelchair, converting it to a commode chair will not possible due to the chair components located directly under the seat. Consideration should be given to bringing a manual chair that has been converted to a commode chair, or a portable commode to which the participant can be transferred, for toileting.

Special consideration must be given to maintenance of normothermia, protection of skin, bowel and bladder programs, and prevention and treatment of autonomic dysreflexia. Attention should be given to body areas that lack sensation, especially at pressure points. Do not use chemical heat packs on areas that lack sensation. Frequent (every 30 minutes) weight shifts are essential to prevent pressure sores.

Autonomic dysreflexia, also known as *hyperreflexia,* is a life-threatening medical condition that requires immediate intervention. Autonomic dysreflexia is an exaggerated and unopposed sympathetic response to a noxious stimulus below the level of the injury that results in extreme hypertension, sudden-onset severe headache, and diaphoresis above the level of the injury. It may occur at any time in people with SCIs at or above the level of T6. Untreated or delayed treatment of autonomic dyslexia may result in cerebral or subarachnoid hemorrhage.

Recognize the signs and symptoms and be prepared to intervene immediately (Boxes 94-5 and 94-6).

Other potential complications of SCIs that may occur in wilderness environments are pneumonia, atelectasis, pressure sores, lower extremity edema, deep vein thrombosis (DVT),

FIGURE 94-7 Adaptive wheelchair commode. **A,** Wheelchair seat modified to a commode seat; open position. **B,** Wheelchair seat modified to a commode seat; closed position. *(Courtesy Jeff Pagels.)*

BOX 94-5 Common Causes of Autonomic Dysreflexia

Bladder distention
Fecal impaction or constipation
Tight shoes or belt
Ingrown toenail
Insect bite
Exposure to extreme temperatures
Menstrual cramps
Intercourse
Pregnancy, labor, ectopic pregnancy, ovarian cyst
Vaginal inflammation
Appendicitis
Renal calculi
Gallstones

BOX 94-6 Emergency Interventions for Autonomic Dysreflexia

Sit the person as upright as possible
Eliminate the cause of the dysreflexia as soon as possible
Always check for a distended bladder and empty as soon as possible
Loosen belt or any tight clothing and remove shoes
Give nifedipine (Procardia) 10 mg initially (swallow capsule whole) or nitroglycerin 0.4-mg spray (metered dose) or sublingual tablet
Consider clonidine (Catapres), captopril (Capoten), prazosin (Minipress), or labetalol (Normodyne) as directed

urinary tract infection (UTI), hypothermia, and heat-related illness. Pay particular attention to respiratory effort, because most people with complete cervical injuries have compromised breathing resulting from loss of function of thoracic and abdominal muscles. Coughing and clearing the airway may be extremely difficult. DVT prevention includes adequate hydration and range-of-motion exercises, or repositioning legs to a nondependent position. Sitting in a position where the legs are dependent for long periods of time results in stasis and increased potential for DVT.[67]

Bowel and bladder management of SCI patients in the wilderness requires strict adherence to a schedule. Options for bladder management are intermittent catheterization using hydrophilic-coated catheters, indwelling catheters, or external "Texas" catheters. Catheterization techniques such as the Credé' maneuver are not ideal in wilderness settings. In order for intermittent catheterization to be successful, the urethral sphincter must remain constricted to retain urine while the bladder remains relaxed to be able to collect urine. Participants may be taking oxybutynin chloride (Ditropan) or tolterodine tartrate (Detrol) to relax the bladder.

If intermittent catheterization is selected as the bladder regimen of choice, pay strict attention to urinary output at each catheterization to determine the appropriate amount of fluid intake to avoid dehydration or overdistention of the bladder. Catheterization frequency may require adjustment based on increased fluid intake or excess fluid loss as a result of exercise or perspiration and/or diuresis due to exercise or altitude. The urinary volume per catheterization should be below 500 mL. If urinary leakage occurs between catheterizations, the cause may be UTI, bladder or sphincter problems, or a change in fluid intake amount. Handwashing using soap and water, antiseptic wipes, or waterless hand sanitizer is key to prevention of UTIs. Catheters should be hand washed with soap and water, air dried, and stored in paper (not plastic) bags if reuse is the plan.

Consider using touchless catheters. A touchless catheter is contained within a collection device. It becomes lubricated as it passes through the prelubricated outlet on the collection bag prior to insertion through the urethra. After draining the bladder, the catheter is withdrawn and slipped back into the collection bag. The bag is recapped and the entire bag and contents can be discarded in accordance with wilderness protocols.

Reflex voiding can be accomplished in males if there is an intact sacral micturition reflex. Bladder filling triggers sacral efferent nerves to cause involuntary bladder contractions. Voiding occurs because of intermittent sphincter relaxation during bladder contractions. A condom catheter (Texas catheter) is worn at all times and is the collection device of choice. The collection device should be cleaned or changed once a day and the penis washed and allowed to dry for 20 to 30 minutes before reapplication of the catheter. Secure the drainage tube carefully and change the connection site each day if taped to the skin. Complications may include a leaking condom, skin breakdown, UTI, urethral fistula, inadequate bladder emptying, high intravesical voiding pressures, and autonomic dysreflexia.[43]

If there is detrusor sphincter dyssynergy, suprapubic bladder tapping, using an alpha-adrenergic blocker (e.g., tamsulosin HCl [Flomax], doxazosin [Cardura], or terazosin HCl [Hytrin]), botulinum toxin injections, urethral stents, or sphincterotomy may be necessary to effectively empty the bladder.

PERSONS WITH SENSORY CHALLENGES

Persons With Vision Loss

Low-vision blindness is one of the most common disabilities; in the United States, it occurs in 3.3 million people 40 years of age or older.[72] Low-vision blindness is defined as a best corrected vision of less than 20/40 in the best eye. Blindness is defined as a best corrected vision of less than 20/200.

Leading causes of vision loss are refractive errors, corneal opacities, age-related disease such as macular degeneration, cataract, and optic nerve atrophy. Refractive errors may be due to nutritional deficiencies or metabolic abnormalities. Corneal opacities occur due to infectious diseases and trauma.

Decreased visual acuity usually results in less physical activity, fewer social interactions, emotional distress, and a lesser quality of life.

Trip Preparation. People with vision loss may be able to perform at high physical levels with the help of adapted equipment guides, support groups, and social training opportunities provided by people who understand the disability. Prior to the trip, spend time with the participant to learn about his ability to navigate independently, or with assistance or guidance, and the types of assistive devices required. Determine how instructions are to be given and what special equipment will be required.

Exercise may increase visual loss due to glaucoma; it will improve when exercise ceases. Be particularly aware that altitude blindness may occur, especially above 10,000 feet, if ascent occurs in the early postoperative period following LASIK surgery.

Challenges During the Trip. Allow the participant as much independence as is safe. Be the person's eyes and vividly describe surroundings, including obstacles and hazards. Offer assistance, support, and encouragement.

Users of long white canes often experience neck and back pain due to the need to maintain an extreme upright "stiff" posture, shoulder pain while keeping the elbow in toward the chest, and wrist and forearm pain due to repetitive "sweeping" of the cane using only a forearm and wrist movement (Figure 94-8). These anatomic position requirements make it difficult to hike steep or winding trails without assistance.

Persons With Hearing Loss

Thirty-six million people in the United States (17% of the population) have some degree of hearing loss. High-frequency hearing loss has occurred in 26 million Americans between the ages of 20 to 69 years because of frequent sustained exposure to loud sounds or noises produced by leisure or work activities.[72] This is especially prevalent in military members and veterans who have been exposed to blasts and loud explosions.

People who are hard of hearing (at 35 to 69 decibels) have difficulty understanding speech without use of an assistive device.

FIGURE 94-8 Eric Weihenmayer, the first blind climber to reach the summit of Mt Everest. *(Courtesy Luis Benitez.)*

The National Institute on Deafness and Other Communication Disorders reports that only 1 in 5 people who would benefit from a hearing aid wears one.[54] People who have hearing loss above 70 decibels are unable to understand speech, so hearing aids are not helpful for them.[8]

Trip Preparation. People with hearing losses may use lip reading, sign language, hearing aids, or other amplification systems. In preparation for a wilderness trip, consider the type of communication assistance needed. Someone with hearing loss may also have difficulty with speech, reading, and writing. Visibility of lips for lip reading or hands for signing may not be possible much of the time in the wilderness, so it is essential that alternative forms of communication, such as touch, large hand signals, or writing, be determined prior to the trip.

Challenges During the Trip. During the trip, communicate face-to-face whenever possible. Gain the person's attention using a light touch on their shoulder or via a visual sign. Maintain eye contact whenever possible and speak directly to the listener. Remember to bring along writing utensils and a white board or paper. If you do not understand what the person is saying, do not pretend that you do. Let the person know you do not understand. Make sure that assistive devices and/or amplifiers are available if appropriate. Carry extra batteries for hearing aids. If possible, try to have an interpreter available. Learn to take your time communicating and allow time for questions.

American Sign Language (ASL) is the most common form of sign language. It is important to know that ASL is not English; it is a visual and spatial language that has its own grammatical structure and syntax. Learn some common signs and/or bring along a poster with pictures of common hand signals that can be selected and a finger alphabet that can be copied (Figure 94-9; https://www.start-american-sign-language.com/).

PERSONS WITH COGNITIVE CHALLENGES

Approximately 15.2 million adults (6.3% of the U.S. population) experience cognitive, mental or emotional disabilities; 1.2 million adults and 2.7 million children have learning disabilities.[72]

Persons With Intellectual Disabilities

People with significantly subaverage intellectual functioning may have difficulty with communication, self-care, and social skills. They may lack the ability to self-direct and be aware of health and safety issues, and have decreased attention spans. They may require assistance with adaptive skills, safety issues, and environmental concerns. They may not be able to think concretely or determine risks. In addition, they may have muscle imbalances and balance and posture issues. They often have visual, speech, and swallowing challenges and are prone to dehydration and exhaustion.

The International Classification of Diseases, 11th edition, working group proposes replacing the term *mental retardation* with terms for a group of developmental conditions characterized by significant impairment of cognitive functions that are associated with limitations of learning, adaptive behaviors, and skill.[36] Four levels of severity reflect the extent of intellectual impairment: mild, moderate, severe, and profound.

People with intellectual development delays may exhibit delays in language development, poor memory skills, difficulty in understanding and practicing social skills, difficulty in problem solving, and delays in self-care and self-help skills. They may also lack social inhibitions.

Wilderness experiences for people with intellectual development disorders may enhance learning opportunities and produce enjoyable interactions with the environment. Levels of support vary across four dimensions: intellectual ability and ability to adapt, psychological and emotional concerns, physical and health concerns, and environmental issues.

Persons With Autism

Autism spectrum disorder and *autism* are terms used for a range of complex disorders involving brain development. Adults and children with autism spectrum disorder may exhibit the following characteristic verbal and nonverbal communication difficulties:

- Difficulty with social interactions
- Repetitive behaviors
- Intellectual disabilities
- Lack of motor coordination
- Physical health issues (e.g., sleep and gastrointestinal disturbances, ranging from constipation and diarrhea to inflammatory bowel disease) and seizure disorders

They may excel in such areas as art, math, music, and visual skills; 40% of persons on the autism spectrum have exceptional visual, musical, and academic skills. Approximately 25% are nonverbal, but can learn to communicate via other means, such as pictures, sign language, and electronic word processors.[6]

One in 68 U.S. children has been identified as being on the autism spectrum. It is more common in male children than females, with data showing 1 in 42 boys and 1 in 189 girls diagnosed. The apparent recent increase is partially explained by the increased awareness of the presence of autism leading to recognition and diagnosis, and possibly by environmental factors. A very small number (15% to 20% of cases) appear to be associated with genetic conditions, such as fragile X syndrome, tuberous sclerosis, Angelman syndrome, and chromosome 15 duplication.[12]

Many people with autism have difficulty understanding that others have a different perspective from theirs. They have difficulty understanding emotions or gestures, such as hugging or smiling, and are hypersensitive or hyposensitive and underresponsive to touch or sound. Many who speak do so in single words or repeat the same phrases, or repeat what they hear (echolalia). Mildly affected children may develop a significantly large vocabulary but have great difficulty forming sentences and maintaining significant communication. Movements, gestures, and expression may not match what they are thinking or saying. Repetitive behaviors may include body rocking, hand flapping, jumping, running, rearranging objects, and repeating words or phrases.

Trip Preparation. Children and adults on the autism spectrum range from mildly to severely affected. Consideration of inclusion in a wilderness activity must be carefully discussed and meticulously planned by the person's family in collaboration with any counselor and healthcare team. A wilderness adventure may not be appropriate for everyone. That being said, an outdoor adventure or wilderness experience may be of great value in providing learning and socialization opportunities in a natural environment. The focus of an outdoor adventure program for a person with mild autism might include maximizing social skills and experiencing new physical challenges. Personal motivation may be one of the primary obstacles to ongoing participation and cooperation in a given activity.

The wilderness may provide a positive environment for occupational and physical progress and for opportunities that promote growth and development in social and emotional aspects of life. Levels of support with wilderness activities must be considered based on the level of intellectual functioning and adaptive skills, psychological and emotional status, physical and health status, and appropriate environmental opportunities for the person in question. Support may be required intermittently, on a limited basis, or continuously.

Persons With Traumatic Brain Injuries

Traumatic brain injuries (TBIs), ranging from mild to severe, are among the most common causes of disability in the United States. They occur in more than 2.5 million people annually, resulting in 2,213,000 emergency department visits, 283,630 hospitalizations, and 52,844 deaths.[12,64] TBIs may have accompanying emotional and behavioral issues, mobility disorders, and cognitive impairment, including memory deficits, impulsive behaviors, emotional instability, and sleep disorders. In addition, 30% to 60% of persons with TBIs have traumatic vestibular pathology and may experience vertigo, disequilibrium, ataxia, and reduction of perceptual function.

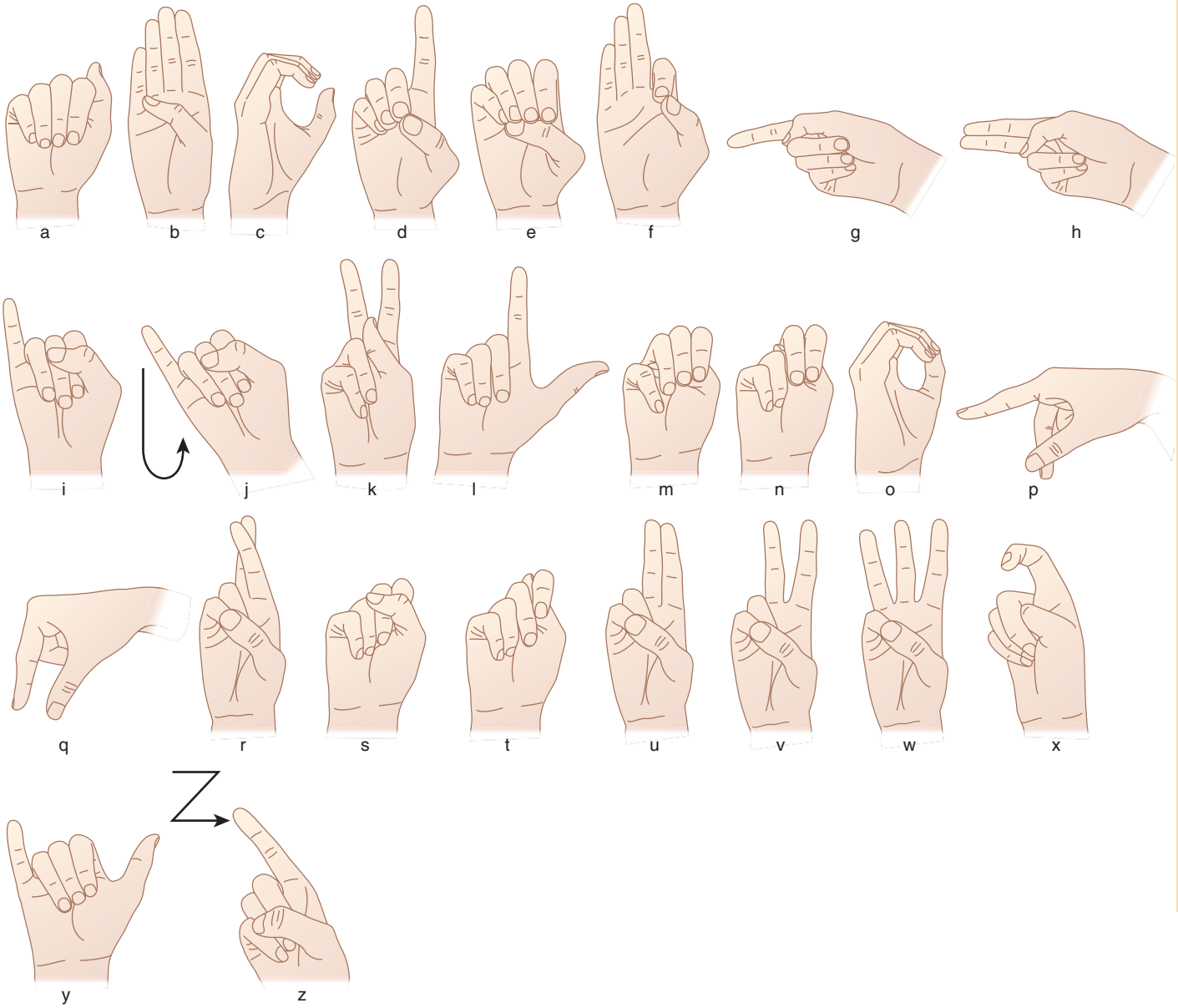

FIGURE 94-9 American Sign Language Finger Alphabet. *(Courtesy National Institutes of Health.)*

Trip Preparation. It is essential to have complete information about the person and the injury. Medical clearance must be obtained prior to a wilderness adventure. Ensure that all instructions are written as well as spoken. Bring a full supply of all routine and other necessary medications. Be familiar with effects and side effects of medications, especially psychopharmacologic medications.

People with mild TBIs may become fatigued more easily in the wilderness. Pretrip aerobic and neuromuscular training may improve locomotor efficiency. Offering outdoor opportunities may lead to better physical and emotional well-being and reduce concurrent depression.

Ataxia may interfere with a person's ability to independently perform activities of daily living, such as eating, hygiene and toileting, and ambulation. Adaptive equipment, such as weights or cuffs, may help with stabilization. Medications, such as propranolol, used to treat tremor, may limit the cardiovascular response to exercise and therefore may be somewhat counterproductive when rigorous exercise is expected.

PERSONS WITH PSYCHOLOGICAL OR MENTAL HEALTH CHALLENGES

The DSM-5 development website (dsm5.org) proposes the following new definition of mental disorder: "A behavioral or psychological syndrome or pattern that occurs in an individual that reflects an underlying psychobiological dysfunction, the consequences of which are clinically significant distress (e.g., a painful symptom) or disability impairment in one or more important areas of functioning. It must not be merely an expectable response to common stressors and losses (for example, loss of a loved one) or a culturally sanctioned response to a particular event (for example, trance states in religious rituals) that is not primarily a result of social deviance or conflicts with society."[21]

Trip Preparation

The success of a wilderness adventure for someone with a psychological or mental health condition will more likely be ensured if there is thorough pretrip preparation that includes gathering

TABLE 94-4 Psychopharmacologic Medications and Possible Side Effects

Psychopharmacologic Medication	Side Effects
Antianxiety agents	Drowsiness; withdrawal; heightened effects of alcohol
Antidepressants	Insomnia; weight gain; dizziness
Antipsychotics	Gait disturbances secondary to tardive dyskinesia; dehydration
Beta-adrenergic blockers	Slow heart rate
Fluphenazine (Prolixin)	Increases blood pressure
Haloperidol (Haldol)	Increases heart rate; possibly lowers blood pressure; prolongs QT interval

complete illness information (including information about medications), determination of the psychological and/or emotional status, assessment of the physiologic status as it relates to medications and medication side effects, and the person's understanding of what such a trip entails. Psychopharmacologic agents may affect cardiovascular function, gait, balance, and mood (Table 94-4).

A SELECTED EMERGENT MEDICAL DISABILITY

There are countless medical conditions that require specific knowledge pertinent to being in a wilderness environment. Information about these diseases can be found in other chapters throughout this book. No matter what the disease, common sense should prevail. Pretrip planning and conditioning are always essential. Select activities that are safe and within the abilities of the participant. Consider complications that might occur while in the wilderness and be prepared to intervene. Always think about hypothermia and hyperthermia, dehydration, sunburn, and heat-related illnesses. Carry routine and other medications that may be required. Plan for adaptive equipment and dietary and elimination needs. Obtain medical clearance when required. Be realistic and honest with the participant and be certain to keep expectations within abilities and limitations.

HEREDITARY ANGIOEDEMA OCCURRING IN THE WILDERNESS

Hereditary angioedema (HAE), somewhat similar to idiopathic anaphylaxis, manifests gradually, painfully, and without the typical anaphylactic dermatologic manifetations.[28] It is caused by deficiency of the plasma protein C1 esterase inhibitor (C1-INH).[10,28,79] The term *angioedema* describes localized, transient, and episodic edema of deeper layers of the skin and intestinal mucosa characterized by abdominal pain, skin swelling, and life-threatening upper airway obstruction.[10] Abdominal pain is caused by plasma extravasation and subsequent edema in affected areas.[32] Episodes may be provoked by emotional stress, infection,[24] localized trauma (particularly injection of a local anesthetic, surgery, or trauma),[42] dental procedure,[39] or exercise.[22] Laryngeal edema can cause immediate life-threatening airway obstruction and is the major source of death related to HAE. Historically, the mortality rate for attacks involving the upper airway exceeds 25% in untreated patients.[39] Angioedema manifests as swelling of the extremities in 75% of patients and swelling of the face and throat in 30%. Abdominal pain is a major symptom, occurring in 93% of patients.[39]

HAE has been estimated to affect 1 in 10,000 to 50,000 persons.[22,28,38] Although urticaria and angioedema are common problems that affect nearly 20% of the general population, true HAE occurs in approximately 2% of the U.S. population.[22] Of all angioedema cases, HAE accounts for only 0.4%.[39]

Clinical Presentation

The skin and gastrointestinal tract are more commonly involved than the airway. The ratio of laryngeal edema to skin swelling to abdominal pain is approximately 1:70:54. Cutaneous edema is the most common symptom. It can occur anywhere on the body, most frequently on the upper extremities.[22,24] It usually develops over several hours, progresses for up to 36 hours, and resolves over 1 to 3 days. Intestinal wall and mesenteric edema cause abdominal pain, nausea, and vomiting.[65] The intense pain mimics peptic ulcer disease, biliary colic, appendicitis, or a perforated viscus.[22,39]

Edema of the upper airway is a medical emergency. The individual with airway involvement may first experience a full or tight sensation in the throat, dysphagia, and/or voice alteration.[21] Soft tissue edema can rapidly result in stridor and progress to complete airway obstruction.[22] Following the onset of angioedema, the patient's condition can deteriorate from mild discomfort to complete airway obstruction within a few hours.[29] The mean time from onset to maximum development of laryngeal edema is 8.3 hours. The mean age of persons suffering a first event is 26 years, with most cases of laryngeal edema due to angioedema occurring in individuals ages 11 to 45 years (Figure 94-10).[29]

The relatively short time frame from onset to full development of symptoms is significant for wilderness adventurers because the first episode of HAE-associated laryngeal edema may occur as a result of increased exercise. Significant advanced planning for airway management must be undertaken for anyone with a diagnosis of HAE who is considering a wilderness activity.

Trip Preparation

It is imperative that the individual diagnosed with HAE and any travel partners be fully aware of potential triggers and manifestations of the disease.[10] The treatment goal is prevention of the attack through long-term prophylaxis. Therapeutic intervention after an episode begins is aimed at reducing the severity and/or duration of the attack. Because vigorous activities can precipitate HAE attacks, Elnicki[22] suggests that a short course of anabolic steroids before the planned event may lessen frequency and severity of attacks.

A person with HAE must immediately bring to the attention of travel partners the onset of HAE symptoms. The face and neck

FIGURE 94-10 Hereditary angioedema, lateral view. *(Courtesy Sheryl Olson.)*

should be closely monitored for edema and signs of airway involvement. The possibility of the need for airway management should be anticipated. Nebulized racemic epinephrine is the emergency drug of choice to decrease upper airway edema during an attack. For anaphylaxis-induced hereditary angioedema, inject epinephrine intramuscularly into the anterolateral mid-aspect of the quadriceps muscle. Initial dose for adults is 0.2 to 0.5 mL (0.2 to 0.5 mg) of 1:1000 dilution (1 mg/mL) epinephrine. The dose may be repeated every 5 to 15 minutes. Pediatric dose is 0.01 mg/kg (to a maximum total dosage of 0.3 mg) of 1:1000 dilution epinephrine.

If airway obstruction becomes severe and ventilation is compromised, advanced airway management, such as endotracheal intubation or cricothyrotomy, becomes essential. Even though an individual with known HAE may have had no prior episodes of airway obstruction, it is advisable to have equipment, medications for rapid sequence intubation, and a person skilled in their use, available for advanced airway management. Rapid sequence intubation allows for an opportunity for early intubation if the person is in severe respiratory distress while still conscious and alert.

The trachea should be intubated before laryngeal edema becomes so severe that intubation would be very difficult to achieve. If endotracheal intubation cannot be achieved, cricothyrotomy is the emergency surgical procedure of choice. This must be accompanied by airway maintenance equipment once the procedure has been completed. Without life-saving airway maintenance, the first episode of HAE may be fatal.[10]

Acute management goals include decreasing duration and severity of signs and symptoms after onset. An episode of abdominal colic may require narcotics to relieve symptomatic pain. Extreme edema of the extremities or abdomen may indicate vascular fluid loss. Intravenous fluid replacement should be considered. The awake and alert patient who does not have airway compromise or dysphagia should be encouraged to increase oral fluid intake until symptoms resolve.

An algorithm for treatment of HAE was developed in 2003 through consensus of European and North American investigators, patient care providers, patient group representatives, and individual patients.[11] Fresh frozen plasma would be the first-line intervention in a hospital setting. Anticoagulant therapy may prevent recurrent or ongoing thromboembolic occlusion of the circulation.[22] Heparin 30,000 units can be administered in aerosolized form via a nebulizer during an acute attack.[24]

At the first recognition of airway involvement, C1-INH concentrate, if available, should be given as soon as possible. In one study, use of Cinryze, a nanofiltered C1 inhibitor concentrate, when used in treatment of acute angioedema related to HAE, significantly shortened the median time to unequivocal relief of symptoms when compared with placebo. When used for prophylaxis, Cinryze significantly decreases the number of attacks.[80]

Long-term management of HAE consists of therapeutic prophylaxis to minimize frequency and severity of attacks. Individuals who experience frequent symptoms may require daily suppressive therapy with an androgen steroid, such as danazol (Danocrine), stanozolol (Winstrol), oxymetholone (Anadrol-50), or oxandrolone (Oxandrin). Persons with frequent severe attacks of HAE should be discouraged from participating in wilderness activities until the frequency of attacks is controlled.[45]

Challenges During the Trip

Known causative stimuli should be prevented or eliminated whenever possible. In the wilderness, it is especially important to pad pressure points that may trigger an acute attack. Every sport involves certain unique pieces of equipment that can result in pressure on parts of the body. When hiking or skiing, special attention should be paid to the feet. Trail shoes, hiking boots, and ski boots should fit well and be broken in prior to the wilderness adventure. Shoes and boots have tongue flaps and seams that may cause a pressure point. One-piece liners that are heat-molded to the foot and ankle eliminate pressure points. Check to ensure that socks are form fitting and wrinkle free.

Backpacks should be appropriately fitted. Waist belts should be wide and well-padded to distribute weight evenly, preventing pressure points on the iliac crests. Shoulder straps should be padded and fit the shoulders so as not to exert pressure on the axillae. A chest strap at the level of the sternum can aid in decreasing pressure of the lateral aspects of the shoulder strap. The backpack should be worn and gradually weighted during training, to increase weight and endurance tolerance.

River sports require use of helmets and paddles. Attention must be given to pressure points on the head, chin, and mandible. Gloves should be worn to protect hands from blistering during paddling.

ADAPTIVE SPORTS

Most outdoor activities have methods and adaptive equipment to make them available to persons with a disability. The website abilities.com has information on sports and sports organizations and clubs that have programs for people with disabilities, ability expositions around the country, and information about participating in sports activities, regardless of ability or experience level. The website nolimitstahoe.com lists several videos ("No Barriers," "Beyond Barriers," "Wheels of Fire," and "Courageous Climber") that demonstrate how people with disabilities participate in climbing, skiing, kayaking, surfing, sailing, diving, and hang gliding. Several selected outdoor sports are now discussed.

RIVER SPORTS: CANOEING, KAYAKING, AND RAFTING

Watercraft, such as canoes, kayaks, and rafts, offer opportunities for persons with disabilities to access wilderness environments and enjoy activities on lakes, streams, rivers, and oceans. If arm mobility is good, solo navigation in a craft may be possible. If arm mobility is not good, partnering with someone is an option. Before the wilderness experience, time should be spent at a swimming pool or small water space practicing entering and exiting the craft, navigating it, and learning and practicing what to do in the event of a capsize or ejection event. Ski or hiking poles may provide assistance with entering and exiting watercraft and the water.

Determination of the degree of difficulty of rapids or projection of wave size to be encountered should be made in advance. Regardless of size or degree, a personal flotation device and helmet should be worn at all times. Both of these items are mandatory on commercial whitewater activities. In a typical ejection situation in rapids, the person ejected is instructed to float on his or her back with legs together and feet forward.

If the person does not have leg movement, the common practice is to strap the legs together at the knees so that they stay together in the event of ejection, avoiding the possibility of legs getting trapped below the water's surface. A pull buoy can be attached to the strap. Do not tighten the strap to the point where circulation is compromised. Also, be sure to tuck in any loose ends of the strap.

Check frequently for cold water surrounding the legs and lower trunk and protect the participant from hypothermia. Standard seats in kayaks and canoes commercially offered typically provide a place to sit and something to lean against. If a craft has only a bench seat, consider securing a well-padded seat to the bench that has a back rest and side supports to provide pelvic stability and back support unless the participant has sufficient balance and trunk and leg strength to maintain a sitting position without using a seat and backrest. Trunk and pelvis stability are essential to be able to effectively paddle. The group Disabled Adventurers (disabledadventurers.com) has created a number of adaptive devices to enable people with disabilities to use kayaks (Figure 94-11). Instructions are located on the group's website so that some of their ideas can be built by users.

CLIMBING

Adaptive climbing (rock and ice) has become increasingly popular over the past two decades. It was pioneered in the late

FIGURE 94-11 Motorized kayak with sip-and-puff steering device. *(Courtesy Mark Theobald, Disabled Adventurers:* disabledadventurers.com.*)*

1980s by extreme athlete Mark Wellman, who was the first paraplegic to summit the 3000-foot granite face of El Capitan in Yosemite National Park. He had to perform 7000 pull-ups to reach the summit.[75] The first U.S. Paraclimbing Competition took place in 2013, and the International Federation of Sports Climbing Paraclimbing World Cup competition occurred in September 2014.[40]

Climbing can increase confidence, help to develop problem-solving and adaptation skills, increase independence, and improve self-awareness and willingness to trust. Many persons who suffer from posttraumatic stress disorder (PTSD) and/or TBIs have benefited greatly from climbing, as have persons with motor, sensory, and cognitive deficits. Physiologically, when climbing, a person with a disability can learn to use muscle groups in different ways and enhance fine and gross motor skills.

Persons with motor, vision, and hearing disabilities have been able to participate in climbing activities. Blind climbers rely on their sense of touch to identify the next handholds. Climbing can be accomplished using appropriate adaptive equipment, such as harness or pulley systems, prosthetic climbing feet, prosthetic knees, and specialized protective equipment, such as padded chaps to protect legs.[37] Many climbing clubs and organizations have programs using climbing walls specifically for training people with disabilities, such as the Adaptive Climbing Group of Brooklyn[1] and Paradox Sports in Boulder, Colorado.[57] They also arrange for climbing adventures.

HAND CYCLING AND TANDEM RECLINING CYCLES

Hand cycling has become a popular outdoor sport for people with lower motor impairments. Special cycles are available that are designed for use by persons with various disabilities. Racing, off-road, and mountain bike models are available that have adjustable seats and seat heights, hand-operated brakes, and tires appropriate for the terrain. Pedaling is accomplished by arm cranking (Figure 94-12).

Hand cycles come in a variety of styles. They are land vehicles that typically have one steerable front wheel powered by hand cranking and two coasting or stabilizing rear wheels. The brakes are located on the hand grips. Hand cycles used for rough terrain typically have two front wheels and one rear wheel.

Tandem reclining cycles can be used by a nondisabled cyclist pedaling and steering in the front seat and a disabled cyclist who is able to pedal, such as a blind cyclist, in the rear seat. If this type of cycle is used, be sure to attach safety flags on the rear of the cycle so that motorists can clearly see the cycle when it is on a road or trail (Figure 94-13).

The motivational documentary/video "Crank It Up!" is the story of three paraplegic men who hand crank specially designed hand cycle mountain bikes on the very dangerous and challenging White Rim Trail in Canyonlands, Utah (nolimitstahoe.com).

FIGURE 94-12 Jeff Pagels pedaling the one-off wheelchair on a rough road where vehicles require four-wheel drive. *(Courtesy Sheryl Olson.)*

HIKING

Hiking is something that can be done by many people with disabilities. Hiking may assist with balance, stability, and depth perception, and provide leverage for an extra push. The key to successful hiking is conditioning prior to the hike. New hikers who are disabled should check with their primary care providers to obtain medical clearance to participate in the activity. Persons with lower limb amputations should check with their prosthetists to be certain that they have the proper prosthetic and fit for hiking.

Begin by walking on flat surfaces, and progress to gentle hills, then more difficult hills and increasingly steep and long sets of stairs. Cardiac exercises should be added to the regime, along

FIGURE 94-13 Blind rear seat cyclist on a tandem cycle. *(Courtesy the Borden Institute [US Army] from the "Warrior Transition Leader: Medical Rehabilitation Handbook.")*

with leg strengthening using power lifting and weight training to strengthen the core and abdominal muscles.

Proper footwear is essential. Wear shoes or boots that provide stability and cushion the feet to absorb shock. Warm socks of good quality that will wick away moisture and prevent blisters are essential. Bring extra pairs in the event of excess moisture. Amputees should wear prosthetic socks to prevent blisters and pressure sores and allow for stump expansion.

Dressing in layers is important to adjust for temperature changes. The first layer should be a lightweight synthetic garment that wicks moisture away from the body. The second layer should be an insulation layer, such as fleece, wool, down, or a synthetic fabric. The third layer should be water and wind resistant. Be sure to pack sunscreen, sunglasses, and a protective hat.

HORSEBACK RIDING

Horseback riding (also known as *hippotherapy* when used as a physical therapy modality) is an activity that provides physical exercise as well as the psychological benefits of a person with a disability experiencing an outdoor environment. It improves self-confidence and self-esteem. One can expect to see improved muscle strength in the chest and back and improved core strength. One study demonstrated that as few as 8 minutes of hippotherapy in children with cerebral palsy resulted in significant improvement of symmetry of muscle activity.[5] Riding assists range of motion, joint flexibility, and balance when the rider is coached to focus on posture and body alignment.

People with multiple sclerosis have mixed results when horseback riding. Some benefit because it improves retaining functional ability while on the horse and afterwards. For unknown reasons, others with the same diagnosis experience worsened symptoms of the disease. Be sure to assess riders before, during, and after riding at each session.

HUNTING

In some states, it is permissible for a person with a disability to hunt from a vehicle. There are mobility devices and hunting equipment that can be adapted to the special needs of the person with a disability, including camping equipment and hunting blinds. Wheelchairs must be appropriate for the type of terrain that will be traversed. The Action Trackchair (actiontrackchair.com) is an off-road wheelchair that can maneuver over sand, mud, snow, grassy fields, and wooded trails. It has tank-like tracks that rotate in a continuous loop, to provide continuous extraction (Figure 94-14).

Several other types of wheelchairs are suitable for use by hunters who are disabled. The Extreme 4 × 4 (Mobility USA [mobility-usa.com]) is a power chair equipped with either large off-road tires or tracks. It has a camouflage option and can be fitted with gun mounts. The Go-Getter wheelchair can be attached to a four-wheeler. The Landed All-Terrain Wheelchair has large tires and can navigate over mud, sand, gravel, and snow. There are several companies that can customize all-terrain vehicles and motorcycle sidecars to accommodate physically disabled people and can install motorized ramps on larger vehicles to transport motorized assist devices.

Power-assist wheelchairs help propel wheelchairs where the user prefers a manual chair but is not strong enough to propel it themselves. There are wheelchairs that can be converted from a seated position to a standing position (thestandingcompany.com).

Guns, rifles, and bows and arrows should be securely attached in a position where a person with tetraplegia can easily use them. If there is gross arm movement but no hand and finger movement, a device can be rigged to a firearm between the trigger and the person's arm so that the trigger can be pulled. Bow-and-arrow equipment can be adapted to the special needs of the disabled hunter. Physically Challenged Bowhunters of America provides and/or recommends adaptive products (pcba-inc.org).

FIGURE 94-14 Teddy Perron and father Troy Perron after a successful wheelchair hunt. *(Courtesy Stephanie Perron.)*

The following are examples of adaptive equipment:
Activity trays and hand controls (beadaptive.com)
Binocular and flashlight holds (bigskyimagination.com)
Duck and game calls (hands free) (woodswise.com)
Rifles (custom) (randyscustomrifles.com)
Rifle scope (wheelchair mounted) (riflevision.com)
Rifle rests (hands free) (sr77.com)
Toilet systems (cleanwaste.com)
Wheelchair-accessible game blinds (ameristep.com)

SCUBA DIVING

Persons with many different disabilities can enjoy scuba diving.

Scuba Diving for Persons With Spinal Cord Injuries and Amputations

People with SCIs or amputations may enjoy the freedom of constraints from gravity when scuba diving. Most can meet the criteria for scuba certification with the assistance of a dedicated dive assistant who can help with flooding, clearing, and removal of the face mask if needed. Neoprene wetsuits should be custom fitted to the person with a disability, accounting for amputated limbs.

Balance Challenges. Because balance may be a challenge for the person with an SCI because of inability to use arms and legs to make trunk adjustments, counterweights may be added to achieve symmetric balance. The weights should be carefully positioned to maintain gravity along the center axis of the body.[58] They should constantly be monitored for readjustment to maintain desired body position.

Neoprene wetsuits and boots may increase the tendency for legs to rise toward the surface. Strap the legs together, and weight them near the ankles to prevent uncontrolled floating. Adjust weights to accommodate surface floating, ascent, and descent. Keep a record of use of weights and locations in a dive log for future reference.

Thermal Issues. Due to loss of thermoregulation, people with SCIs may be at risk for hypothermia while in the water. Plan for preventive and/or intervention measures in the dive preparation plan. Exposure to cold water may increase sympathetic nervous system activity, predisposing individuals with SCIs at and above level T6 to autonomic dysreflexia.[70]

A full-length wetsuit with a hood and dive booties should be worn to prevent hypothermia and unexpected direct contact with ocean life. Foot fins are not necessary for paraplegics and tetraplegics. However, hand fins can be quite advantageous for navigation for paraplegics. Consider use of a thin nylon or polyester body suit prior to donning the wetsuit to make donning the wetsuit easier. Wearing gloves should also be considered.

Anxiety. A person with limited physical capabilities may have anxiety about diving because of the fear of not being able to move in event of an emergency. It is very important that the person with the disability practice in a pool with complete scuba equipment and a dive buddy to develop familiarity with the equipment, experience flotation without gravity, and develop complete trust in his or her dive assistant.

The first pool session should focus on balance and weight distribution to adjust body position and develop a comfort level. Practice entering and exiting the water from a dive platform or boat. Practice with someone lifting the diver who is disabled onto the platform or boat. It may be necessary to remove weights and the air tank before attempting to lift the person onto the platform or into the boat. Leave the buoyancy compensation device in place to be able to use the handholds during the lift. Entry into the water can be made from the beach by carrying, or using a large, wheeled water device, boogie board, or surfboard.

Other Equipment and Considerations. A second-stage scuba regulator should be easy to purge and breathing resistance be adjustable. Ensure that the regulator is easily accessible and attached to the front of the buoyancy compensation device in the event of dislodgment.

A diver with a lower leg amputation should consider wearing a weight-integrated buoyancy compensation device rather than a weight belt. A weight-integrated buoyancy compensation device is less confining and allows better mobility in the water. It requires great finesse to control body movements when only one fin can be worn. The diver should be able to choose the fin that works best, perhaps a split fin or stiff fin.

The diver should empty his or her bladder prior to entering the water, because descent increases body pressure and diuresis. A person with an SCI may not sense a full bladder; there is a risk for autonomic dysreflexia.

Be aware of the strength of the current and possibility of having to swim against the current during the dive. The disabled diver may be capable of swimming into a strong current.

Scuba Diving for a Visually Impaired Person

Blind divers, with greater acoustic adaptation, often express joy at being able to hear the sounds of the underwater world not typically heard by sighted divers. They feel the currents, water pressures, and slight changes in water temperatures, and appreciate those unique opportunities.

The buoyancy compensation device, tank, and regulator require no special adaptation for the visually impaired diver. Diving can be safely accomplished with a dive buddy to monitor the dive time and tank pressures. Discuss the direction of the dive in relation to underwater currents prior to the dive. The blind diver may lead with the sighted diver tracking, or the sighted diver can lead with the blind diver following the sound of air bubbles. Both divers should have a tank-banger for communication. Establish a simple code prior to the dive. For example, two bangs could mean, "go to your right"; three bangs could mean, "go to your left." Be sure to establish a code to call for immediate help.

The dive buddy should never lose sight of the blind diver. If separation occurs, the tank-banger can be used to establish communication if the divers are within an audible distance from one another. Without proprioception input in an environment without gravity, a blind diver may become disoriented in relation to upright and upside-down positions. Reorientation can occur by placing a hand over the air bubbles as they leave the regulator to feel the direction in which they are rising in order correct the body position.

FIGURE 94-15 Blind skier preparing for a ski run. *(Courtesy the Borden Institute [US Army] from the "Warrior Transition Leader: Medical Rehabilitation Handbook.")*

Scuba Diving for a Person With Hearing Impairment

There is no contraindication to scuba diving for the hearing-impaired individual. In fact, if there is more than one hearing-impaired diver in the group and they both sign (ASL), they will have a better way of communicating when underwater than non–hearing-impaired individuals.

SKIING

A wide variety of skis are available for disabled skiers. Monoskis, sit-skis, toboggan skis, and cross-country skis allow for a variety of terrain, both alpine and cross-country, to be available to disabled skiers. Monoskis may have hydraulically controlled up-and-down positions. Sit-skis are usually constructed from fiberglass and use short poles with picks for the skier to be able to start, turn, and stop. Persons with bilateral amputations can use four-track skis, which have two skis and two outriggers. Skiers with SCIs or amputations, those who are blind or have hearing loss, and those with other disabilities have been able to enjoy the thrill of skiing. The national organization Ski for Light[66] offers ski lessons and assistants for vision-impaired skiers and persons with other disabilities (Figure 94-15).

In the spring of 1993, Matt Wellman was the first paraplegic to traverse the Sierra Nevada mountain range on a sit-ski. His 4-day journey took him across Ellery Lake on the east side of the Sierra, where he ascended over Tioga Pass to finish at Crane Flat on the west side of the Sierra.

ASSISTANCE DOGS

Several types of dogs are trained to assist people with various disabilities. Typically, breeds of assistance dogs are German shepherds, golden retrievers, and Labrador retrievers, selected because of their intelligence, loyalty, attentiveness, empowerment, and size. That being said, the type and size of dog selected should depend upon the expected work to be accomplished by the animal.

There are therapy dogs, service dogs,[23] leader dogs (also known as guide dogs for the blind and seeing-eye dogs), hearing dogs,[34] seizure dogs,[19] diabetes alert dogs,[26] and companion dogs for persons with PTSD. Assistance dogs bring many benefits and companionship to their owners.[62] For many people, the assistance dog gives them a reason to continue with their struggles, to get out of bed and out of the house each day. People with disabilities who have assistance dogs are able to make new friends easily because dogs are generally loved by most people.[41,46]

Therapy dogs are specially trained primarily to visit patients in hospitals and nursing homes. They are sociable, gentle, and calming and bring smiles to the faces of persons they visit.

Service dogs are trained to assist people with mobility, sensory, and other types of disabilities. They are professionally trained to accomplish tasks (sometimes up to 28 individual tasks[23]) for one individual, such as to open doors, assist with dressing, retrieve items, and navigate outdoors and inside the home.

Leader dogs or *guide dogs* for the blind are trained to assist people with limited or no vision. The first known assistance dogs were trained after World War I to assist soldiers returning from the war with vision loss.[62]

Hearing assist dogs, which are typically smaller size than other assistance dogs, are trained to alert people who are deaf to important sounds, such as a baby's cry, ringing telephone or doorbell, or smoke detector alarm. They are trained to respond to their human partner's voice and hand signals.

Seizure alert dogs are astute at recognizing an impending seizure and trained to protect their human partner when he or she seizes. The size, breed, and gender of this assistance dog is irrelevant, as long as there is a bond between the dog and its partner.

Diabetic alert dogs are trained to sense impending hypoglycemia and to notify their human partners. Diabetic alert dogs are relatively new to the class of assistance dogs; the first diabetic alert dog was trained in 2003.[26]

PTSD assistance dogs are the newest members of the assistance dog group. They are usually large dogs and are matched with military members or veterans who have been diagnosed with PTSD. The dogs provide companionship and a calming influence on their partners and alert and respond when there is a PTSD crisis event. The use of these specially trained dogs has become more prevalent for people with PTSD and depression in civilian communities.

People with disabilities who are partnered with assistance dogs may take their dogs along with them on wilderness trips. Be sure to check the Transportation Security Administration (TSA) website for rules and regulations pertaining to travel with an assistance dog (tsa.gov/travel/special-procedures) and for guidelines and rules for passing through security clearance. Carry paperwork that identifies and verifies that the animal is an assistance animal. Labeling on the dog's harness is also expected. TSA officers have been trained not to communicate, distract, interact, play, feed, or pet service animals and to ask permission before touching the service animal or its belongings. The TSA recommends advising the security officer on how to best achieve screening (i.e., side-by-side, dog in front, dog behind) when passing through the metal detector as a human-dog team. If the alarm goes off, secondary screening will occur. The officer will obtain permission from the handler before touching the dog or its belongings.

Three other U.S. federal agencies that may be encountered when traveling with a service animal are the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), and Veterinary Services. Cooperate fully and advise the inspectors about how to interact with the animal and how to accomplish the desired tasks. An APHIS-accredited veterinarian can complete an international health certificate and certify that the animal is in good health, conduct tests, and record test results. A completed international health certificate must be endorsed by a Veterinary Services area office for export of the animal from the United States. Information about the Veterinary Services office for individual states can be found at aphis.usda.gov/import_export/index.shtml.

Become familiar with the import rules for animals when traveling outside the United States. Contact the country's embassy to determine rules specific for service animals for the country where travel is planned. A list of consulates can be found at the U.S. Department of State website state.gov. The APHIS website on animal welfare offers excellent references to find state regulations, foreign country requirements, disease restrictions, and U.S. Customs and Border Patrol publications on pets (aphis.usda.gov/aphis/home/).

Contact the destination wilderness location regarding regulations about assistance dogs. Check with a veterinarian for rules and regulations for travel and wilderness, such as immunization requirements and preventive measures. Since passage of the ADA, assistance animals are defined as "any guide dog, signal dog, or other animal individually trained to do work or perform tasks for the benefit of an individual with a disability, including, but not limited to, guiding individuals with impaired vision, alerting individuals with impaired hearing to intruders or sounds, providing minimal protection or rescue work, pulling a wheelchair, or fetching dropped items."[2] Service animals are in a class of their own and not considered to be pets. Therefore, they are permitted to go where other pets are not allowed.

On occasion, park superintendents may close a specific area of a park to service animals if it is deemed that the service animal may pose a direct threat to the health and safety of people or wildlife.

Remember to pack animal-specific supplies, such as food, special harnesses, water, bowls, play toys, and sleep surfaces.

OPPORTUNITIES FOR WILDERNESS ADVENTURES

There are hundreds of websites that offer information about adaptive equipment, organizations, teachers, coaches, and guides, and activities for people with disabilities. Here is a list of organizations that offer opportunities in specific outdoor sports:

RESOURCES FOR WILDERNESS SPORTS

Archery

United Foundation for Disabled Archers
320-634-3660
uffdaclub.com

USA Archery
719-866-4576
teamusa.org/USA-Archery

Canoeing

American Canoe Association—Disabled Paddlers
703-451-0141
americancanoe.org/?page=Courses_Adaptive

Cycling and Racing

Hand Crank Racing Association
530-244-3577
shasta.com/geneva/CrankRace/

Hand Cycle Racing
757-422-1912
handcycleracing.com

Wheelchair Motorcycle Association
508-583-8614
iandr.mwcil.org

Horseback Riding

American Hippotherapy Association
970-818-1322
americanhippotherapyassociation.org

National Center for Equine Facilitated Therapy
650-851-2271
nceft.org

Professional Association of Therapeutic Horsemanship International (PATH Intl.),
800-369-7433
pathintl.org/

Hunting, Shooting, and Fishing

Amateur Trapshooting Association
618-449-2224
shootata.com

Buckmasters American Deer Foundation
334-215-3337
buckmasters.com/

Disabled Hunters Resources
huntingpa.com/disabledhunters.html

Fishing Has No Boundaries
800-243-3462
fhnbinc.org

Mountain States Chapter, Paralyzed Veterans of America
800-833-9400
mscpva.org/shooting.html

National Skeet Shooting Association
800-877-5338
nssa-nsca.org

National Wheelchair Shooting Federation
877-865-4893
livingwellwithadisability.org

NRA Disabled Shooting Services
703-267-1495
nchpad.org

Outdoor Buddies Hunting Program
719-783-9044
outdoorbuddies.org

Physically Challenged Bowhunters of America
855-247-7222
pcba-inc.org

Wheelin' Sportsmen (National Wild Turkey Federation)
800-THE-NWTF
nwtf.org/wheelin

Rock Climbing

Lover's Leap Guides
530-318-2939
loversleap.net

Montana Mountaineering
208-420-6842
montanamountaineering.org

Rowing and Sailing

U.S. Rowing Association
800-314-4ROW
usrowing.org

Sailing
footeprint.com/sailingweb

Running

Achilles Track Club
212-354-0300
achillesinternational.org/

Scuba Diving

Handicapped Scuba Association International
949-498-4540
hsascuba.com

International Association for Handicapped Divers
iahd.org

Snowboarding and Skiing

National Ability Center
435-649-3991
discovernac.org/

Sitski Extreme Adaptive Sports
908-313-5590
sitski.com

Snowmass Village
800-SNOW-MASS
gosnowmass.com/

U.S. Ski and Snowboarding Association—Disabled
435-649-9090
usskiteam.com/

Swimming

USA Swimming
719-866-4578
usaswimming.org

Water Skiing

Water Skiers with Disabilities Association
usawaterski.org

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CHAPTER 95

Physiology of Exercise, Conditioning, and Performance Training for Wilderness Adventure

ROBERT B. SCHOENE

For millions of years, humans have survived in wilderness environments. It is only in the last few millennia that socialization has led to what we call "civilization." Modern life has formed a construct for human existence that has largely overcome the need for competence in survival. However, there are still populations that rely on physical capabilities and resourcefulness to survive on planet Earth, most of which is still wilderness (Figure 95-1).

Many people now seek their ancestral origins with an ineffable call to return to oceans, mountains, deserts, and rivers in all corners of the globe. It is this yearning to seek both solitude and fellowship with other kindred spirits that takes us from what we call civilization to wilderness. Some persons are prepared with skills to thrive in the wild but others wander unprepared to endure the unavoidable physical stresses that one may encounter.

This chapter addresses the physical and psychological challenges faced in the wilderness and attempts to offer insights into the best ways to prepare for survival, enjoyment, and the ability to thrive.

MENTAL AWARENESS

Especially during the past three decades, there has been growing interest in seeking adventure to experience wilderness via guided trips, group ventures, and solo forays. The press and popular literature have recounted these experiences for the general public, many of whom would otherwise have little concept of adventure and the attendant risks. The romantic notion of rafting a remote river, trekking in the Himalayas, or riding a camel in the Sahara Desert does not often anticipate the possibility of 2 weeks in torrential rain on a cold river, biting snow and altitude illness, contaminated food and diarrhea, or even a camel bite. The western traveler is often a person who comes from a comfortable home and who assumes that he or she will be cared for—or even rescued, if necessary—and then transported home with a minimum amount of inconvenience to be able to recount his or her adventures with persons who are similarly ignorant of the actual risks.

To enjoy the wilderness, one must accept that occasional hardships are frequent aspects of adventures. Therefore, self-reliance or group reliance is critical, and a modicum of medical and survival skills must be obtained. Reading the great tales of survival and studying survival theories can be helpful, but mental preparation cannot be taught solely in the classroom and library; it must be learned and then practiced until one becomes experienced. Thus, one should strive to learn, know oneself, accept the risks of the adventure, and become a strong member of the team; being unprepared may put many participants at risk.

PHYSICAL CONDITIONING

Wilderness adventures require a wide range of physical capabilities. Rather than being a specialized endeavor where one particular form of conditioning will ensure success, wilderness travel is varied and at many times unpredictable, and requires strength, flexibility, endurance, speed, and mental resourcefulness. Each of us begins our training with a different dose of each of these characteristics and must do our best to optimize them. Having the strength to pull a colleague out of a crevasse or drag oneself with a broken ankle up a steep trail may be essential for survival. Having the reflexes and speed to avoid rockfall or grab a teammate before he or she falls into a river may mean the difference between life and death. Having the endurance to hike for days out of the mountains to initiate a rescue for an injured friend will minimize that friend's exposure to cold or heat.

This chapter deals primarily with aerobic fitness and exercise physiology with an emphasis on high-altitude fitness, because adaptation and exercise performance in that environment carry with them concepts universally applicable to all wilderness endeavors.

AEROBIC FITNESS

The best way to prepare for any form of wilderness venture is to be in the wilderness on a regular basis. However, for most persons who are not professional river or mountain guides, it is not possible to be active in these terrains every day. Thus, we need to improvise and incorporate physical training into our busy schedules so that when we enter the wilderness, we are prepared.

The concepts of aerobic fitness are similar for champion and recreational athletes. The parts of the "engine" are the same; it is the quality and fine-tuning that are different. Three essential characteristics are the maximum oxygen consumption ($\dot{V}O_2max$), lactate or anaerobic threshold (which defines sustainable work), and efficiency. These factors are interrelated in a way that results in effective performance, and each is trainable. The interrelationships result in improved endurance, the most important overall factor for enjoyment and survival in the wilderness.[42]

MAXIMUM OXYGEN CONSUMPTION

Oxygen consumption ($\dot{V}O_2$) is defined by the Fick equation:

$$\dot{V}O_2 = \text{Cardiac output} \times \text{Extraction of oxygen}$$

Cardiac output is equal to the heart rate multiplied by the stroke volume. Oxygen extraction is the difference between the content of oxygen of the arterial and mixed venous blood (i.e., the amount of oxygen that is used as blood traverses tissue beds). The metabolic response of exertion is limited by cardiac output and the limits of oxygen extraction, both of which can be modulated with training. The role of $\dot{V}O_2max$ and its various considerations are discussed by Levine.[48]

$\dot{V}O_2max$ is the fingerprint of an individual's physiology. It is a reproducible marker of fitness in an individual that varies depending on training, altitude, and illness. The many genetic factors (i.e., polygenic) that contribute to a person's $\dot{V}O_2max$ make it highly unlikely that any one individual could be endowed with all of the necessary genes.[76] One's $\dot{V}O_2max$ is influenced by both inherited and environmental factors.[8] What remains to be explained is the observation that, among sedentary subjects in family groups who were maintained on a supervised aerobic exercise program for 20 weeks, there was great variability in how much $\dot{V}O_2max$ could be improved[7] (Figure 95-2). The

FIGURE 95-1 View in the Khumbu region of Nepal, with Mt Everest, Mt Lhotse, and Mt Ama Dablam appearing most prominent. *(Courtesy Robert B. Schoene.)*

improvement in $\dot{V}O_2max$ ranged from negative values to 30% improvement, and these various levels of improvement were grouped in family clusters. Further data from this series of studies looked at age, race, gender, and initial fitness and found that all subjects experienced gains in $\dot{V}O_2max$, but with a great deal of variability and little correlation among the aforementioned factors that contributed to those gains. It is clear that there are limits in training to improve $\dot{V}O_2max$. In other words, a "normal" individual with a $\dot{V}O_2max$ of 42 mL/kg/min may be able to improve his or her $\dot{V}O_2max$ to the high 40s mL/kg/min but will never be able to approach the 75 to 85 mL/kg/min range of high-performance middle- to long-distance athletes, who chose their parents well.

What parts of one's aerobic capacity can be trained? Considering the Fick equation, it becomes apparent that an increase in cardiac output or improved extraction of oxygen, or both, will improve $\dot{V}O_2max$. In fact, both things happen, but it is clearly the heart that can be trained more by increasing its stroke volume and improving its muscular strength.[22,31] Thus, the heart rate necessary to achieve an appropriate cardiac output for any given metabolic rate is lower in the trained state as compared with the untrained state. Although the maximum heart rate does not change with training, resting and submaximal heart rates are lower and can be used as simple markers to monitor training. Although the elements of oxygen extraction somewhat improve, the heart's stroke volume conveys increased ability to perfuse large volumes of muscle mass such that, with training, there are increased capillary and mitochondrial densities and optimization of the components of oxidative metabolism.[3,30,36,37]

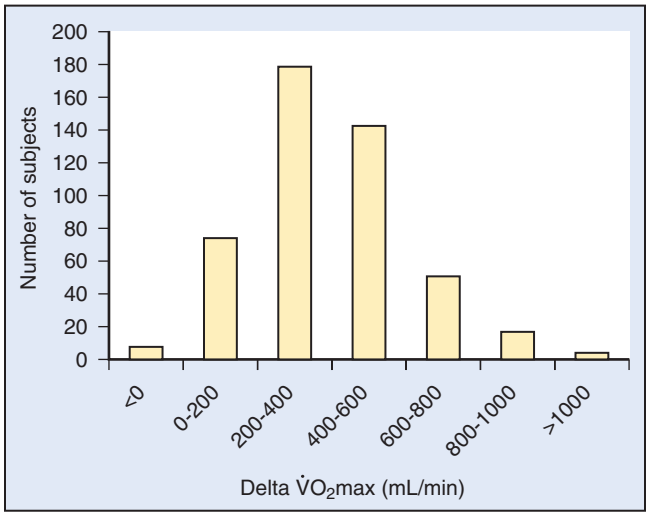

FIGURE 95-2 Distribution of 481 subjects by classes of increase (δ) in maximum oxygen consumption ($\dot{V}O_2max$) as compared with baseline levels. *(From Bouchard C, An P, Rice T, et al: Familial aggregation of VO(2max) response to exercise training: results from the HERITAGE Family Study,* J Appl Physiol *87:1003, 1999.)*

It is fascinating to put human physiology in perspective with the rest of the animal kingdom. Normal humans in the age range of 20 to 40 years have a $\dot{V}O_2max$ somewhere around 40 mL/kg/min, and accomplished endurance athletes have one in the range of 70 to 85 mL/kg/min; alternatively, some large mammals have extraordinarily high aerobic capacities. For instance, horses have $\dot{V}O_2max$ values that range from 134 mL/kg/min in standardbred horses[2] to 160 mL/kg/min in thoroughbreds.[46,52] The North American pronghorn antelope is said to have values as high as 300 mL/kg/min. Although thoroughbred horses were bred several hundred years ago to be great aerobic athletes, the antelope's evolutionary strategy is to have exercise capabilities that optimize its chance of preserving the small family groups that live on an open plain full of predators (i.e., the pronghorn can run sustainably at 80.5 km/hr [50 mi/hr]).

Does $\dot{V}O_2max$ correlate with being able to go faster, last longer, jump higher, climb faster, or survive better in the wilderness? The answer is "yes and no." Certainly, the high-performance endurance athlete needs to have a large aerobic capacity, but even in this group, there is heterogeneity in $\dot{V}O_2max$ and performance. This indicates that there are other components of physical characteristics that translate into endurance and performance and that are also influenced by training. Most athletic events attract athletes that share certain phenotypic characteristics that, as with animals in nature, result in some homogeneity; in addition, among people who venture into the wilderness—including even among elite high-altitude climbers—there is a great deal of phenotypic heterogeneity. Regardless of the lack of a strong correlation between $\dot{V}O_2max$ and performance in the wilderness, there is one precept that is sacrosanct: The body must translate energy expenditure into sustainable and efficient mechanical output.

THRESHOLD OF SUSTAINABILITY

Exercising at the highest possible sustainable workload results in the best individual performance. The point in progressive exercise above which the level of intensity cannot be sustained has been given many names. *Anaerobic, ventilatory,* and *lactate thresholds* are the most commonly used terms, although none clearly defines the phenomenon well. At any given point of training or health, the threshold is fairly reproducible. The term *lactate threshold* (LT) will be used for sake of this discussion. It is important to understand that the LT—more than $\dot{V}O_2max$—can be trained to move to a higher level of intensity; this translates into a functional increase in endurance and performance, whether in athletic endeavor or wilderness adventure.

The onset of unsustainable work intensity essentially involves a shift of fuel supply within the cell. At workloads below the LT, free fatty acids are the primary oxidative fuel. Above the LT, when the oxidative turnover of free fatty acids cannot keep up with the demand for adenosine triphosphate, glycolysis occurs. Muscle glycogen is broken down as fuel, with lactic acid being produced at a rate beyond the body's ability to use it.[41,61] Blood lactate levels correlate with the intensity of work and thus are inversely correlated with the duration of a competitive event (Figure 95-3).

For example, a 10,000-m runner may have only a slightly elevated blood lactate level as compared with the resting level as he or she slowly depletes muscle glycogen; alternatively, an 800-m runner will have a markedly elevated blood lactate concentration at the end of the race, because glycolytic signaling is invoked early at high levels of exertion. With sustained aerobic training, use of free fatty acids, which is abundant, is shifted to higher intensities and functionally spares muscle glycogen. The point at which lactate starts to rise in the blood is quite variable, but usually occurs at about 60% of $\dot{V}O_2max$ in untrained

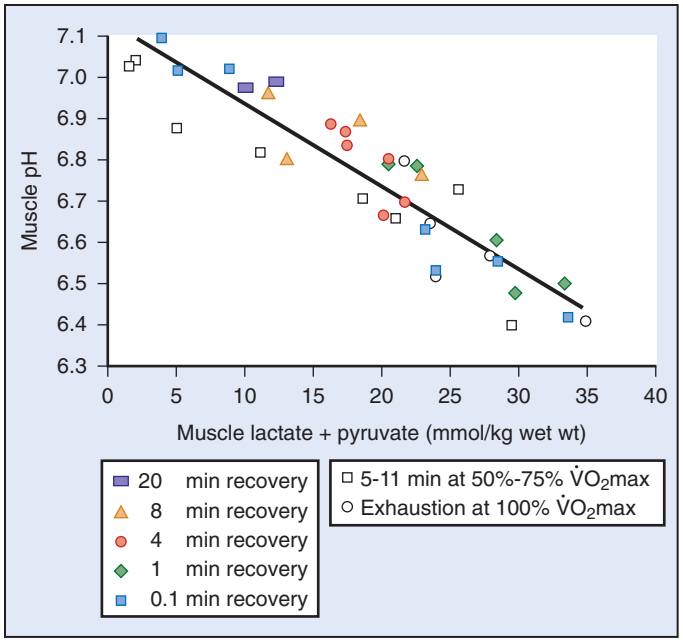

FIGURE 95-3 Linear relationship between the amount of muscle lactate and pyruvate as compared with muscle pH. Data are combined from different exercise intensities and different durations of recovery after exercise to exhaustion. *(From Robergs RA, Ghiasvand F, Parker D: Biochemistry of exercise-induced metabolic acidosis,* Am J Physiol Regul Integr Comp Physiol *287:R502, 2004; and Sahlin K, Horris RC, Nylind B, et al: Lactate content and pH in muscle samples obtained after dynamic exercise,* Pflugers Arch *367:143, 1976.)*

individuals; in highly trained individuals, this point may come at 75% to 85% of $\dot{V}O_2max$. In the trained individual, this difference is due both to improved convection of oxygen with a high cardiac output and increased capillary density, as well as to distribution of muscle fiber types with improved oxidative efficiency.

Lactate has often been portrayed as the culprit that leads to fatigue. However, two misconceptions about this need to be corrected. First, as long as there is blood flow, the LT is actually not associated with mitochondrial hypoxia or anoxia. "Anaerobic" metabolism is not occurring. Convection of oxygen to the cell, and diffusion gradients from the blood across the cell membrane into the cytosol and from the cytosol into the mitochondria, are adequate to supply oxygen for oxidative phosphorylation. Second, it is not accumulation of lactic acid that causes muscle fatigue or pain during exhaustive exercise. More likely, muscle fatigue is accumulation of the associated hydrogen ion when progressively increasing amounts of pyruvate being delivered to the mitochondria cannot undergo oxidation, thus leading to the generation of lactic acid and the associated hydrogen ion.

IMPROVING HUMAN PERFORMANCE

MALLEABILITY OF THE LACTATE THRESHOLD

Understanding the top end of the body's physiology is only the beginning of understanding the translation of energy potential into endurance, efficiency, and performance. This next section stresses the importance of sustainable work, which is the key to engaging in any wilderness endeavor. Sustainable work is defined as the level of exertion that can be sustained for many minutes, hours, or days. It is an intensity of exertion that is below one's LT. Levels of intensity above the LT are reserved for more explosive events in sport or flight of less than a few minutes' duration, such as the 100-m to 800-m events in track and field. In the wild, the short spurt of energy exerted by a cheetah to capture prey is above the animal's LT and not sustainable, which is why the gazelle sometimes wins.

The ability of a muscle to sustain work is related to its oxidative capacity. This capacity is quite malleable, and depends on the level of the muscle's activity while it is engaged.[20,35] Among high-level athletes, oxidative capacity can be several-fold greater than among untrained individuals. Functionally, then, competitive endurance athletes have inherently high $\dot{V}O_2max$ levels, and can perform sustainable work at a much higher percentage of their maximum capacity. For example, an international cyclist may have a maximum work capacity of 550 watts and be able to sustain 450 watts of work during an hour-long hill climb. This is an extraordinary level of work output. A more usual and quasi-sedentary individual may have a maximum workload of 200 watts and be able to sustain 50% to 60% of that work intensity, which is considered to be "normal."

In highly specialized athletes, such as cyclists, the muscle mass involved in the effort has been shown to be progressively recruited in a way such that the oxidative stress is balanced and shared.[14,16] As much as 25% of the cyclist's muscle mass can be spared on a rotating basis, which reduces the oxidative stress of muscle fibers, thus prolonging the onset of the LT. This phenomenon may perhaps be a way to acquire more endurance, delay fatigue, and promote efficiency. Furthermore, with a finite fuel supply, this strategy would preserve glycogen stores and delay the onset of glycolysis (and thus production of lactate).

Functioning "at the edge" of performance requires delicate juggling of aerobic and anaerobic metabolism. This success translates into activities like running an efficient marathon, where 10% of the activity may be above the LT, or being able to hike as quickly as possible out of the high mountains to effect a rescue for a fallen colleague without collapsing from fatigue.

The crux of cellular oxidative metabolism is convection of oxygen to the cell by the circulation, diffusion of oxygen across the cell membrane into the cytosol, and then diffusion of oxygen into the mitochondria. The actual diffusion gradient necessary to get oxygen to the mitochondria is on the order of 2 to 3 mm Hg at each of these steps.[66] Thus, perfusion rather than hypoxemia per se is a limiting factor. Therefore, one of the most important adaptive steps is augmenting blood flow through angiogenesis of the microcirculation. In this regard, in two studies, highly trained cyclists and triathletes with comparable values of $\dot{V}O_2max$ were exercised at 88% of their maximum aerobic capacity until fatigue.[14,15] There were two patterns that showed a shorter and longer time to fatigue. The athletes with more endurance had a substantially greater capillary density than did the athletes who fatigued earlier, despite comparable maximum aerobic capacities. Because both groups were highly trained, it is not clear whether, in certain athletes, there is some inherent propensity for greater signaling of angiogenesis that comes from training. The authors speculated that this augmented perfusion may be important not only for the convective phase of oxygen but also for providing a greater volume of the effluent portion of metabolic by-products.

Another study looked at subtle factors that contribute to fatigue at very high levels of exercise and found that very small changes in energy expenditure when a person is at exercise intensities of greater than 80% of $\dot{V}O_2max$ can lead to rapid onset of fatigue.[53] Therefore, it is critical for an athlete—whether on the field or in the wilderness—to know the location of his or her "edge" so there is some reserve for optimally finishing an activity.

TRAINING EFFECT ON THE LACTATE THRESHOLD

Much has been written since the late 1970s about plasticity of the LT. It behooves any athlete to be able to perform at the highest percentage of his or her maximum aerobic capacity. One of the first studies to look at the effect of aerobic training on the LT involved nine sedentary men who performed 9 weeks of supervised endurance training for 45 minutes per day for 4.1 days per week.[17] There was a comparable untrained control group. The exercise group increased its LT by 44% expressed as absolute $\dot{V}O_2$, and 15% expressed as $\dot{V}O_2max$. $\dot{V}O_2max$ also increased 25%. The maximum work rate increased 28%, with decreases in the ventilatory equivalent seen at submaximal levels of work. The volume of work was similar in the test group, so the study

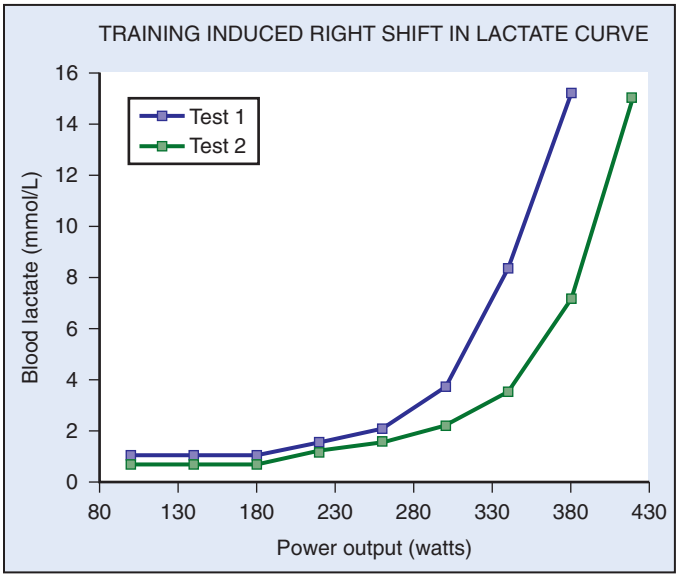

FIGURE 95-4 Training moves the lactate threshold to a higher level of sustainable work.

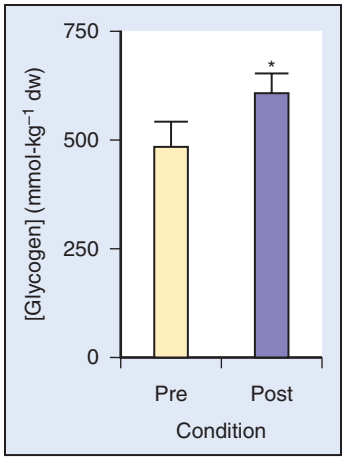

FIGURE 95-5 Muscle glycogen concentration measured in resting biopsy samples obtained before and after a 2-week sprint training protocol. Values are given as mean ± standard error of the mean for 8 subjects. dw, dry weight. *$p < 0.05$. *(From Burgomaster KA, Hughes SC, Heigenhauser GJ, et al: Six sessions of sprint interval training increases muscle oxidative potential and cycle endurance capacity in humans,* J Appl Physiol *98:1985, 2005.)*

did not answer the following questions (Figure 95-4): How much volume is necessary to induce these changes? If some work is good, is more or less better?

The focus of studies then became the effect of volume versus intensity of work on the aforementioned variables, all of which had important implications for performance and health.[27] As understanding of endurance training expanded, there was emerging and ongoing interest in the effects of other types of training, such as interval training (IT), which for many years had been a standard training technique for athletes. IT can take many forms, but is usually described as a series of intense training bouts above the LT, interspersed with recovery periods. Middle distance and endurance athletes perform some level of endurance (i.e., below LT) training every day and then add IT sessions 2 to 3 days per week. Historically, with IT, the time and volume of training have been thought to be able to be markedly reduced. The thinking has been that very intense exercise levels signal greater changes in muscle oxidative capacity, which otherwise would not be stimulated by endurance-oriented aerobic training. Most studies have been done in athletes who were already engaged in active training, so one of the questions that arose was whether IT could add further benefits to performance for athletes who were already performing at a highly trained level.

Several studies have looked at a number of variations on the IT theme and its effect on performance, LT, serum lactate, time to exhaustion, muscle physiology, and so forth. One study enrolled seven trained male distance runners and added 3 days of intense levels of training (i.e., > 95% heart rate maximum) per week for 8 weeks.[1] The results showed no change in $\dot{V}O_2max$, but there was improvement in 10,000-m times, increased time to exhaustion on a set treadmill pace and incline, decreased serum lactate concentrations at 85% and 90% maximum heart rate, and correlations of the decrease in lactate with improvements in performance times. In another study among recreationally active young males, a mere six bouts of four to seven "all-out" Wingate tests spread out over 2 weeks (with recovery days in between) resulted in a 100% increase in cycle endurance time, with muscle biopsies showing a 26% increase in muscle glycogen and a 38% increase in citrate synthase, both markers of muscle oxidative capacity[11] (Figures 95-5 and 95-6).

These two studies provide an interesting contrast in that intense training improved the already trained athletes somewhat and the modestly trained recreational athletes a great deal.

Another study divided 16 active young males into intense IT and endurance training groups that were followed for 2 weeks. The time commitment for the two groups was 2.5 hours and 10.5 hours, respectively. Training results for both groups were similar in that they showed improved time trial times and similar changes in markers of oxidative capacity and buffering capacity in muscle biopsy samples after the training intervention[26] (Figure 95-7).

In a study of a somewhat similar design and intent with more outcome variables, this same investigative group showed comparable improvements in performance, endurance time, and oxidative markers in muscle biopsies[10] (Figure 95-8). After 4 weeks of speed IT in a group of healthy recreationally active subjects, similar findings resulted when compared with those of an endurance group, and the ratio of muscle to capillary to fiber was similar in both groups.[39]

Thus, training intensity was heralded as an important part of overall training.[14] From a practical standpoint, for busy lives, efficiency of training may be an important consideration; thus, this is a significant finding.

These studies are only a few of the better examples of a large body of literature looking at endurance versus intense or interval styles of training. For wilderness activities, the lessons are crucial. Endurance training in the classic sense is the core of training philosophy, but the adventurer also wants to be able to perform at the highest sustainable level that can be created by following

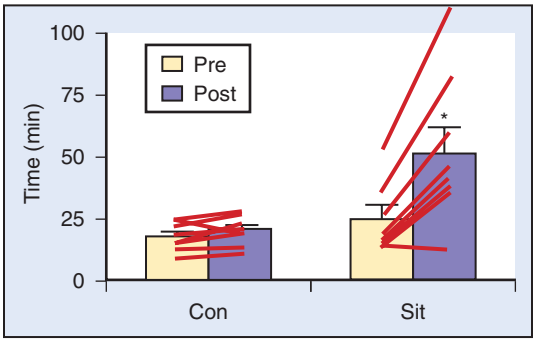

FIGURE 95-6 Cycle endurance time to fatigue before and after a 2-week sprint training protocol (training group; *Sit*) or equivalent period without training (control; *Con*). Values are given as mean ± standard error of the mean for 8 subjects. Individual data are also plotted for all subjects in each group. *$p < 0.05$. *(From Burgomaster KA, Hughes SC, Heigenhauser GJ, et al: Six sessions of sprint interval training increases muscle oxidative potential and cycle endurance capacity in humans,* J Appl Physiol *98:1985, 2005.)*

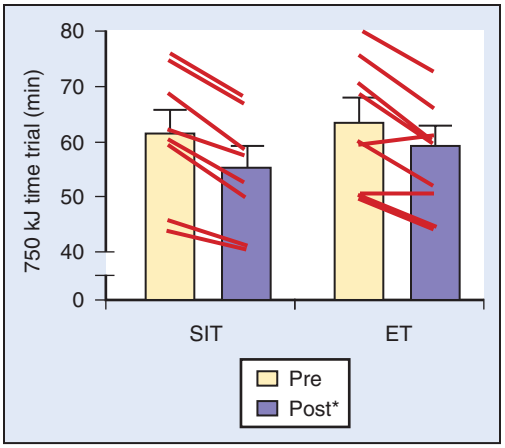

FIGURE 95-7 750-kJ cycling time trial performance before *(Pre)* and after *(Post)* six sessions of sprint interval training *(SIT)* or endurance training *(ET)* over 2 weeks. *$p \leq 0.05$ as compared with pretraining values (main effect for time). The lines denote individual data for eight subjects in each group. *(From Gibala MJ, Little JP, van Essen M, et al: Short-term sprint interval versus traditional endurance training: similar initial adaptations in human skeletal muscle and exercise performance,* J Physiol *575:901, 2006.)*

a training routine that is reasonable and realistic (i.e., compatible with one's other life responsibilities). If it can be accommodated, inclusion of 2 to 3 days of IT per week can be an important addition to endurance training.

From a practical standpoint, how does one perform IT? First, if one has never done that type of training, it is important to realize that it is an intensity of exercise that is not particularly comfortable. Thus, when exercising for minutes at a time above LT, at about 40 seconds into the exercise interval, it will feel like it is time to stop. One should design an IT session and stick to it, especially through the last few seconds. Intervals can easily be incorporated into one's usual routine. Always include an aerobic warm-up and cool-down period. Whether on a bike or on foot, on a trail or road, find a modest hill that takes 1 to 2 minutes to "sprint" up; then slowly jog down and repeat. Start out with a single interval, and then, over the course of a few weeks, build up to 10 intervals. Improvement and familiarity with the new territory of anaerobic training will come rapidly. Start out with one interval day per week, and then increase to two interval days per week over a couple of months. It is felt important not to train above LT every day, because adequate recovery time is essential.

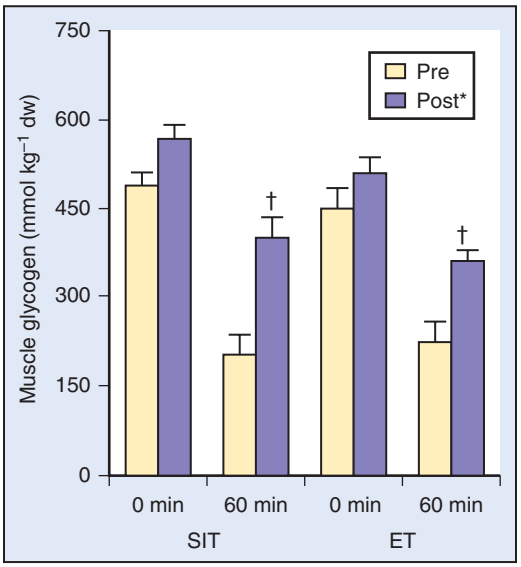

FIGURE 95-8 Muscle glycogen concentration measured at rest and during cycling exercise that consisted of 60 minutes at 65% peak oxygen consumption before *(Pre)* and after *(Post)* 6 weeks of sprint interval training *(SIT)* or 6 weeks of endurance training *(ET)*. Values are given as mean ± standard error of the mean ($n = 10$ per group). dw, dry weight. *Main effect for condition ($p < 0.05$) such that posttraining (Post) > pretraining (Pre). †Condition (Pre and Post) × Time (0 and 60 minutes) interaction ($p < 0.05$) such that Post 60 minutes > Pre 60 minutes in both groups. *(From Burgomaster KA, Howarth KR, Phillips SM, et al: Similar metabolic adaptations during exercise after low volume sprint interval and traditional endurance training in humans,* J Physiol *586:151, 2008.)*

There are a couple of ways to achieve recovery between intervals. One can arbitrarily state that there will be a certain number of intervals of 1 to 2 minutes' duration, with 2 to 3 minutes between intervals assigned for recovery. For instance, one can run 400-m intervals and walk 200 m between each of them. Whatever one does, my best advice is to stick to it compulsively. A more physiologic way to recover is to use a heart rate monitor. Make sure that, at the end of each interval, a near-maximum heart rate is attained. The maximum heart rate is a person's actual maximum heart rate rather than the "220 beats/min minus age" number that is often used but is only vaguely accurate. Determining the maximum heart rate is actually not as easy as it sounds, because most people do not reach it in a reproducible manner. The heart rate at a true anaerobic interval could be considered the maximum heart rate, or one can do a formal cardiopulmonary exercise test during which a trained observer can look for the heart rate at a plateau of $\dot{V}O_2max$. At the end of each interval, one should walk or cycle slowly until a certain desired postrecovery heart rate is achieved, at which point the next interval may begin. Determining the recovery heart rate will likely take some trial and error. It should be defined as the heart rate after recovery from which the next interval can be done at very close to the previous pace. For example, one may run 400-m intervals and reach a maximum heart rate of 180 beats/min and then undergo a recovery walk. Then, for example, when a heart rate of 110 beats/min is reached, the next interval is started. There are obviously much less rigorous ways to perform interval work, but engaging in the creative design process will make one's workouts more fun and varied.

A more tolerable regimen has been proposed by Gliemann and colleagues.[29] The routine they studied involves intervals of a minute in duration, beginning with the first 30 seconds at a sustainable but hard intensity, followed by 20 seconds above the LT, and then 10 seconds of all-out effort. The number of intervals can be increased over time. Their studies showed similar improvement in fitness and performance, and production of vascular endothelial growth factor (VEGF), a marker of microvascular angiogenesis. They propose that this ramped format of IT is more tolerable than and just as beneficial as an intense minute at maximum effort.

EFFICIENCY OF MOVEMENT

In the final step to understanding movement over ground or water, energy must be turned into work with some degree of efficiency (i.e., using the biomechanics of the body to optimize the energy generated by oxidative metabolism). Most of that biomechanical efficiency is inborn. There are many athletes who are so efficient that their excellent performance may be achieved with a less-than-elite aerobic capacity. By the same token, there are many individuals with prodigious $\dot{V}O_2max$ levels and high LTs with suboptimal biomechanics such that their transformation of energy to movement prohibits them from performing at an elite level. This is contrasted with high-altitude mountaineers who have high (but not extraordinary) levels of $\dot{V}O_2$, whose efficiency of movement and high LTs allow them to move quickly and efficiently for hours.

A fascinating example of efficient energy expenditure comes from a study at 4700 m in Tibet, where the authors did maximal exercise testing for 17 Tibetans native to the area and 14 recently migrated Han Chinese. Although the Han had higher $\dot{V}O_2max$ values than did the Tibetans (i.e., 36 versus 30 mL/kg/min), the

Tibetans generated significantly higher work output (i.e., 176 versus 150 watts) at those maximum $\dot{V}O_2$ levels, LTs at higher percentage of $\dot{V}O_2$max (i.e., 84% versus 62%), and lower blood lactate concentrations.[25] There is ongoing speculation as to whether these characteristics are genetic or adaptive; however, regardless of the mechanism of these differences, the Tibetans appear to be ideal work machines at high altitude, and they are able to perform more efficient work with less energy expenditure. Thus, the question arises: Can we train ourselves not only to be more fit but also more efficient (i.e., the perfect adaptation for the wilderness adventurer)?

There are a number of studies demonstrating that—with aerobic, anaerobic, and resistive training—modest improvements in work efficiency can be attained. In a previously cited study,[39] speed endurance training in competitive runners resulted in 5.7% to 6.6% lower oxygen consumptions at three set levels of speed on a treadmill compared with endurance-trained runners. In another training study in runners comparing endurance and IT for 4 weeks,[6] many of the measured variables, including $\dot{V}O_2$max, were unchanged. The most notable finding was that, at maximum energy expenditure (which was unchanged between the two groups), velocity was significantly higher in the runners who had used IT, suggesting greater running economy. Although the topic of exposure to intermittent hypoxia will be discussed more later in this chapter, it is worthy of brief mention to note that, in one study, college track athletes were randomly assigned to 29 days of low-altitude normoxia, constant simulated high altitude (3000 m), or nocturnal hypoxia. Although there were no changes in $\dot{V}O_2$max, hemoglobin, endurance, or LT, the athletes exposed to intermittent nocturnal hypoxia showed about 5% improvement in running economy at a high race speed.

The mechanisms for these improvements are only speculative, but some insight may be gained from a study looking at work efficiency in highly trained cyclists. The investigators looked at work related to caloric expenditure and found a positive correlation with type I (aerobic) muscle fiber types taken from thigh muscle biopsies.[16] Of note was the large range (i.e., 32% to 76%) of type I fibers in these athletes. One of the potential mechanisms of energy cost saving with intense training of any type may be a decrease in ventilatory demand and thus the work of breathing, which, although modest, may be critical to performance.[24] The addition of explosive strength to normal endurance training in competitive runners as compared with ongoing endurance training resulted in improved 5000-m times, which correlated with the improvement in running efficiency. It has even been suggested that ongoing training and competition by a repeat Tour de France winner have resulted in improved efficiency.[14] Although the improvements in efficiency are modest in most of these studies, such improvements may be critical not only to competitive athletes but also to survival in a wilderness environment.

AGING AND TRAINING

As one ages, wisdom—more than speed—in the wilderness may be one's saving grace, but it does not preclude ongoing commitment to conditioning. There is a wealth of literature about the effects of aging on muscle and aerobic performance; a brief summary is important to include here, because so many of us will continue to venture into the wilderness. It is difficult to define old age, but one could say that it begins with the later part of the sixth decade, when there seems to be an inexorable decrease in aerobic capacity and strength. There is another phase of aging, called *senescence,* when there is a profound and irretrievable decline in mitochondrial function, muscle mass, and cardiac compliance. The topic of master athletes and the underlying physiologic mechanisms accounting for the decline in aerobic capacity with age despite rigorous training are also important areas for aging wilderness adventurers to consider.[71]

Almost all organs involved in exercise show declining elasticity and flexibility with age. For example, in the lungs, there are decreased compliance and elastic recoil, decreased respiratory muscle strength, greater gas exchange heterogeneity, and decreased chemosensor sensitivity. These changes result in a greater work of breathing with exercise, impingement on expiratory flow limitation, enhanced tachypnea with smaller tidal volume, higher-frequency breathing pattern, and potential hypoxemia.

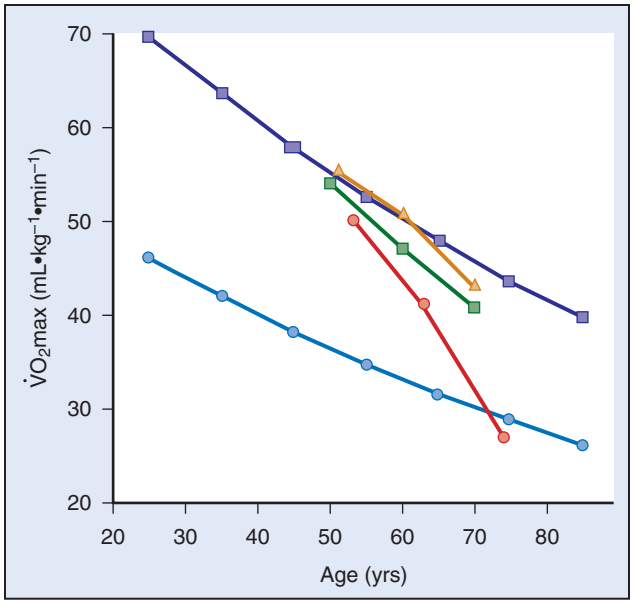

FIGURE 95-9 Maximum oxygen consumption ($\dot{V}O_2$max) of older endurance athletes who continued to train at a high (■), moderate (■), or low intensity (●) after 10-year and 20-year follow-ups (present study). Curves for athletes (▲) and untrained healthy persons (●) are cross-sectional norms. *(From Heath GW, Hagberg JM, Ehsani AA, et al: A physiologic comparison of younger and older endurance athletes,* J Appl Physiol *51:634, 1981.)*

The heart also loses elasticity as the ventricles stiffen and impair end-diastolic filling. In addition, there is a reduction of maximum heart rate. This reduction can be minimized if one continues to train into older age. The oft-quoted maximum heart rate of 220 beats/min minus age is but a gross approximation taken from the cross-sectional data of mostly unfit individuals. There is a decline in peripheral vascular compliance, which may play a role in further hindering blood flow and oxygen delivery.[58] Some of the earlier data also suggested a linear decline in $\dot{V}O_2$max beginning sometime during the third decade of life,[18,40] but subsequent studies have shown that little reduction in $\dot{V}O_2$max occurs from the age of 20 years to the mid-50s if athletes continue active training[57,72] (Figure 95-9).

The cross-sectional data certainly reflect the changes in lifestyle that come with families, jobs, and geography. Although $\dot{V}O_2$max declines in everyone at a certain point, the decline is a result of decreases in oxygen delivery and cardiac output as well as a decrease in oxygen use with declining mitochondrial function, especially among the truly elderly.[5,47,68]

It also used to be thought that, after a certain age, neither strength nor aerobic capacity could be improved.[4,19] However, many studies over the last two decades have clearly shown that older individuals who are otherwise healthy can train and improve both strength and aerobic capacity. The earlier studies were of rather low intensity and duration; whereas, later studies showed that substantial gains could be made with higher intensity and longer duration of training. These gains can translate into practical function in any wilderness environment.

Comparing the decline in $\dot{V}O_2$max between masters and sedentary subjects more than 60 years old, Rogers and colleagues[64] showed that, with ongoing aerobic training, older individuals could decrease the decline per decade in $\dot{V}O_2$max from 10% to 5%. Kohrt and colleagues[45] took 110 untrained men and women between the ages of 60 and 71 years, measured their prestudy $\dot{V}O_2$max, and then had them perform 9 to 12 months of walking or running 4 days per week for 40 minutes per session at 80% of their predicted maximum heart rates. Men and women

improved their maximum values by 26% and 23%, respectively. When they were divided into three equal age groups, there also was similar improvement. In terms of improvements, these values are comparable with those seen among younger subjects.

Conley and colleagues[13] engaged sedentary healthy men and women between the ages of 65 and 92 years in 4 months of both aerobic and strength training and used $\dot{V}O_2max$ testing, Cybex strength measurements, muscle biopsies, and nuclear magnetic resonance spectroscopy to measure creatine phosphate dynamics before and after training. They compared the results of these subjects with those of healthy controls, and found substantial improvements in all of the outcome variables, which were equal in percentage of improvement to those obtained with younger subjects.

These studies are a few of many that have confirmed two important facts: (1) older healthy individuals can be trained in both endurance and strength to a degree comparable with those of younger subjects; and (2) individuals who continue to train throughout life can slow the inevitable rate of decline in aerobic capacity. As is true for younger individuals, it is the total amount of work done that is the important factor for the making of aerobic gains. The American Academy of Sports Medicine recommends approximately 250 to 300 kcal per session. The energy expended is a combination of duration and intensity that must add up to the recommended total. In other words, 40 to 50 minutes of moderate walking would be comparable with 20 to 30 minutes of jogging or slow running for these elder groups.

HIGH ALTITUDE AND EXERCISE

During the summer of 1968 in Mexico City, three world records were set in track and field, and one favored American miler was soundly defeated. Tommie Smith (200 m), Lee Evans (400 m), and Bob Beamon (long jump) set records that stood for decades. Jim Ryun, the favorite in the 1500 m, was beaten by Kip Keino from Kenya. Aside from the fact that the first three were serendipitously some of the greatest sprinters and jumpers of all time, part of their advantage may have been the slightly thinner air at the altitude of 2200 m (Figure 95-10).

Alternatively, Jim Ryun and the American middle-distance hopes were dashed. The burning questions then became the following: Was Ryun not acclimatized to the higher altitude? Was there something special about Keino's being born and raised at that altitude in Kenya? These questions set off an intense interest in high-altitude training, which was thought to be the answer for improved aerobic performance. Initially, no one thought of any potential deleterious effects of training at higher altitudes. As has been discussed previously, in spite of certain acknowledged benefits, training at such altitudes does not allow one to reach the intensity of training that is necessary for improved aerobic fitness and higher sustainable workloads. Prudent investigators started a series of studies to answer these questions more precisely. In fact, before the 1988 Seoul Olympics, the American road cycling coach wanted to take the team to an altitude of more than 3700 m for 2 weeks right before the games, which were to be held at sea level. Fortunately, he was prevailed upon to not do so. By that time, it was clear that there was a decrease in intensity of work that athletes were able to do at those altitudes. High intensity of work, as has been noted previously, is needed for greater gains in aerobic capacity and beneficial alteration of the LT.

EFFECT OF HIGH ALTITUDE ON EXERCISE

The next two sections of this chapter cover the effects of altitude on exercise as well as the positive and negative aspects of training at high altitude (Figure 95-11). Both topics have important implications for wilderness travel, much of which occurs in the cold, thin air. Chapter 1 covers the broad topics of high-altitude acclimatization and illness.

All levels of climbers dream of scaling the world's highest peaks. Those who are successful at high-altitude climbing are athletes whose characteristics are not uniform. However, as is true of other elite athletes, certain traits are necessary.[33,56,60,74]

FIGURE 95-10 Peter Norman, Tommie Smith, and John Carlos at the award ceremony for the 200 m race at the 1968 Summer Olympics in Mexico City, an altitude of 2200 m (7218 feet).

Many of the same physiologic limitations are encountered to a lesser degree at more moderate altitudes frequented by trekkers and adventure travelers, but for both groups, an understanding of the common hindrances is quite important.

Anyone who has sojourned quickly to 3000 m or higher cannot exert themselves without dyspnea and exercise limitation. With acclimatization over time, the limitations discovered at 3000 m can be substantially diminished.[34] At altitudes of 3500 to 8000 m, sea-level performance cannot be attained despite prolonged adaptation. Although the fraction of oxygen in the earth's atmosphere is constant at 0.2093, the barometric pressure and thus the content of oxygen decreases as one ascends. For example, with some variation depending on the weather, the

FIGURE 95-11 Mt Ama Dablam in the Khumbu region of Nepal. *(Courtesy Robert B. Schoene.)*

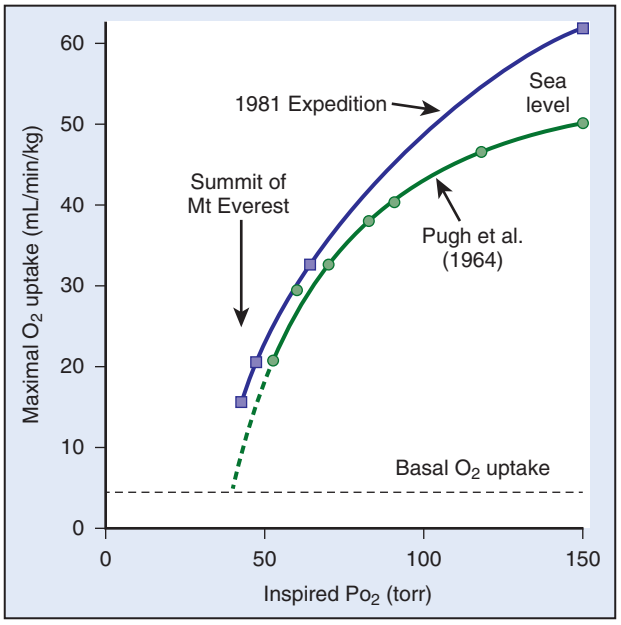

FIGURE 95-12 Maximum oxygen (O_2) consumption plotted against inspired partial pressure of oxygen (P_{O_2}). The present data (■) are contrasted with measurements (●) made previously by Pugh. Note that, although the curve derived from the data in the present study is only slightly shifted to the left, because of the steepness of slope, gain in maximum oxygen uptake at extreme altitudes is substantial. *(From West JB, Boyer SJ, Graber DJ, et al: Maximal exercise at extreme altitudes on Mount Everest,* J Appl Physiol *55:688, 1983; and Pugh LG: Cardiac output in muscular exercise at 5800 m (19,000 feet),* J Appl Physiol *19:441, 1964.)*

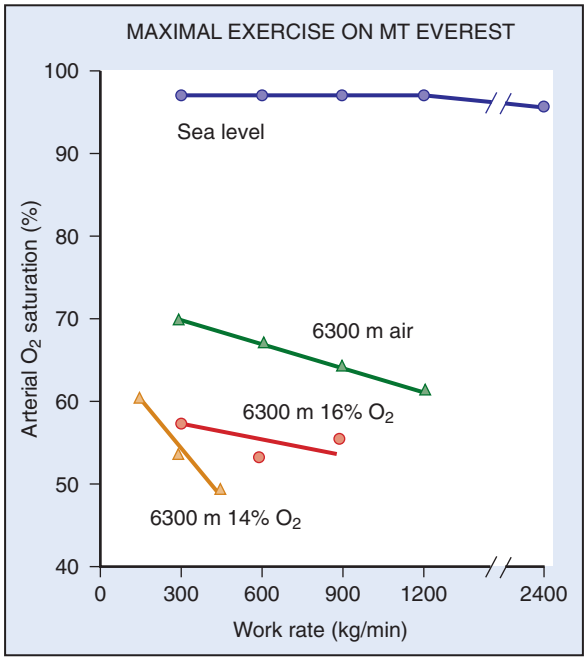

FIGURE 95-13 Arterial oxygen (O_2) saturation against work rate for four conditions studied. Note the steeply falling oxygen saturation as work rate was increased when the inspired partial pressure of oxygen was very low. This can be explained by diffusion limitation of oxygen transfer across the blood-gas barrier. *(From West JB, Boyer SJ, Graber DJ, et al: Maximal exercise at extreme altitudes on Mount Everest,* J Appl Physiol *55:688, 1983; and Sutton JR, Reeves JT, Wagner PD, et al: Operation Everest II: oxygen transport during exercise at extreme simulated altitude,* J Appl Physiol *64:1309, 1988.)*

barometric pressure at sea level is approximately 760 mm Hg, whereas, at the summit of Mt Everest (as measured by Chris Pizzo on October 23, 1981), the barometric pressure was 253 mm Hg. Thus, at the summit, there is approximately one-third of the amount of oxygen available for aerobic activity as compared with sea level.[75] With less oxygen available in the air, there is a decrease in oxygen availability at each step of the delivery of oxygen from air to the lungs to the blood to the tissues and mitochondria. As a climber ascends, his or her $\dot{V}O_2max$ decreases[70,73] (Figure 95-12), and the speed of ascent and sustainable work rate decrease.

One of the limiting factors is the increased work of breathing that occurs for any given level of energy expenditure. For example, the ventilatory equivalent is almost four times greater at 6300 m than it is at sea level.[12,67] Thus, blood flow necessary to perfuse the muscles of respiration is stolen from the muscles of locomotion. Furthermore, because of a diffusion limitation of oxygen from air to the blood at high altitude, the higher one ascends, the greater the amount of oxygen desaturation with exercise (Figure 95-13).

The body at high altitude goes through a complex series of adaptations that do their best to optimize delivery and use of oxygen, despite less availability. The breadth of acclimatization involves a progressive increase in ventilation that is immediate and goes on for weeks; an improvement in ventilation and perfusion match in the lungs and thus gas exchange, which occurs over the course of several hours; an increase in oxygen-carrying capacity as a result of an increase in red blood cell production through erythropoiesis that occurs within 10 to 14 days; and an improvement in tissue oxidative capacities over a number of weeks to months.

For persons going to high altitudes, the most important thing to remember is that everyone's rate of adaptation at each of these steps is different, which results in a range of time for adaptation. Thus, when on a trek, everyone with enough time to do so should adapt well and be equal in terms of acclimatization and fitness; however, it is difficult to predict who will be a slow versus fast adapter. Sometimes the individual who feels less well at the beginning may be the best acclimatized at the end.

In terms of training for high-altitude ventures, other than being generally fit, there is not much a lowlander can do to prepare. Chapter 1 suggests rates of ascent to minimize the chances of getting altitude illnesses. These rates are similar to those needed for people to gain acclimatization and fitness. The most common mistake is to take too little time for a trip to the Himalayas or the Andes—or even a week-long ski trip to Colorado. A rigid schedule that does not allow sufficient time for acclimatization is dissatisfying at best and dangerous at worst. Having been preexposed to high altitude before going on a challenging trek is always beneficial, but usually neither feasible nor practical.[55] Such issues have become important considerations for military personnel, who may need to ascend rapidly for certain operations.[54]

HYPOXIC TRAINING

Interest in training at high altitude for low-altitude athletic events has not abated over the last four decades. What started as a positive assumption turned into an area of intense research to try to answer whether living or training at high altitude is beneficial for low-altitude competition. Some of these principles apply not only to competitive events but also to travel and adventure to high altitudes. The purpose of altitude training and intermittent hypoxic training is to induce some physiologic adaptation from hypoxia that is presumably beneficial to endurance performance.[51]

When it finally dawned on trainers and coaches that full-time hypoxic exposure might not be beneficial, a number of methods were tried to get "enough" hypoxic exposure without having too much. Levine and Stray-Gundersen[50] set out on a prolonged series of experiments in accomplished runners. The study design included four groups: (1) athletes who lived and trained at low

altitude (LLTL); (2) those who lived high and trained high (LHTH); (3) those who lived low and trained high (LLTH); and (4) those who lived high and trained low (LHTL). Part of the rationale for such a design was to test the hypothesis that training at high altitude does not allow an athlete to achieve as intense a training effect as he or she could achieve at lower altitude. The altitude exposure of the LHTL group was 4 weeks of 20 hours per day at 2500 m. The upshot from these series of studies was that the athletes who improved their $\dot{V}O_2max$ and 5000-m times were in the LHTL group, and this improvement correlated with those who had an erythropoietic response. The increase in $\dot{V}O_2max$ corresponded precisely with the increase in oxygen-carrying capacity. However, even in the LHTL group, there were responders and nonresponders, which were differentiated by improvements in 5000-m race time. The responders' improvements corresponded with whether they had an erythropoietic response. Levine contends that there is a threshold (i.e., specific hypoxic dose) that is necessary to inducing these responses and that, in a number of previous studies, the dose may not have been long or high enough.[49] In his discussion, he reminds the reader that the mechanism of response to hypoxia is signaled by hypoxia-inducible factor-1α and that this protein is one of the most evanescent proteins of gene transcription described in the body: when the hypoxic stimulus is removed, hypoxia-inducible factor-1α immediately disappears. Thus, all subsequent gene transcription ceases, and no further growth factors (e.g., erythropoietin) are stimulated. The hypoxic exposure must be intense and sufficiently prolonged to keep the cycle going. Not everyone responds, and the gains are minimal among those who do. So is it all worth it?

Many athletes think it is worth it. The urge to excel has led to "hypoxic sleeping tents" that can be purchased. With such a tent, the athlete can sleep in his or her bed and dial in progressive altitudes for weeks of "natural acclimatization and blood doping." This trend has led to a number of studies of intermittent hypoxia (i.e., normobaric or hypobaric) to see if effects similar to those obtained at true altitude could be found. Julian and colleagues[43] exposed athletes to progressive normobaric hypoxia (i.e., a fraction of inspired oxygen of 0.11%) for 2 weeks for 70 minutes each day and found no changes in performance or erythropoietic markers. Using normobaric hypoxia (i.e., a fraction of inspired oxygen of 14.5%) for 6 weeks, Zoll and colleagues[77] divided runners into two groups: LLTL and LLTH. They looked at performance (i.e., $\dot{V}O_2max$ and time to exhaustion) and muscle biopsies to evaluate markers of hypoxic transcription and oxidative phosphorylation. With the LLTH design, the researchers found a modest improvement in $\dot{V}O_2max$ (5%), a remarkable improvement in time to exhaustion (26%), and substantial increases in the transcription factors and markers of oxidative phosphorylation. Gore and colleagues[32] exposed athletes to a simulated altitude of 4000 to 5500 m for 3 hours per day on 5 days per week for 4 weeks and found an increase in erythropoietin but no increase in markers of red cell production. With a similar design, this same research group studied swimmers and found no improvement in swimming times with the intermittent hypoxia.[63] They concluded that the "hypoxic dose" was not adequate enough.

Other studies have shown similar modest or negative results with various paradigms of altitude training. Siebermann et al.[69] used normobaric hypoxia simulated to 3000 m for 16 hours per day for 4 weeks. They found no difference in physiologic markers and performance between the low-altitude and simulated high-altitude exposure. On the other hand, Saugy and colleagues[65] used hypobaric hypoxia and compared findings with exposure at comparable altitude and duration to subjects in normobaric hypoxia, and found a modest improvement in the normobaric hypoxia group. The mechanism of the difference is not clear.

Not all intermittent hypoxic studies have been negative. Katayama and colleagues[44] exposed a small group of runners to a simulated altitude of 4500 m for 90 minutes per day three times per week for 3 weeks. In the hypoxic group, they found improvements in running time and time to exhaustion as well as lower $\dot{V}O_2$ levels at submaximal exercise levels, with no other changes in hemodynamic or hematologic variables. Thus, the authors contended that this type of exposure led to an improvement in running efficiency. However, they did not offer any insight into the mechanism of presumed efficiency. Humberstone-Gough and colleagues[38] compared a group living high and training low (LHTL) with intermittent hypoxic training, and found a greater increase in hemoglobin as well as improved running efficiency and speed in the LHTL group. Another construct was utilized by Faiss and colleagues[23] in athletes from team sports. They used intermittent hypoxic exposure to repeat sprint training during hypoxia, and found decreased fatigue in the interval-trained athletes. Presumed improvement in efficiency was invoked as the mechanism of improvement.

So, are all of these manipulations much ado about nothing? There seems to be a benefit in performance for some athletes who are "responders," but clearly the "dose" and duration of the hypoxic exposure have to be adequate. That dose is a tedious one to determine, and such efforts may only be worthwhile for highly competitive athletes. As for those who venture into the mountains, remember to go slowly and enjoy the scenery.

ARTIFICIAL TRAINING METHODS: BLOOD TRANSFUSION

With the advent of competitive wilderness events (e.g., endurance high-altitude races, "X-games," speed climbs), the use of dangerous and arguably unethical methods to improve one's performance has inevitably emerged. This is not surprising given the presence of such methods in other sports for decades or perhaps even centuries. Although there is no role for such interventions in wilderness activities or competitions, a short comment on one of the most egregious approaches is warranted.

There is a surfeit of information on blood transfusions ("doping") and erythropoietic medications.[21,28,62] The interest in enhancement of performance by increasing oxygen-carrying capacity with extra red blood cells was brought to attention via the 1968 Mexico City Olympics and then into the 1970s, when certain middle-distance Scandinavian track athletes were suspected of blood doping. Subsequent data supported the benefit of increased red blood cell mass and improved aerobic performance.[9] Such augmentation was achieved by either autologous or allogeneic transfusions, and later when recombinant erythropoietin (EPO) was developed. Administration of this drug was rampant in a number of sports venues, most notoriously European cycling. Although the benefit of increased red cell mass was acknowledged, the philosophy that, "If some is good, more is better" led to fatal complications in a number of young athletes, because the downside sequelae of increased red blood cell mass were increased blood viscosity, strokes, and death.

Both the scientific community and international sports governing bodies have rallied to try to prevent such abuse and minimize the physical risk to young, vulnerable athletes. Detection of both blood doping and EPO has reached a scientific level of sophistication such that most athletes, when properly screened, can be discovered.

It is the opinion of this author that to summit Mt Everest, win a high-altitude endurance race, or be publically acclaimed as a champion in an extreme sport, one should compete and perform within the boundaries of "fair means." To do otherwise clearly sometimes incurs unacceptable risks of injury and death, because the wilderness environment in and of itself can accentuate dehydration, hemoconcentration, and subsequent medical consequences, including death. As emphasized earlier, one should go to the wilderness for enjoyment, fellowship, and self-fulfillment.

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CHAPTER 96

Exercise, Conditioning, and Performance Training

JOLIE BOOKSPAN

A surprising number of exercise and conditioning activities do not build function for daily life, the trail, or survival in the wilderness. Sets and repetitions of stretches and exercises do not change poor movement ergonomics or repair injuries. Some reinforce movement habits leading to increased injury, which may be mistaken for overtraining and pain syndromes. Stretches and exercises are most beneficial when they directly train and practice real-life function and healthful biomechanics. This chapter covers healthy, functional training for lifetime health, pain prevention, and healthier wilderness travel.

FITNESS AS A LIFESTYLE

To many people, fitness means stopping "real" life to do repetitions of motions in a gym with poor similarity to movement patterns in daily life or sport, and then returning to moving with poor ergonomics, bending in unhealthful ways dozens of times daily, and slouching when standing, sitting, and moving. Fitness as a lifestyle does not necessarily mean working out or going hiking. It is how one moves in all regular daily activities everywhere, sometimes called functional movement. Where conventional exercises are sometimes not healthy and will not prevent poor movement that injures, functional fitness adds strength, mobility, injury prevention, awareness, stretch, and other benefits that would otherwise not be achieved. Gymnasium training can be helpful or harmful, depending on the nature and quality of the exercises, stretching routines, and workouts taught and performed.

Changing exercises into healthy functional movement is a large and inspiring area of rethinking and retraining. Instead of sitting and moving slouched and then stopping to stretch to relieve the resulting pain, one should sit, stand, and lift properly to enact exercise and muscle length as a lifestyle, and prevent pain in the first place. Instead of isolated abdominal exercises, one should employ a neutral spine posture that uses abdominal muscles to prevent an unhealthful spine angle during running and movements of daily living; this deploys substantial functional abdominal exercise in daily standing and moving. It is important to be active, but not as a different, inconvenient part of the day. Ordinary daily actions to bend, move, lift, reach, and balance, when changed to healthful patterns, provides healthy, built-in exercise as a lifestyle.

SPECIFICITY

Strength, power, muscular endurance, balance, and cardiovascular fitness engage different body systems. Each develops through different practices. Working one part, such as arms or legs, or one system, such as strength or flexibility, does little to develop other parts or systems.[9] Running, for example, creates cardiovascular, metabolic, and structural changes specific to running but not necessarily to hanging from rock ledges. Trained runners may exhaust themselves during long swims, and paddlers during climbs, even though all may have high aerobic capacity. Another example is a common weight-lifting practice of lifting at slow speed. This does not train the more rapid joint angle movement needed in common wilderness, daily life, and rescue situations.[13] Slow lifting can build strength, just as can any weight lifting, but not power that depends on speed, or injury-prevention capability that comes from training for rapid stabilization. To get off a ridge before bad weather hits, and be fast and safe when these attributes are most needed, one needs to train different body parts and systems to work together.

It is best to train as needed for function, and to train abilities together. Wilderness skills and activities of daily living are multisystem, multijoint, multispeed, and multifunctional entities. The wilderness often demands endurance, strength, power, and balance simultaneously (e.g., holding healthy joint positioning under the weight of a pack while crossing a rope bridge, descending carrying a stretcher on skis or in foul weather, rock hopping, escaping a flash flood, or hiking with small children).

STRENGTH, MUSCULAR ENDURANCE, AND POWER

Strength is generally defined as how much a person can move or carry in a single or a few efforts. Muscular endurance is how long one can continue being strong. Power in a fitness setting is how quickly one can be strong; power is work per unit of time.

The ability to perform strength, endurance, and power tasks depends on the individual level of fitness, workload, type of work, exercise efficiency, and leverage, and on whether the work is external, such as carrying weights,[54] or internal, such as carrying oneself,[176] which varies with body weight. On ascents, a heavy person may work harder and closer to his or her maximum than does a lighter person of similar fitness or even of lesser fitness, depending on the workload. Internal work such as hiking and climbing may favor the smaller, lighter person. For external work such as that involved in a portage, rescue, and hauling gear, a larger person of high muscular fitness may have an advantage. Several factors influence advantage more than do strength and size.

Different activities require different ratios of strength to muscle contraction speed. A higher strength component compared with speed of contraction (e.g., used during portage and rock climbing scrambling) is strength-dominated power.[9] Kicking with fins, swimming, running, jumping, and deploying safety equipment primarily employ speed-dominated power.[125] Many situations, such as navigating rapids, require both strength and speed in constantly changing proportions.

Abdominal Muscles and the Core

It is a common assumption that strong abdominal or other muscles support the back, spine, or body, for certain activities. However, abdominal strength or endurance does not automatically support any structures or reduce the incidence of back pain. The word *support* is often used without understanding what the muscles actually do. Merely being strong or tight does not effect any change or support. Actual support entails a voluntary and specific change in vertebral and pelvic angles to reduce loading and pain-producing positioning.[20] For the abdominal muscles to support the back, it means they need to move the spine away from an injurious into a healthful angle that can be maintained during movement and standing. Merely strengthening muscles by conventional exercises does not accomplish that.

Abdominal muscles do not lend a special "support" function different from other muscles. Like any other skeletal muscles,

abdominal muscles pull on the bones to which they are attached. Specifically, abdominal muscles pull the ribs and pelvis to bend (flex) the spine forward. The times during which one needs abdominal muscles to pull to flex the spine forward is not when lying on the back, but when standing, walking, running, carrying loads, and during all other movement (even some instances of sitting), not to bend forward but enough to prevent the spine from hyperextending into compressive hyperlordosis (swayback). Hyperlordosis increases the lower spinal curve, compressing posterior vertebrae and associated facet joints. Hyperlordosis is a major cause of "mystery" lower back pain felt after prolonged periods of upright position because of the compressive loading from the acutely pinched lumbar angle. Sitting and bending far forward temporarily stretches the compressed painful area, giving rise to mistaken practices of forward bending to cure back pain, rather than stop the damaging cause of allowing the painful hyperextended posture. It should be noted that in certain circumstances of anatomic abnormality, such as spinal stenosis, slightly bending forward for a moment can provide pain relief and is diagnostic. Using a neutral spine can also provide this in many cases.

Hyperlordosis means too much inward curve to the lower (lumbar) spine. It is not a structural problem but an unhealthful and easily changed bad posture. Tightening or strengthening abdominal muscles does not change a hyperlordotic spine angle or prevent return of the resulting pain. Preventing the overly large arch of hyperlordosis by moving the pelvis and lumbar spine to a neutral angle discontinues unhealthful loading and the cause of that specific pain.

Maintaining a neutral spine posture employs voluntary use of abdominal muscles. Strengthening abdominal muscles through exercises does not cause or promote a neutral spine. Through practice, abdominal muscles are in constant use to flex the spine sufficiently to habitually maintain a neutral spine posture.

It does not take great core strength to transform a hyperlordotic to a neutral lumbar spine. Therefore, even smaller people can tolerate a heavy pack with less strain, whereas someone with a strong core who stands with an increased lordotic arch (hyperlordosis) imposes a high load on vertebral facets[107] and disks[23] from the weight of the upper body and the pack on the unfavorable vertebral angle. The person who uses core muscles to prevent an injurious spinal angle will acutely reduce back pain, and prevent its return without exercise or medical treatments.[21] To feel the change from hyperlordosis to a neutral spine posture, try the following and refer to Figures 96-1 to 96-3 for change of hyperlordosis to neutral:

- Stand with your back against a wall. Touch the heels, buttocks, and upper back to the wall. Notice if you have a large space between your lower back and the wall, and/or if you need to lift ribs to enable your upper body to touch the wall. If this causes back pain, you may have a hyperlordosis component. Reducing this to neutral spine will immediately reduce lower back compression and therefore pain.
- Change the large lumbar space to neutral spine posture by gently pressing the lower back closer toward the wall, reducing the large arch. Tuck hips as if starting a crunch, without curling the upper body forward. Do not tighten hip or abdominal muscles or curl your upper body away from the wall. Learn to stand comfortably upright, not bent forward. If previous pain existed from too high an angle, low back pressure should be gone by reducing the angle to neutral. Do not tighten abdominal muscles or flatten your lower back completely against the wall. Reduce a large inward curve to make the curve smaller and feel how the spine and pelvis moves without tightening to achieve the movement.
- Now try again to stand with your back against a wall, this time also touching (or approximating) the back of your head to the wall. Notice if you need to increase the lower back arch or lift ribs to allow your head to touch or come closer to the wall. If this causes lower back pain, you may have a hyperlordosis component, and reducing it to neutral as described above would help.

FIGURE 96-1 Hyperlordotic lumbar angle shifts load to the low back *(left)*. Hyperlordosis components include tilting the pelvis anteriorly and/or leaning the upper torso rearward (thoracic leanback). To reduce hyperlordosis to neutral spine posture, tuck the pelvis until it is vertical and bring the upper body forward until it is upright *(right)*. Moving the spine to neutral and maintaining neutral spine posture (not strengthening or tightening) is how abdominal muscles prevent back pain.

- If you cannot reduce hyperlordosis and still maintain the back of your head touching the wall or close enough to it to stand comfortably upright and vertical, your anterior chest and/or anterior hip may be too tight to allow healthful upright standing. Use the functional stretching section that follows for stretches to address these issues. Until then, learn the movement to reduce a significant lumbar hyperlordosis to a smaller healthier neutral spine angle without

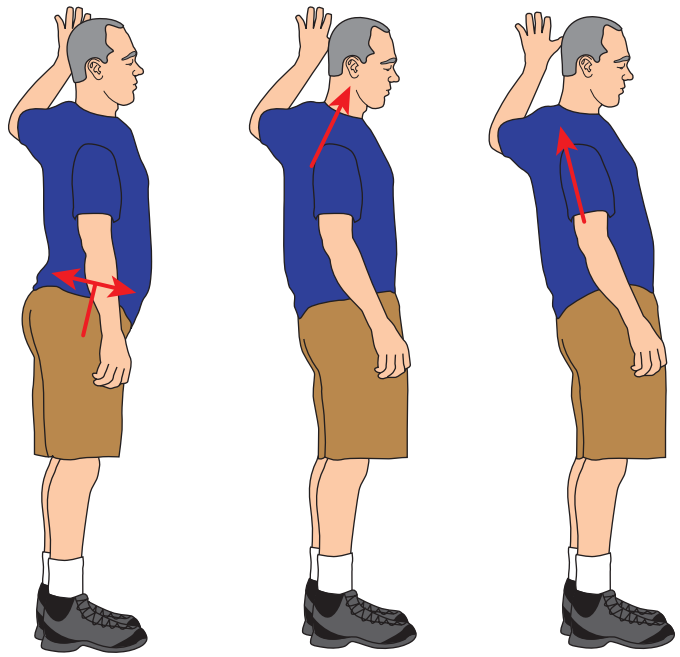

FIGURE 96-2 Restore muscle length to the anterior chest to prevent tightness that favors unhealthful and painful neck and upper back positioning. Maintain a vertical pelvis position *(center)*. Avoid hyperlordosis caused by a flexed, anteriorly tilted hip *(left)*, forward head *(center)*, and hyperlordosis by deploying thoracic leanback and/or pushing the pelvis forward *(right)*.

FIGURE 96-3 Hyperlordosis *(left)* shifts the load to the low back joints *(facets)* and is not necessary to balance the pack. Instead, pull upper body to an upright position and tuck the hip to achieve a neutral spine posture and vertical pelvis position, which shift body and pack weight off the lumbar facets and into core musculature *(right)*.

the back of your head against the wall, so that you can put a healthier spine angle and more ergonomic position to immediate use on the trail.

Use abdominal muscles functionally in this way to reduce a hyperlordotic spine during all activity, particularly when lifting overhead and carrying loads, whether in the gym or wilderness (see Figure 96-1). When performed correctly, this reduces loading and pain from functional poor posture, [21] as well as increased vertebral sheer attributed to spondylolisthesis.[24] See Conditioning, later, for functional retraining of core muscles.

FLEXIBILITY

Flexibility training is said to reduce the incidence of activity-based injury.[131] One proposed mechanism is increased muscle length before reaching a tearing point,[137] probably from change in the viscoelastic properties of muscle-tendon units.[178] Another is reduced tendon organ activation.[120] However, the number of injuries that continue to occur seems to dispel the idea of stretching, as it is commonly practiced, as preventive.[150] The disparity seems to lie in how stretching is commonly accomplished, and in movement patterns used during exercise and daily life.

Most conventional stretch practices exacerbate the original problem of pain and dysfunction from excess thoracic kyphosis and stretch weakness of the back and hips. After rounding forward all day over the computer, desk, steering wheel, handlebars, or backpack, more forward rounding is neither healthful nor desired. The widespread phenomenon of forward bending for the majority of stretching and exercise creates a widely occurring lack of extension range of motion needed to simply stand straight, often resulting in chronic low-grade aches, injury, and wear and tear from habitual unhealthy ergonomics and positioning.

To understand functional flexibility for healthy muscle length for all activities, try the following test to see if you can comfortably stand up straight:

- Stand against a wall with the back of your head, shoulders, hips, and heels touching the wall. A small space remains between your lower back and the wall. Check the following to see if you are too tight to stand comfortably upright: Do you have to increase the lumbar arch or lift your ribs to touch your head against the wall? Does your chin jut forward or lift up? Is it too uncomfortable to stand upright against the wall? That means you cannot stand comfortably upright with healthy muscle length in real life.
- When lying supine, can you rest comfortably flat with both legs straight without a pillow under the head or knees?

Anterior muscle tightness of the chest and hip are often the limiting factors in being able to stand comfortably upright in a healthy position. A tight, rounded anterior chest and shoulders contribute to neck, upper back, and shoulder pain.[71] Tight anterior hip muscles, common in people who use flexion-dominated exercises, change the normal angle of the hips and low back, inhibiting normal standing, walking, and running, and add a large share of low back pain.[46] Tight hip muscles, calf muscles, and Achilles tendons contribute to walking duck-footed, or toe-out.[151] The resulting change in gait and stance may wear on ankles, knees,[80] hips, and big toe,[151] and contribute to bunion formation.[142] Tight feet add to some, but not all, causes of plantar fasciitis.[162] Tight hamstrings may be prone to strains. It has been reliably established that tight hamstrings are not related to back pain. It is also found that high hamstring flexibility is not statistically correlated with a reduced incidence of back pain [26] Constant hamstring stretches by bending forward from a standing or sitting position is associated with an increased incidence of disk injury. See the Conditioning section for functional stretches to remedy these issues.

CONDITIONING

This section covers specific functional exercises for health during wilderness travel.

FUNCTIONAL CONDITIONING

Training in the manner used for actual activity is called functional exercise. Strength increase through lifting weights by isolating specific muscles with discrete exercises does not train the multifunctional movement needed to prevent injury, for example, when opening a window or carrying a heavy pack. Many people

accustomed to running on a treadmill or elliptical trainer later turn an ankle on uneven terrain because they have not trained balance, proprioception, stabilization muscles, changing direction, push-off phase, and so on.

An effective approach to training for wilderness skills is to change the practice of exercise for each body part to integrated, functional motion for real-life health and physical ability. Instead of using a treadmill, walk and move over uneven ground for movement and balance training to reduce the risk of sprain on uneven footing and unstable slopes. Use muscles to hold the neck, back, and legs in healthy positions all the time, rather than slumping under heavy packs, for built-in, functional exercise and injury prevention. Climb stairs and hills, not a stair-climber machine, to train for the hills. Use good bending technique, covered below, for the innumerable activities of daily living, to strengthen and accustom the body to needed movement. Lift, move, lunge, walk, and squat to prepare for portaging, hauling, climbing, hoisting, and squatting.

STRENGTH, ENDURANCE, AND POWER FOR WILDERNESS PREPAREDNESS

To increase strength, lift a weight heavy enough to produce muscle failure after 8 to 10 lifts in each manner needed for each task. Continuously lifting a weight light enough to be moved or lifted more than 10 times increases muscular endurance. Lifting the same weight faster trains power.

For external work of dragging sleds, building shelters, rescuing, and carrying gear and packs, train by carrying and moving real-life loads in functional movement patterns at varying speeds, while maintaining healthy positioning of the back, neck, and knees.

To develop muscular ability to move your body for hiking, climbing, skiing, and hauling up inclines, practice lifting your body at varying speeds for various repetitions with pull-ups, push-ups, lunges, and squats. Lifting external weight improves strength, but the joint and muscle mechanics of lifting weights are different from moving one's body against the ground or overhead support. To progress, lift yourself while wearing a backpack or other weight. Loading in addition to body weight also trains the important skill of safely moving under the weight of external loads.

Climbing with packs and other skills requiring both internal and external strength to lift and haul is best trained with intelligent cross-training to optimize several fitness components. Vary lifting and training workouts to avoid injury and stagnation.

Upper Body

Push-Ups. Push-ups are functional for strengthening, for endurance if done as many repetitions, for skill in maneuvering body weight, and when done properly, for training the neutral spine posture. Push-ups are effective, convenient, and easy to improve. A supplemental benefit is to strengthen forearms and wrist bones. One of three main sites of osteoporosis is the wrist. Although principal movers for push-ups are the arm and chest muscles, the back, hip, and core are needed to produce and hold a neutral spine posture and prevent hyperlordosis. Push-ups without preventing hyperlordosis do not train stabilization or exercise core muscles, and transfer body weight to the lumbar spine. Use a mirror when possible to determine positioning. To do push-ups with healthful ergonomics, follow these guidelines:

- During the entire range of push-up movement, tuck the pelvis to reduce the low back arch, as if beginning a crunch. When abdominal muscles are used enough to straighten the back, you will feel them working. The more tuck, the more abdominal involvement. Do not bend at the hip to the extent that the posterior hip lifts upward. Hold a straight position with a minimal lumbar curve throughout the push-up.
- Hold the head and neck straight in line with the back, without drooping.
- Keep the upper back straight, not hunched or rounded.
- Keep the elbows slightly bent at the top of the push-up, not locked straight. Do this as well when holding the top push-up position, called a "plank." If the arms are too weak to support the body weight, strengthen them, but do not add to elbow injury by holding them locked in extension.
- Keep weight distributed over the entire hand to strengthen the wrist without compressing the joint.
- When proficient in holding a neutral pelvis during slow push-ups, increase power with increasingly rapid executions of single push-ups, and then multiples. Try to push off quickly and powerfully so that you can clap your hands. Try pushing off enough to lift the feet as well while safely executing jumping push-ups that maintain back posture. Land with shock absorption, without increasing the lumbar arch on landing. Keep hips tucked to neutral without lifting them.
- Push-ups can be done in inventive ways that simulate extreme wilderness situations; for example, one can do push-ups with one foot lifted, both feet propped on a bench, both hands on a medicine ball or exercise ball that rolls, or even hands and feet on two separate medicine balls or other rolling object. Use abdominal muscles to prevent low back arch, not by tightening, but by moving the spine into neutral spine posture without pelvic rotation.
- Prop feet on increasingly high supports until the position is vertical like a handstand. Do small elbow bends, like upside-down push-ups. Work up to holding a handstand without a wall, doing full dips.

Holding a tucked push-up position even for a few seconds without increased lumbar arch and hyperlordosis may be difficult; such a finding makes it clear why the posture sags under body weight throughout the day, pressuring the lower spine joints and soft tissue. Properly done push-ups train spine positioning in the manner needed for real-life neutral posture, and for wilderness situations of carrying loads with healthy ergonomics. If full push-ups cannot yet be done, start with a high plank to train the neutral spine posture. Make increasing efforts to dip down and push back up. Done correctly, you will feel much abdominal, back, and arm activity.

Pull-Ups. Pull-ups are functional training for hauling yourself up, an often-needed outdoor skill. Hang from a bar, door jam, or tree limb for pull-ups.

- Tuck hips under, as described for push-ups. This lordosis-reducing maneuver specifically trains core muscles in a functional manner with the bonus of training a neutral standing posture.
- If full pull-ups cannot yet be done, start with hanging from a bar to train grip, arms, and neutral spine posture. Make increasing efforts to pull. Use a step to boost the initial lift; then pull up the lower body weight unassisted.
- Avoid exclusive use of machines that allow pull-ups using less than body weight. These machines prevent needed training of hanging against full body weight.
- To practice for special climbing situations, hang feet on another overhead support while doing pull-ups. Reducing weight on arms assists pull-ups while adding tilt and stabilization components.

Lower Body

An average day entails hundreds of bending actions for household and work activities. Instead of doing sets and reps of artificial lunges and squats, use the same advised bending actions for the hundreds of bends that can occur daily.

Squats. The squat is a functional strengthener, enhancing the ability to lift, carry, jump, and rise from the ground quickly and easily, and while carrying loads. Functional movement trains a wide range in the amount of squat and whole-body movement. This combines balance, posture, strength, flexibility, and specific movement skills to prevent pain and injury to the knees and back that arise from bad bending.

One can transform all the different daily actions of retrieving objects from the floor and surfaces of various heights into many dozens of functional squats. Done with unhealthy positioning, squats may accumulate damage to the back and knees. Done properly, squats strengthen legs while training for a good bending position.

Practice at first with a mirror to observe positioning:

- Stand facing the mirror with feet apart, and observe your knees.
- Bend both knees, keeping both heels firmly touching the floor.
- As you squat, notice if you allow knees to sway inward of the feet. Use lateral thigh muscles to pull knees over feet.
- Stand sideways to the mirror and watch your knees in side view while squatting. Notice if your knees slide forward. Look down and pull knees back until you can see your toes. Hips should move back without arching the back. Keep hips tucked to neutral spine posture, not increased in arch. Increasing the arch was a fitness fad for many years, but as with all hyperlordosis, it added back pain and reduced use of core muscles.
- Keep kneecaps in line with the direction of the feet.
- Keep weight distributed around the entire soles of the feet, not tilting inward onto the arches.

Each time you bend daily, use the squat, always keeping both heels fully touching the floor for functional built-in Achilles tendon stretch. If you keep both feet and knees facing forward, you will achieve this stretch. If you are not able to maintain fully the advised feet and knees position, at least keep the knees facing in the same direction as the feet.

- To progress, perform squats while lifting a judicious amount of weight with each squat. Try lifting weights to develop other muscle groups by performing curls, bench and military presses, overhead lifts, shrugs, and lifts to the side and to the front, among others. Maintain healthful knee, back, and neck posture. Notice if you arch the low back to lift overhead. Prevent that sort of arching by tucking hips to neutral and bringing your upper body more upright.
- Standing (neutral spine posture) places less load on the back than if the weight is carried while sitting. Therefore, instead of sitting to perform biceps curls or other lift, stand or combine repetitions of curling the weight with repetitions of squatting.
- If you use a barbell, hold the weight across the chest. Avoid weight behind the neck unless practicing the fireman's carry or other required task. Observe the neck and spine position.
- Try upside-down squats (leg presses) lying on your back, lifting your pack or a friend with your legs. Do not curl your back, because this stresses intervertebral disks. Keep your hips firmly on the ground.

Apply healthy knee and foot posture for all daily bending and walking. Do not be daunted if it takes time to solidify these habits, but stick with it, because using muscles is important. Get built-in daily bending as a lifestyle, instead of as isolated sets and reps and then returning to bad bending the rest of the day.

Avoid squatting on the balls of the feet with heels raised. An acute knee angle under the body weight pries the knee joints, depending on the size of one's thighs. Certain meniscal injuries of professional baseball catchers are caused by repetitive squatting on toes.[8] To sit in a full squat to rest, or for toileting, keep heels on the floor, a customary sitting posture in much of the world. Squatting with heels down is a functional Achilles tendon stretch.

Lunges. The lunge functionally strengthens the ability to lift oneself to a stand while carrying an overloaded pack or rescued friend, to duck in order to dodge falling rocks, and to climb difficult terrain. Use the lunge for a healthy way to bend and pick up things. Done properly, lunges are beneficial to knee strength and health. The lunge is often done with unnecessary strain on the knee and back, and/or with ineffective use of muscles.

To perform healthy and effective lunges, do the following:

- The key to healthy lunges is torso and knee position. Reduce lower back overarch by tucking the hip, as if starting a crunch, to neutral spine posture. Done correctly, you will immediately feel stretch increase in your rear anterior hip and lower spine.
- Keep your body weight centered between both legs, not leaning toward the front leg.
- Lift the rear heel with the foot straight, not turned out, and bend both knees to lower directly down.
- Keep the front knee over the front heel as you lower. Do not let the front knee slide forward.
- Lower further as you progress, anywhere from an inch to almost to the floor. Keep the rear knee off the floor. Keep the body upright as you lower and rise.
- Use lateral thigh muscles to keep the front knee over the front heel, not sagging or tilting inward (knock-knee, or valgus knee).
- Keep feet in position and do lunges one after the next without moving the feet.
- Practice landing from jumps in proper lunge or squat form. Do not let the body weight fall inward on your knees or arches. Land with soft shock absorption using the torso, thigh, lower leg, and gluteal muscles. Learn to hold proper posture during jumps to train power, strength, and speed, while reducing injury potential. Add sequential jumps and landings for plyometric training (see Power and Plyometrics, later).
- To progress, lift hand weights with each lunge: curls, presses overhead, shrugs, and lifts to the side and the front. Keep good knee, back, and neck posture. Do not arch your back to overhead lift. This multisegmental activity simulates actual daily needs, such as lifting baskets and children, and trains lifting skills for the trail.
- Practice lunges first slowly, and then more quickly (and carefully), to train functional speed and power.

Abdominal and Core Muscle Conditioning

Strengthening core muscles is commonly thought to solve back pain by correcting muscle weakness. On scrutiny, core strengthening has not been found to reduce pain[70] or effect any greater relief than does aerobic exercise or nonstrength programs.[1,57,101] Exercising abdominal and torso muscles does not alter the poor mechanics that are the source of pain.[116] Tightening and clenching muscles is not functional and in fact inhibits optimal muscle use. Using abdominal and core muscles to reposition the spine to reduce hyperlordosis to a neutral angle is how the abdominal muscles unload the facets and support the back.[20] Using abdominal muscles to flex the spine sufficiently to prevent hyperlordosis when standing, running, and lifting overhead gives functional abdominal exercise during most daily activities.

Crunches, and other common flexion-based exercises, may increase strength, but not functional strength for standing and lifting in the upright position of real activity.[20] Holding neutral spine posture against a stationary or moving load is the key to learning how to use abdominal and core muscles for back pain and posture control. For effective abdominal muscle strengthening specific to daily life and trail ergonomics, try the following:

Isometric Abdominal Muscles Retraining Drill

- Lie face up on the floor holding a pair of light dumbbells. Hold legs straight, not bent at the knee, to simulate standing.
- Extend your arms with biceps next to your ears, holding dumbbells approximately an inch off the floor. Notice if your ribs lift and your lower spine arch increases. Press the lumbar spine to the floor. You will feel the load shift to the abdominal muscles.
- The key to using abdominal muscles is to prevent the ribs from lifting, or the low back from arching from the floor. Press ribs downward.
- Raise and lower the dumbbells to about an inch from the floor as many times as you can (at least 8 to 10 times), continuously using abdominal muscles to keep the lower

back from rising from the floor at any point during the exercise. Keep breathing.

- When you have mastered controlling torso positioning during slow arm movement, increase the speed of raising and lowering the weights. Raise the weights no more than a few inches from the floor. If you can see them, they are too high. As the weight lowers, the momentum and weight will encourage lifting the ribs and arching to shift the work of the exercise from the abdominal muscles to the vertebral joints. Use abdominal muscles to prevent this. This abdominal exercise also works the arms and back. The benefit is to learn to use abdominal muscles to hold safe, effective, and functional neutral spine posture when using the rest of your body.
- It is commonly repeated that knees must be bent to protect the back. However, normal standing and function during real activity are not done with knees bent. Bent knees do not protect the back. Using core muscles to maintain a neutral vertebral angle is what prevents a painful angle and load.[20]
- You may feel the thighs lift if your anterior hip is tight. A tight anterior hip is another problematic result of flexion-based exercise systems. If your anterior hip muscles are too shortened to allow flat supine lying down (or prone without increasing the lumbar arch), you are too tight for standing upright with straight legs, as needed for ordinary life.
- Use this straight-leg exercise (isometric abdominal muscles) to retrain use of these muscles to hold the spine and pelvis in position when standing, and to lengthen the anterior hip muscles to normal extension needed for upright activity and comfortable supine positioning.

Using Neutral Spine Posture and Preventing Hyperlordosis for Push-Ups, Planks, and Pull-Ups. This was described earlier. Tuck hips to neutral. Without the tuck to remove low back overarch, core muscles are not in use, and body weight shifts to the vertebral joints (facets). To add resistance to training functional neutral spine posture, do the following:

- Hold a neutral spine push-up position with one arm raised to or above ear level. Keep the body level, not turned. Raise the opposite leg, keeping a straight neutral spine posture.
- Do neutral spine push-ups on a medicine or exercise ball. Practice holding a neutral torso posture, using abdominal and core muscles to train healthy postural habits. Do not take a good exercise adjunct, like a ball, and lose benefits by doing crunches on it.
- Do push-ups with neutral spine posture and one leg out to the side 90 degrees and parallel to the floor. To progress, lift the opposite arm to the side.
- Remember neutral spine posture during pull-ups. It is common to sway the lumbar spine to make the pull easier. Tuck hips and spine while hanging, and while pulling up.

Using Bands and Cables While Standing With Neutral Spine Posture. Pulling cables connected to weights is a common exercise. Without maintaining the spine and pelvis in neutral position as described above, you will miss the majority of the exercise, and practice injurious faulty posture during exercises. Neutral spine posture during various arm directions against resistance of cables provides large core muscle training, when used to maintain spine position.

Using abdominal muscles does not mean "sucking them in," "tightening," or "pressing your navel to your spine." Breathing and healthy movement are restricted or impossible with tightened abdominal muscles, and tightening does not change the poor posture that loads the low back. To understand this, try the following: tighten abdominal muscles as commonly taught. Press your navel to your spine. Tighten the entire area. Note that such tightening would not be possible or useful for daily activity. Next, stand with arched posture. Tighten the abs and surrounding musculature. Note that posture does not change. Stop tightening the area so that movement is unrestricted. Tuck the spine and hips to remove the lordotic arch, straightening posture. Train the abdominal musculature for wilderness activity by using muscles to hold healthy spine and pelvic positioning under load, during standing, lifting, and movement. Neutral spine posture (preventing hyperlordosis) provides efficient exercise at the same time as retraining posture and back pain prevention habits.

Hands and Wrists

Hands and wrists require strengthening and training for daily use and wilderness needs of grabbing, holding, lifting, hanging, pulling, belaying, carrying, and rescuing.

- Open jars. Wring wet clothes. Work with clay. Squeeze things. Give massages. Use pliers and screwdrivers. Saw wood.
- Hang from a bar or tree limb to strengthen grip. Increase the time held. Hang from fingers, then fewer fingers, and different groupings of fingers. Perhaps, eventually, hang from one finger.
- Carry groceries with hands, not a cart. Do not lean back when carrying. Stand straight, torso tucked using core muscles (see Abdominal and Core Muscle Conditioning, earlier).
- Carry suitcases and other items with handles, arms by your sides, holding with finger grip (farmer's carry). Carry heavy dumbbells across the room (lifting and setting down properly, using legs, not bending forward). Use a farmer's carry on unwieldy items like plate weights and heavy books like encyclopedias, as if they were suitcases.
- Train the pinch grip and holding grip strength of fingers and palm by carrying partially inflated medicine balls of different weights or rubber balls filled with water.
- Do push-ups to strengthen wrists and arms, and become accustomed to holding and pushing weight with your hands. Keep weight on the whole hand and fingers, not concentrated on the wrists.
- Do push-ups, or hold the push-up position on fingertips, then fewer fingers, and groupings of fingers.
- Use fingers to push and pull things.
- Instead of hanging directly from a pull-up bar, loop a towel over the bar. Grip the towel at each end and hang to train grip for climbing and rescue.
- Hang from door jams and oddly shaped overhead structures for finger grip training.
- Instead of first gripping and then lowering body weight, jump up to hang from fingers, to practice unexpected situations requiring quick, sure grasp.
- Get rest and stretch fingers back (extension) between intense periods of finger grip and handgrip training to prevent tendon irritation.
- Regularly stretch fingers back softly, and open fingers as widely as possible.

Feet and Ankles

Feet and ankles need exercise but are often overlooked in fitness routines. Tight, weak feet and ankles are more likely to cramp, hurt, strain, and develop plantar fasciitis[103,183] and deformed toes. When the big toe joint does not extend normally when walking (hallux rigidus, or stiffness in the first metatarsophalangeal joint), it alters gait and posture, reduces needed plantar stretch, and promotes hallux valgus (big toe bent away from midline) and bunion. Altered gait may affect the hip and low back dynamics. Weak, unused toes easily deform and curl. Toes must be straight and strong for balance and healthy gait. Weak, overly stretched ankles without a good proprioceptive sense of neutral position are prone to recurrent sprains.

Feet are easy to condition because they routinely bear body weight, giving built-in opportunities to retrain positioning using foot and ankle musculature and proprioceptive skills. Healthful foot and ankle training uses accustomed activities with attention to using foot, ankle, and leg muscles to hold foot and ankle positioning, instead of letting muscles atrophy in tight or supportive shoes. Here is how:

- Keep feet facing straight ahead for gait. Parallel gait builds needed, functional stretch to the fascia and Achilles tendon

with each step. Gait with feet and legs turned outward contributes to hip and knee pain, bunion and valgus toe formation, and is often mistaken for "flat feet" because it weights the medial edge of the feet, thereby pronating, everting, and flattening arches. Toe-in strains the foot, knee, and hip, and affects normal gait.

- Maintain neutral ankle position and prevent eversion and pronation (arch flattening) by deliberately using lateral ankle and thigh muscles to reposition the feet and ankles to neutral level position. Many cases of flat feet are acquired pronation sequelae (bad posture and weak, untrained muscles), not a structural problem.
- Learn to preserve arch and ankle stability without supportive shoes or devices. When standing on the ball of the foot (tiptoe), do not allow ankle inversion, which would tilt toward the small toes. Keep body weight over the big toe and second toe. Practicing neutral ankle on "tiptoe" position deliberately prevents inversion.
- Stretch feet daily using the lunge and bending of the squat, described earlier. Keep the back foot facing straight forward, not turned even slightly outward, or stretch that benefits the foot and calf will be lost. Lift the heel to stretch the bottom of the foot. When stretching the sole of the foot with your hands, stretch the entire sole, not just the toes.
- When you lift weights, stand with feet, ankles, and knees in healthful position, as described above.
- To add function, balance, and strength, lift weights standing on one leg in a healthful position. One-legged standing presents a greater challenge to prevent knee torsion (usually adversely rotating medially) and hold a healthful position.
- Put the toes and forefoot under something weighty such as a door, your other foot, or a friend, and lift the toes and foot.
- Play hopscotch. Hopscotch was possibly developed for Roman soldiers to exercise their feet and ankles. Do other fun combination balancing and hopping games.
- Have fun with balance exercises while training healthy foot and ankle positioning (see Balance Skills for the Trail, later). They strengthen and train ankles and feet in ways needed for normal life and to keep balance on narrow, rocky, uneven, and slippery trails.
- Stand on one foot for increasingly long periods while preventing slouching in other segments. Move the other leg in inventive directions at varying speeds.
- If toes do not move freely, or shoes make toes touch closely to each other, the shoes are too tight for daily wear. Practice moving toes in all directions often. Stretch toes with your hands and by using your foot muscles. When standing, do not clench toes, or lift toes from the ground. Avoid heeled shoes; they are prone to deform feet and are detrimental to posture and gait, affecting the kinetic chain from feet to back and neck.
- Hold foot and ankle posture comfortably level against pronation and supination by using your own muscles. Do not wear a tight boot to do what your own muscles and kinesthetic sense can and should practice doing. Do not let foot muscles atrophy from the disuse caused by a tight, supportive shoe.
- Keep feet facing straight ahead, not turning in or out, except where terrain requires pivoting. Allow the foot to bend at the toe knuckles and push off the ball of the foot, not the sides of the toes. For slopes, heel-first walking often works best. When descending stairs, come down toe-first, and then bring the heel down. Do not crash down on heels. Bend knees for shock absorption with each step.

POWER AND PLYOMETRICS

Plyometrics are exercises designed to train muscles for quick powerful moves.[18] The muscle is first quickly stretched under load (contracted eccentrically) and then immediately forcefully contracted concentrically. Examples are push-ups with a clap between each pair, and rapidly jumping over a line of boxes with quick deceleration crouches between each pair. Plyometric exercises stress muscles and associated attachments more than do other exercises.[55] Learning and maintaining healthy joint positioning and good shock absorption are the keys to safety during plyometric training. Here are some training examples:

- Throw and catch a heavy ball against a (sturdy) wall or in the air in a quick succession of forceful throws and quick deceleration catches, fully bending the arms. Many small children love being thrown in the air and safely caught. Remember safety for all in this exercise. Do not arch the low back when throwing or catching. Keep hips tucked, using torso muscles to handle the load, not the low back. Do not lean back when standing and throwing overhead (see Abdominal and Core Muscle Conditioning, earlier).
- Jumping is a natural plyometric exercise. Use healthful foot, ankle, and knee positioning and neutral spine posture.
- Lie on your back, feet in the air. A partner leans heavily on your feet. Bend your knees to do leg presses. When the partner and you are secure in healthful positioning, press strongly enough to fling the partner off the surface of the feet (a few inches to start); then catch him or her again on the feet, bending knees before straightening knees to press him or her away from you into the air.

STRETCHING FOR WILDERNESS PREPAREDNESS

Heavy packs and difficult terrain may tempt one to adopt poor body positioning. Sagging usually occurs in directions already favored by tightness. Strain and injury often result, confused with overtraining. Fitness classes are filled with people stretching, often in unhealthy ways that emphasize the injurious positioning that first caused their tightness, pain, and injuries. Flexibility training, whether in a gym or during actual daily life movement, needs to retrain muscle length so that you no longer stand, sit, and move with strained unhealthful positioning, rather than holding arbitrary poses for set lengths of time. The main areas to stretch for functional wilderness health and ergonomics are the anterior shoulder and chest, hamstrings, hips, and feet. Stretches should be functional, which means they will support how you move in real life.

Anterior Shoulder and Chest

- Stand upright near a wall with arms relaxed at your sides. Notice if your thumbs point toward each other. This internal arm rotation usually indicates pectoral shortening. Note that trying to hold arms with thumbs facing forward instead of inward may feel tight or unnatural, because tightness prevents it. Next, stand with your back against a wall, touching heels, buttocks, upper back, and the back of the head. Notice if this aligned standing is uncomfortable or if you increase lower spine lordosis instead of having sufficient muscle length to stand reasonably upright.

To restore healthy resting length to the anterior chest, try these stretches:

- Anterior (pectoral) stretch: Face the wall and pull one bent elbow out to the side, with the inside of the arm against the wall. Turn your body and feet away from the wall and use the wall to gently brace the inside of the elbow. Feel the stretch in the anterior chest muscles. Do not hunch or tighten the shoulder. Hold for a few seconds on each side. Drop the arms and observe thumb positioning, which this stretch should correct by lengthening the previously tight anterior chest. Restored functional anterior muscle length should now allow comfortable straight standing against the wall, with heels, hips, back, and the back of the head touching (see Fitness as a Lifestyle, earlier). Do this stretch in the morning, before exercise, and throughout the day to restore healthy shoulder and head positioning (see Figure 96-2).

- Top of the shoulder (trapezius) stretch: Remain with your back against the wall, and the back of your head touching the wall. Place one hand behind the opposite hip, as if in an opposite pants pocket. Slide your free arm down toward the knee, keeping the back of your head touching the wall and allowing your neck to stretch comfortably. Do each side for a few seconds each. Do not lean forward. Try the preceding wall-stand posture check again. It should become even more comfortable and possible.
- A stretch that is both diagnostic and therapeutic for tightness is to lie flat on your back without a pillow under either the head or knees. Do not lift your chin or arch your back. Practice a relaxed straight posture. Can you put your arms straight out to the side on the floor without arching your back? Can you bend your elbows keeping your hands against the floor? Can you relax your upper arms against your ears, still touching the floor without arching your back? Many people are so round shouldered that this is uncomfortable or impossible. Use the two preceding stretches.
- Lie supine with a small rolled towel or pillow between your shoulders. Retract your shoulders to the floor over this roll without arching the low back.
- Lie face down, hands at sides and off the floor. Slowly lift your upper body a few inches, and then lower it. Feel the lift from your upper chest, not by lifting your chin. Notice if you bend from the neck. Your intent is to keep your neck in neutral position and feel the range of motion from your chest. This upper back extension is an effective postural strengthener that combines the range of motion. As you progress, move hands to the side and then overhead.

Hip and Thigh

- The squat and lunge described in the strengthening section are important functional stretches. Done as described, the lunge stretches the anterior hip and thigh, Achilles tendon, and foot. For both, tuck your pelvis to vertical position and spine to neutral posture. For the lunge, you should immediately feel the crucial hip flexor stretch when you tuck to neutral position. When used for daily bending and reaching, you gain hundreds of built-in stretches daily.
- For deep lateral rotators, lie supine with knees bent, both feet on the floor. Cross one ankle over the opposite knee. Move the foot on the floor away from the midline until a deep stretch is felt. Gently press the crossed knee away. Hold briefly, and then gently drop both legs to each side. Repeat with the other ankle crossed. For this stretch in a chair, sit up with one ankle crossed over the other knee. Press the crossed knee down. Sit upright and lift the head up, chin held in.
- An effective low back and hip strengthener that includes a functional stretch is good bending using the squat. For all daily bending where you use a partial squat, keep both heels down and the upper body upright. You will get hundreds of built-in functional stretches daily.
- To stretch the quadriceps while standing, hold one foot behind you. Tuck the pelvis to vertical and spine to neutral position. Arching the back will lose the stretch.
- For better quadriceps stretch, stand on one leg, and bend the knee of the other leg in such a way that you hold the foot behind the body. As soon as you change the pelvis angle to vertical and simultaneously attain a neutral spine posture, you will feel a better quadriceps stretch.

Hamstrings

Hamstring flexibility or tightness is not correlated with back pain when one is standing or running, sitting (usually), or exercising.[26] It is also not true that tight hamstrings pull the pelvis posteriorly. Many people with tight hamstrings tilt the pelvis anteriorly and stand with hyperlordosis, which would not be possible with a tight posterior pull.

Lack of hamstring flexibility reduces the capacity to sit on the floor with the feet together and outstretched without rounding the back, which in turn, unequally loads the lumbar intervertebral disks. The result is that many people sit (and stretch) rounded because tightness makes slouching more comfortable and customary than does a healthy position.

Stretching the hamstrings can restore the resting length sufficient for healthy sitting with legs outstretched and for functional use of hamstring length needed for kicks, leaps, dancing, climbing moves, and other real-life ranges of motion.

Bending forward from a standing position is not healthy for low back structures.[146,170] To stretch hamstrings without forward bending, try the following:

- The most functional hamstring stretch, meaning the way you need hamstring length for real activity, is to stand upright on one leg and lift the other straight out in front of you. Make sure your standing foot is facing straight forward, not turned out, even a small amount. If it is turned, then either hop to straighten it or put your other foot down, adjust, and figure how to lift one leg without twisting the other foot. This will be healthy training for walking, running, and other movement. Lift to any height that creates stretch in the hamstring.
- A hamstring stretch lying on the floor is to lie flat and lift one leg, pointing the foot to the sky. Keep the other leg straight and flat on the floor. Notice if your anterior hip is so tight that the leg on the floor lifts also. Include anterior hip stretches by lunges, described earlier, until remedied. Keep the shoulders and neck relaxed on the floor. Do not round the back and call it a leg stretch. Another hamstring stretch is the "downward dog," described next.

Achilles Tendon and Foot

- A common Achilles tendon stretch is to lunge toward a wall. It is ineffective when done with the hip flexed and protruding posteriorly instead of vertically. Bring the hip forward, as if trying to touch it to the wall. Keep the back foot straight, not turned out, or the stretch is lost and the medial knee bears the pressure.
- A more effective Achilles tendon stretch is standing with one heel pressing toward the wall at about shin height. Stand no more than fingertip distance from the wall and stand upright (see Hamstrings, earlier). Keep the hip tucked and back foot straight, not turned outward.
- An effective built-in Achilles tendon stretch is to use squats with heels firmly on the floor and feet facing forward aligned with the knees for routine bending.
- The downward dog is an effective multijoint stretch with body weight supported on the hands, protecting the back. Put the hands and feet on the floor, hands far forward of the feet as if starting a push-up and weight mostly on the hands. Keeping the feet where they are, lift the hips up in the air, pushing the hips backward until the heels relax to the floor. Arch the back, rather than letting it round or hunch. Relax the head downward. Keep the feet straight, not turned, with weight on the rims, not the arches. Push the fingers forward with straight, not locked, elbows.
- During daily walking and movement, do not let the body weight fall inward to the arches; keep weight on the sole of the foot. Point toes straight ahead. This prevents uneven and unhealthy stretch forces that gradually deform the feet, ankles, and knees. Make sure the straight leg posture continues through the knee and hip, to prevent straightening the foot from overstraining another part higher up the kinetic chain.

FLEXIBILITY-ENHANCING TECHNIQUES

Several methods augment stretching gains. Stretch regularly. Be warm before stretching.[58,175] *Warming up* means raising the body temperature, because elasticity increases with temperature.

Active warming is accomplished more quickly and effectively with a few push-ups and lunges than with light jogging. Do not be afraid of exercise without air conditioning. Within limits, warmer environments help. Passive warming in a hot tub or shower, or locally applied heat, can help prepare for movement, although direct activity should also be part of a warm-up.

A quick technique to improve immediate flexibility is called push-pull, contract-relax, or proprioceptive neuromuscular facilitation.[50] While holding a given stretch at a maximal comfortable stretch, push (contract) against resistance in the direction opposite the stretch for 4 or 5 seconds without moving or reducing the stretch, to fatigue the muscle. Then pull (relax) into the stretch. Use this technique slowly and safely for any desired stretch.

BALANCE SKILLS FOR THE TRAIL

Balance is easily and highly trainable, but often overlooked. Good balance is crucial for ease of movement, independence, variety of activity, and preventing falls, ankle sprains, and slips on the trail. Injury and disuse diminish balance, which is a use-it-or-lose-it skill. Vicious cycles grow of poor balance, injury, and decreasing activity because of inability and reduced activity. Recurrent ankle sprains are often a matter of lack of retraining foot and ankle proprioceptors that give information about positioning. Weak untrained ankles turn without warning muscles to regain balance and footing. Many balance exercises are isolated, but balance for real life is multifactorial; training needs to address function.

Examples of basic, low-level functional balance needed for health include the ability to put on hosiery and shoes while standing, to step over a pile of clothes on the floor without falling or spilling a cup of water, descending narrow basement stairs holding a laundry basket in both hands without holding the railing, and standing from a chair or the floor without using your hands. Average balance skills include the ability to leap over a puddle or hole in the street and land lightly on the other foot, or safely climb a stepladder without hands and change an overhead light bulb without holding on. High functional balance skill examples are the ability to walk through a rushing rocky stream and rescue a child on a rock.

Try the following in a safe environment with good limb mechanics:

- Stand to exercise. It is functional and healthier for the back than sitting to lift weights or stretch.
- When you lift weights, stand on one foot (at a time) in a healthful position practicing balance and stabilization.
- Be able to balance while lifting or climbing without needing supportive shoes or devices.
- Lift free weights. Instead of standard linear lifts, make figure-8 and other irregular patterns for stabilization and balance. Repeat standing on one foot and then the other. Do not let your weight fall inward on your arches. Maintain good foot posture by using muscles and balance.
- Throw and catch things standing on one foot. Then, throw and catch standing on the ball of one foot.
- Practice balancing on one foot, one knee, or one knee and hand while on the floor simulating climbing or camping activities.
- Practice rising up from the floor and then back down in a smooth manner. Repeat without using hands. Repeat while holding a package.
- For balance and flexibility, stand to put on and take off pants, socks, and shoes.
- Stand on tiptoe. Keep ankles straight and your weight on the entire ball of the foot, not teetering on the outside of the foot or inverting the ankle. Raise and lower 10 times.
- Raise and lower on the ball of only one foot. Maintain a healthy foot and ankle position with weight centered over the big and second toes, not tilting toward the small toes. When proficient, try balancing with eyes closed.
- Walk over uneven ground. Then walk a line on uneven ground. Walk backward on uneven ground.
- Walk a line sideways. Cross the feet, first one in front and then the other behind (grapevine walking). Practice on uneven ground.
- Hop on a line and then hop the line backward, advancing to hopping on uneven ground.
- Slalom hop a line, and then slalom hop the line backward.
- Try going without trekking poles before the first climb.
- Hop from one line, space, marking, or crack in the sidewalk or ground to the next such indicator. When landing from any hop or jump, use shock absorption by bending the knees and using muscles to slow and pad the landing.
- Kneel on a large exercise ball. Stand on rolling surfaces. Walk on fence rails. Use a skateboard and balance board. Skate.

DEVELOPING SPEED FOR WILDERNESS SITUATIONS

Wilderness conditions often require the ability to react, move, grasp, or run quickly. Speed training aids outdoor activities, from catching falling equipment or companions, to paddling around unexpected logs, to running from bees. Each person has different muscle fiber distributions that favor speed, strength, or endurance. Some have a greater distribution of slow, oxidative (type I) fibers, which are highly fatigue resistant and benefit from long steady efforts. Others may have a greater percentage of fast-twitch fibers (type IIb), favoring bursts of strength and speed. Both types respond to training. Individuals with a predominance of slow-oxidative fibers may need to train speed as a corrective countermeasure.

The way to be fast is to train fast. The practice of slow weight-lifting, sometimes called super slow, is a limited way to train with weights. Slow training increases the total time spent lifting, so it increases strength, but does not develop speed for moving heavy objects. Similar strength and endurance gains can be made from lifting weights more quickly and using more lifts, so that the total muscle work remains the same. As the amount of weight lifted quickly increases, the power component increases. When speed training, maintain posture and a safe lifting technique. Injury potential rises with speed of movement, which is another reason to properly train speed. Following are a few examples of speed games to increase speed of movement. With each, imagine application to wilderness performance situations.

- Run a short distance (e.g., 15, 25, or 50 yards) at maximal speed. Rest 10 seconds. Repeat 10 times. Work to increase speed.
- Run quickly enough to keep a hat or piece of paper placed on your chest from falling, requiring a minimum speed for the duration of this drill. Vary distances using this technique.
- Have a friend point a flashlight beam at the ground, moving it quickly from point to point. Jump quickly to each new point. Try jumping with both feet and hopping with one foot.
- Kneel or squat and try the above game using your hand, grabbing or tapping at the flashlight beam on the floor. Do a few dozen points, and then change hands.
- Have a friend hold a piece of paper near your hand and drop it without warning. Practice catching it.
- Practice moving a heavy weight quickly, both body weight and external weight. Do one push-up at high speed, rest, and repeat, until reaching 10 push-ups. Practice lifting your pack, or throwing and catching a weighted ball (medicine ball). Notice and preserve a healthful spine position.
- Do 8 to 10 push-ups quickly without stopping and without letting your low back arch or hitch upward.
- Try lunges quickly, first singly, then in groups.
- Punch (or grab to simulate catching something) as fast as possible. Then repeat twice in rapid succession. Then repeat three times, then four, and so on, until you can punch or grab like a machine gun. Bring the elbow all the

way back to your side each time, like a piston, or like sawing wood.
- Quickly sit or kneel on the floor, and rise to a stand. Try this (safely) wearing your pack.
- Have a friend poke at your feet quickly with a (nonsharp) stick or squirt you with a water pistol. Jump and duck to avoid hits.
- Practice throwing a heavy ball or rescue device. Carefully practice throwing and catching heavy thrown objects.
- Devise other speed games that simulate real-life needs and varying proportions of speed and strength (e.g., assemble gear, break camp, don rescue clothing, dodge hurtling objects).

CONDITIONING FOR SPECIAL ENVIRONMENTS

To handle predicted thermal environments, train in the cold or heat. For a 30-mile hike, practice covering the entire distance. For a journey at night, train to some extent during those hours. For extended caving, accustom yourself to lengthened wake cycles and lack of external circadian cues. Teach your system what to expect. Cross-train, taking into consideration all anticipated interacting environmental conditions of wilderness travel.

Heat

Because exercise in the heat (see Chapters 12 and 13) can be an enormous cardiovascular load, aerobic fitness is a major factor in heat tolerance.[37] Exercise in high heat may be expected during desert treks, ultramarathons, and jungle expeditions, when working in tropical medical clinics, and during other vigorous activities (or even sedentary situations) in deserts and tropics. Exercising in heat accomplishes heat acclimatization more effectively than does heat exposure without exercise.[118]

Fitness training in heat produces several adaptations. One is expansion of blood plasma volume.[147] Increased blood is pumped with each beat, supplying blood simultaneously to muscles for exercise and skin for cooling. Increased plasma volume increases the sweat reservoir and functions as a heat sink, absorbing heat without an increase in body temperature. Sweating begins earlier, at a higher rate, and with greater electrolyte conservation.[153] With increased fluid available for cooling and muscular activity, a fit, heat-acclimated person's core temperature will not rise as high at rest[30] or at the same exercise intensity as that of a nonacclimated person.[110] The well-conditioned body produces more of several protective heat-shock proteins, further increasing tolerance to heat exposure.[114] Physical training can negate the decrease of heat tolerance with age.[6]

Heat adaptation occurs quickly, with dramatic changes in the first 4 to 5 days. Acclimatization is nearly complete in 1 to 2 weeks of continuous exposure to exercise in the heat.[123] Acclimatization does not occur if time is spent in air-conditioned environments. A protective environment prevents discomfort and heat illness, but such a microclimate reduces acclimatization and heat conditioning. With reduced physical conditioning, adaptations are lost over several weeks.[6]

Physical training in a cool environment improves tolerance to exercise in the heat and the rate of heat acclimatization, but not as much as does training in the heat.[122] To condition for high exertion in extreme heat, spend time in environments matching expected temperatures. Ease into activity, gradually increasing exercise intensity and duration. Stay well hydrated and consume appropriate amounts of electrolytes. For a single exertion in the heat, precooling with air-conditioning or cold baths attenuates a rise in core temperature[19] and provides a margin for increased heat accumulation before overheating occurs.[75] Because precooling provides no acclimatization to exercise in the heat and will not prevent heat illness, it is best used when one is already acclimatized. Some people training for ultramarathons in heat use a sauna while wearing heat-trapping clothing. When they travel by automobile, they close windows and turn on the heater to increase acclimatization time. They avoid air-conditioning for sleep or rest, and wearing cooling garments when training. Such training should be approached slowly and extremely carefully, with full understanding and education about health-preserving methods to avoid dangerous dehydration or potentially catastrophic increases in body temperature. This is exemplified by episodes of fatal heatstroke in athletes and soldiers. To condition for milder heat, spend increasing periods in the target environmental temperature, avoiding air-conditioning. Gradually increase physical activity, closely matching expected conditions. At all times be aware of the signs and symptoms of heat-related illnesses, and make every attempt to be under constant observation and/or supervision.

Cold

To increase cold tolerance and prepare for cold conditions (see Chapter 6), spend increasingly long times exposed to the temperatures and humidity expected, while training to levels of physical activity at or greater than expected levels. Stay well fed, hydrated, and rested to be able to train hard, because cold tolerance is reduced by calorie deficit[56,73] and exertional fatigue.[182] With that knowledge, also train for situations when you will be cold, hungry, and tired.

Cold acclimatization involves at least three adaptations, with the extent of each varying between individuals and with exposure. Shivering begins at lower body temperatures after heat is generated without shivering.[105] There may be simultaneously increased[138] and decreased skin temperature,[47] depending on circumstances and anatomic location.[89] In some cases, skin blood flow increases to keep extremities warm and resist cold injury.[139] In other cases, it decreases to reduce heat loss.[140] For example, skin temperatures of Australian Aborigines[31] and Arctic dwellers[94] were found to be lower while they slept than those of the unacclimatized European investigators. It is also the case that different people regulate body temperature to different set points.[96] A third hallmark of cold-acclimatized people is improved ability to sleep in the cold.[29] Cold acclimatization is noted in indigenous people at their cold residential climates (e.g., in the African Kalahari, Australian desert, and Tierra del Fuego in southern Chile). Many sleep outdoors nearly naked in freezing temperatures. When long-term exposure ends, cold adaptation lessens. Cold tolerance decreases with dehydration, lack of sleep, and food deprivation.

The relationship between fitness and cold is not as marked as that between fitness and heat tolerance. However, structural and metabolic changes that occur with exercise training benefit cold tolerance. A fit person tolerates a lower body temperature than does an unfit person before the onset of shivering, and can generate more heat through shivering.[16] Increased muscle mass in trained athletes increases metabolic heat production ability[17] and insulation, better maintaining body temperature without shivering.[181] Physical fitness allows exercise at a higher intensity to generate heat. Cold tolerance is improved to a greater extent by exercise in cold conditions than from exercise alone. For example, seasonal acclimatization[74] occurs in people working outdoors in the cold and fishermen who immerse their hands in cold water to tend their winter nets.

Altitude

Please see Chapter 1.

Scuba Diving

Being in good physical condition is beneficial for divers, even though sport diving is not generally rigorous (see Chapter 71). Fitness reduces the risk of several diseases affecting general health, increases the tolerance to heat and cold, increases the ability to lift and carry gear, and reduces the chance of sudden death from unaccustomed exertion. Physical fitness can improve diving safety and the ability to dive more comfortably, possibly making the difference between a safe diving trip and a diving accident. Divers with preexisting small lung cysts or end-expiratory flow limitation may be at risk of pulmonary barotrauma, but physical fitness or training does not appear to be a factor in susceptibility.[160] Whether one's physical condition (or how much) may relate to the risk of decompression sickness is not firmly established. Anecdotally, the risk is higher in poorly

conditioned divers, which may relate to lack of strength or swimming ability for handling situations that incur decompression problems. A 2014 case-control study of the relative importance of risk factors found the highest major item was "shortness of breath after heavy exercise during the dive."[157] Higher body fat may predispose to a risk for decompression sickness, but there is not a firm correlation. It may be that fatter subjects in studies of risk were in poorer physical condition, had a higher incidence of fatty blood vessels that compromise circulation, or were older. It also is not known if the risk involves total body fat or percentage of body fat. For example, a 54.4-kg (120-lb) woman with 20% body fat has 10.9 kg (24 lb) of fat, whereas an 81.6-kg (180-lb) man with 15% body fat carries 12.25 kg (27 lb) of fat.

To condition for diving, swim with fins regularly. Wear tanks or simulate tanks by increasing the resistance to forward movement by tilting a kickboard to increase the presented surface area, and by using devices such as drag suits, webbed gloves, tethers, and other commercial and home-made resistance tools. Maintain speed and finning mechanics. On land, lift, carry, and walk around wearing tanks, a weight belt, and other gear. Avoid bending over to pick up gear while wearing tanks. Bend and lift properly using the legs. Practice climbing ladders wearing gear to simulate boat diving.

PERFORMANCE AND INJURY

The most common wilderness injuries are not due to avalanches, stings, bites, or heat or sun; they are the same aches, pulls, strains, and pains that often occur from poor body mechanics and injurious exercise practice.

AVOIDING EXERCISE INJURIES

Many common exercises do not train the body to move in functional ways, or are in themselves not healthful movements and may reinforce unhealthful movement patterns and injuries. Resultant avoidable pain is misidentified as overuse, or attributed to a structural but unrelated finding on radiograph. Some otherwise useful exercises are rendered ineffective or injurious if carried out with commonly accepted but poor ergonomics. One common practice is to make an exercise easier by transferring the body weight to the joints through slouching, rather than doing the muscular work of holding the body in a healthy position. Examples include lifting weight overhead by increasing the lumbar arch and tilting the pelvis forward, instead of preventing a hyperlordotic lower spine, and maintaining a neutral spine posture (see Abdominal and Core Muscle Conditioning, earlier); allowing the knee and ankle to tilt medially under a load, rather than countering with leg muscle repositioning; craning the neck while exercising or lifting; and lack of muscle use for intrinsic shock absorption when stepping down from terrain, stairs, or a step bench. Allowing body weight to sag into joints instead of using supporting muscles negates the benefit of the exercise, and wears joints. Poor positioning (bad ergonomics) during lifting may be associated with a higher rate of exertion.[43] The following paragraphs describe maintaining healthy positioning to avoid injury from exercise.

Healthier Spine Positioning

Flexion (forward bending) and hyperlordosis are two common injurious spine positions encountered in daily life and exercise. Flexion imposes injurious unequal loading of the lower spine.[146,170] Much of an ordinary day is spent slouching and rounded over desks, computers, handlebars, and steering wheels, and bent under packs for hiking. The ubiquitous practice of forward bending during certain fitness exercises and stretches contributes to cumulative disc degeneration and soft tissue injury. Hip hinging (hip flexion while keeping the back straight) is not a healthy bending practice. Forward bending for conventional stretching may stretch back muscles, but at the price of pressure on intervertebral disks and soft tissue, whether done with a straight or rounded back.[146]

Standing, Walking, and Running. Hyperlordosis during standing, walking, and running is a common contributor to low back pain from upright ambulation.[20] Low back arch may increase from tilting the pelvis forward or leaning the thoracic cage backward, or both.[22] Learn to identify components of hyperlordosis. The pelvis should be vertical, and not tilted or pushed forward. The upper body should be vertical, and not leaning back from the lumbar spine. Maintain neutral spine posture. Consciously use abdominal muscles without tightening them, to pull the pelvis to vertical position and the upper body to an upright and vertical position (see Figures 96-1 and 96-3).

Lifting Loads. Instead of sitting to lift weights for exercise, stand for functional strength, practice stabilizing a weight, and practice using neutral spine posture while resisting loads.

Lift weights up from the floor with knees bent over the feet, with the upper body as upright as the weight allows, without inducing hyperlordosis. Lift weights overhead with an upright, vertical upper body, without inducing hyperlordosis.

Carrying Loads. Unhealthful positioning includes forward rounding and hyperlordotic arching.[88] Injury potential is not as much from the weight of the pack or asymmetric distribution of the load[135] as from not maintaining healthful positioning or properly using muscles to counter the pull of the load.[20] Maintain neutral spine posture against the weight of carried objects by consciously using abdominal muscles to pull the pelvis into vertical alignment and a more upright upper body (see Figure 96-3).

When lifting and carrying weights, do not allow the low back to increase the arch under the load. A hyperlordotic arch transfers body weight plus the weight of the load to the low back.[107] Reduce the arch to neutral spine posture by tucking the hips and ribcage, as if starting a crunch until upright. The abdominal muscles gain functional exercise to achieve and maintain neutral spine posture. For anterior loads such as a heavy basket, a child in arms, armful of firewood, or any significant weight, notice if you lean the upper body backward at the lumbar curve. Instead, bring the upper body to upright and tuck the pelvis to vertical and neutral position. Neutral spine posture gives built-in functional abdominal exercise without tightening or flexing. For posterior loads such as packs, notice if you hunch forward, lean back, or hitch to the side to offset the load. Use the above technique to straighten the posture and prevent hyperlordosis. When pushing or pulling heavy loads, or reaching or lifting overhead, use neutral spine posture to prevent poor spine dynamics. Convert gear to a built-in core-muscle trainer.

Stretch and Exercise

Stretch hamstrings in functional way without forward bending (see Flexibility-Enhancing Techniques, earlier). Instead of forward bending to exercise abdominal and core muscles, such as those used in conventional abdominal training classes or Pilates classes that emphasize flexion, use functional training exercises (see Abdominal and Core Muscle Conditioning, earlier).

Healthier Knee Positioning

Letting knees sway medially (valgus knee [genu valgum]) or rotate medially (torsion) strains the medial knee,[106] wears upon cartilage,[40] and interferes with normal muscle use and kneecap tracking.[159] Poor limb positioning, biomechanics, and ergonomics, known to be related to lower limb pain, are not prevented or remediated by conventional strengthening and knee rehabilitation programs. Simple voluntary repositioning, from unhealthful to healthful joint angles, prevents injury from misuse.[25,26] Stand and step with feet parallel, not turning toe-in or toe-out, where terrain allows. Stand and step with feet and knees facing the same direction. Watch for and correct kneecaps that face medially (knee torsion) rather than forward in the same direction of the feet. When walking, running, and stepping up stairs and rocky terrain, prevent medial knee sway (valgus knee). Use thigh muscles to align knees comfortably

over the feet, without slouching inward. Keep the knee over the foot, not tilting forward of the foot. Step onto the whole foot where possible, pushing through the heel, not only the front of the foot. Allowing the knee to shift far forward and stepping up onto the ball of the foot increases the transfer of body weight through the knee joint rather than within the thigh musculature. When stepping down, step lightly. Use conscious muscle control to decelerate. Bend knees with descent for shock absorption.

Healthier Neck Positioning

In daily standing, sitting, and ambulating, a common unhealthful habit is to slouch so that the head and neck tilt or round forward of the body line. The resulting "forward head" is a widespread cause of neck and upper body pain, mistakenly called "stress" and "upper crossed syndrome." Lifting the chin while tilting the neck forward compounds hyperextension of the cervical spine. These are simply bad postures. Looking high overhead is a common position during exercise and stretching, and for wilderness activities of stargazing, belaying, rock climbing, scouting, and drinking from a canteen. The same two poor positioning habits are common. One is to tilt the neck and head forward when looking upward, and to lift the chin, thereby hyperextending one cervical segment, rather than distributing extension throughout the upper vertebral column. Another is to increase the low back arch (hyperlordosis) instead of extending the spine at the upper back. Chronic hyperextension in both the lower spine and neck is a factor in disk degeneration,[33] shears intervertebral disks between the vertebrae,[121] causes facet pain, and promotes a cycle of a forward head position, overly stretched and weak structures, and neck and shoulder pain. Lengthen and unround from the upper back to look upward, keeping the chin in. Lift from the shoulders and chest without arching the low back or tilting the chin forward. Prevent the neck from jutting forward at an angle. Forward head posture commonly results in neck, shoulder, and upper back pain,[69] often mistaken for "stress." The forward head also rotates the shoulder forward, interfering with raising the arm and thereby contributing to impingement.[67] Get the needed range of motion more through straightening the upper spine, not by leaning the torso rearward or lifting the chin. Be aware of the difference between bringing rounded shoulders to neutral position while maintaining the upper body vertical, and leaning the entire upper body rearward. Test the head and neck posture by standing against a wall. The heels, hips, upper back, and back of the head should all comfortably touch without increasing the lumbar or cervical arch, or bringing the chin upward or forward. See the stretching section, Anterior Shoulder and Chest, earlier, to remedy tightness that prevents upright standing posture.

For driving or sitting, move the seat forward rather than rounding the body forward. Instead of perching toward the front of the chair, sit at the chair back. Rather than rounding the lower back against the seat back, use a roll to maintain a neutral lower spine, only if needed, depending on the chair design, and lean the upper body back against the seat back (see Long Sitting in an Automobile, later). "Ergonomic" chairs do not make you sit well; you do that yourself. You can sit well on a bucket, or in injurious way in an expensive ergonomic seat.

AVOIDING INJURIES FROM STRETCHING

Just as not all foods are healthy, neither are all stretches. Many persons practice the same poor positioning as already used all day, imposing unhealthful twist or load on joints and soft tissue, deforming or injuring them over time. Shoulder stands and the yoga plow position (lying on the upper back, legs overhead, with the cervical and thoracic spine in weighted flexion) promotes stretch deformation of the posterior longitudinal ligament,[180] bone spurs, and the common injurious posture of forward head and round shoulders. Overstretched ligaments are plastic, not elastic. They do not return to normal length and cannot hold vertebrae in position or function as a firewall to intervertebral disks. The posterior force of the forced flexion under the body's weight may eventually degenerate and herniate cervical disks and promote bone spurs.[146,170]

Skip the common shoulder stretch typified by bending forward with arms lifted behind with clasped hands. The resultant unsupported, weighted lumbar flexion promotes disk degeneration and herniation. Forced shoulder hyperextension overloads the constitutionally susceptible anterior shoulder capsule. Several yoga stretches involve twisting at the knee, or lying back on folded, twisted knees, forcibly lengthening the collateral ligaments, and twisting menisci and other supporting structures. Avoid assisted stretches where anyone presses your back into a rounded position or flexion. Avoid vigorously oscillating knees (butterfly knees) when sitting with bent knees and soles of feet touching. Do not let anyone stand on or push your knees to facilitate stretching.

Add extension stretches to learn to "unround" the upper spine and prevent chronic thoracic kyphosis. When leaning back to stretch, whether standing, sitting, or lying, lift from the upper body rather than jutting the chin forward and bending at the neck. Keep a neutral neck. When sitting cross-legged, notice the ankle. Externally rotate from the hip rather than inverting the lateral ankle (turning the sole medially or upward). Overstretching lateral ligaments leaves the ankle prone to inversion sprain.

Stretch muscles, not joints. Do not force joints into such ligament laxity that they no longer seat properly. Not all joint laxity is instability. There is a difference between a healthful flexible joint and an unstable joint. Unstable joints wear and tear. In a suddenly forceful situation, weak, unstable joints may be predisposed to pulls or dislocations.

Hard stretching just before an athletic event may reduce the tendinous stiffness that assists elastic recoil in high-exertion situations,[90] reducing maximal force development.[136] Rather than stretching to maximize length before competitive events, use stretches described under Conditioning, earlier, to regain functional muscle length for healthy ergonomics. Similarly, chronically holding a muscle in a stretched position weakens it. Chronic slouching and lengthy sitting weaken the lengthened muscles of the back and posterior hip. Slouching is a stretch, but not a beneficial one. Avoid compounding the problem by avoiding forward rounding and bending.

BACK PAIN PREVENTION DURING LONG TRAVEL TO THE WILDERNESS

Neck and back pain from sitting poorly in airline seats far exceeds the incidence of deep vein thrombosis. Vehicle seats often have concave backs. Long sitting in lumbar, thoracic, and cervical flexion pressures intervertebral disks and soft tissue. A pillow behind the head exacerbates flexion. Sitting stresses disks to a higher extent than does standing, and poor sitting posture amplifies strain. Travel to the wilderness can involve sitting long hours while driving or flying. Try the following for better sitting mechanics to easily prevent strain:

Use of Lumbar Roll

A lumbar roll fills the space between a too-concave chair back and the lumbar spine so that you can sit relaxed and comfortably in neutral spine posture. However, not all seats and chairs need a lumbar roll. A lumbar roll that is too large or inflexible, or positioned incorrectly, can be uncomfortable or unhealthful. To test lumbar roll function and appropriate size, sit in a chair with your entire back against the back of the chair. Place your forearm behind you at the lumbar level between your low back and the chair. Lean your upper back against the chair back so that the low back does not press your arm, but rests lightly. Correct placement and size of the roll should feel comfortable. Your forearm is usually about the right size for a lumbar roll, depending on how hollow is the chair back. A small towel, article of clothing, or inflatable pillow makes an inexpensive lumbar roll that packs flat and is lightweight. Do

not use a roll to force yourself into an unnaturally straight or arched posture.

Long Sitting in an Automobile

Use a lumbar roll, as described. Car seats that are positioned too far back from the steering wheel encourage hunching and leaning forward to hold the wheel. If needed, slide the seat position forward. Tilt the seat to a slight backward slant if needed. With hips all the way against the rear of the seat, see if you can lean back comfortably against the seat, instead of rounding forward. If you feel neck strain, then recheck and correct if you are tilting the neck forward or straining in any direction to be "straight." During rest breaks, do not add to the long flexion of sitting with more flexion stretches. Use comfortable extension stretches instead, described earlier in the flexibility section.

Buses and Flights

Commercial transport seats are often concave, encouraging prolonged, forced flexion.

Where needed, use two pillows for forming a lumbar roll (described above), one in the inward space of the low back, and the second in the overly curved thoracic space left by the extreme concavity of the seat. Lean back to an upright position, rather than rounded forward. Sometimes, one long pillow or folded article of clothing turned vertically can suffice. Make sure it is comfortable. For in-flight sleeping, lean back while preventing as much rounding of the neck and low back as feasible. Flights sometimes have a video message encouraging in-seat stretching. Often the advice is to forward bend. Instead, extension is indicated to counter long periods of flexion. Stretch the shoulders back, not forward. Pull the chin in while leaning back. Press hands to the thighs, and lift the chest to extend the upper spine with the chin held neutral, not forward. Extend the legs as much as space allows, lift the hips, and extend the back, pushing on feet and armrests. Breathe deeply every so often. Pump feet. Squeeze the knees together and apart, upward and downward against the hands. Open and shut the hands. Squeeze the shoulder blades back. Get out of the seat. Try anterior chest stretches (see Flexibility-Enhancing Techniques, earlier) and various lunges with a neutral pelvis (see Hip and Thigh, earlier). Walk around as often and long as feasible.

SORENESS AFTER EXERTION

Anyone, even highly trained competitive athletes, can be sore after hard activity. Soreness develops in the days following activity, rather than during activity, so is called delayed-onset muscle soreness. Mechanical stress initiates a chain of events. At the time of effort, cell membrane damage in muscle fibers disrupts calcium homeostasis.[5] Abnormal influx of the ion inhibits cellular respiration in the mitochondria. Lack of adenosine triphosphate starves structures, activating lysosomal proteases[41] that degrade and release proinflammatory cytokines[152] and other serum proteins[32] that induce inflammation. Free radicals promote release of arachidonic acid from cell membranes.[145] Arachidonic acid (an omega-6 fatty acid) is converted by cyclooxygenase-2 (COX-2) into proinflammatory prostaglandins,[111] which, along with histamines and kinins, accumulate in the interstitium, stimulate nociceptors, and cause pain.[5]

An inflammatory response begins the healing process by attracting polymorphonuclear neutrophils.[41,100] Activation of the complement system may also contribute to mobilization of neutrophils.[34] The inflammatory process is self-regulated by a balance of proinflammatory and antiinflammatory mediators.[44] The extent and magnitude of the response are determined by the presence or absence of both types of mediators.[111] The result of this balance is that a person is stiff, sore, and weak for 1 to 5 days.

Numerous products and protocols are claimed to prevent or reduce exertional soreness. None are completely successful. Although soreness is often more pronounced with eccentric contraction (lengthening under tension), soreness results with sufficient stimulation after all types of muscular contraction.[72] Concentric muscular contraction is contraction that shortens muscles, for example, contracting the biceps to lift a load. Concentric contractions against a high load, such as ascending while carrying a heavy pack, create conditions for soreness, particularly in the most exercised muscles, such as the hamstring, gluteal, and calf muscles. After hard swims, soreness may occur in the latissimus dorsi and leg extensors, depending on the stroke. Isometric contraction maintains the muscle at one length while under tension, for example, gripping a rock ledge. Soreness after technical climbing is common in wrist and forearm flexor muscles. Eccentric muscular contraction is contraction while the muscle lengthens. When lowering a pack to the ground, the biceps lengthens while in a high contractile state, to guide the load at the chosen speed and direction. The high load of eccentric muscle contraction of descending slopes is often felt primarily in the decelerating muscles of the thigh, shins, and ankles, particularly when stepping down hard and not using muscles to decelerate and absorb shock during gait.

Sometimes pain is not soreness, but injury from strained muscle fibers due to poor posture, efforts above tolerance, or joints twisted into harmful positions. During exertion, if pain, tearing, or pinching is felt in a joint, or a feeling like electricity radiates down a limb, that is probably an injury process. Similarly, if joints feel hot, swollen, or sore after effort, that may signify an injury. Soreness from carrying packs with poor body ergonomics, such as forward head, round shoulders, and torso hunched against the load of packs or the cold, is often felt later in the neck, upper back, and shoulders. Pain from a hyperlordotic lower spine under the load of a pack is often felt focally in the low back and posterior hip.

Specific warm-up or stretching before activity does not prevent delayed soreness,[72] but deployed properly after activity may help alleviate soreness. Stretch affected areas gently (see Conditioning, earlier), and keep sore areas moving. Eat food with antiinflammatory components to perhaps soothe the inflammatory component of delayed soreness. Such foods include leafy green vegetables, cherries, and blueberries, which contain quercetin (a plant pigment belonging to the flavonoids); curcumin (turmeric); ginger; and plant foods containing resveratrol (especially grape skins). Several foods with essential fatty acids, including omega-3, are known for antiinflammatory properties: flaxseeds, pumpkin seeds, olive oil, and fermented soy products. These are light and easily carried as fresh food or supplements for wilderness travel.

The science supporting these recommendations is evolving. The yellow spice curcumin inhibits two proinflammatory mediators, tumor necrosis factor alpha and interleukin-1 (IL-1).[35] Antiinflammatory properties of resveratrol in grape skins[156] and ginger[95] act via suppression of the proinflammatory catalyst COX-2. Green tea contains the polyphenolic compound GTP, found to inhibit the proinflammatory cytokine IL-1.[115] Salicylic acid is a chemical produced by plants to protect themselves from pathogens, and is responsible for the antiinflammatory action of aspirin. Organic vegetables were found to have higher concentrations of salicylic acid (117 ng/g) than did nonorganic vegetables (20 ng/g), possibly because they were less likely to be protected from infection.[12]

Arachidonic acid, a component of human nutrition, is also a precursor of prostaglandins involved in the inflammatory response. Avoid proinflammatory foods that promote arachidonic acid in excess, such as foods containing omega-6 fatty acids, which are converted by COX-2 into prostaglandins[111] and leukotriene B_4.[145] Sources of proinflammatory mediators include peanuts, beef, chicken, and eggs.[145] Another food popularly implicated as proinflammatory is sugar. Diets heavy in inflammatory components may produce what is described as the "diet-induced proinflammatory state."[145]

FITNESS MYTHS

Myth: Walk and run toe-out, because that is the natural direction of the foot and leg muscles.

Fact: Toe-out (duck foot) position may signal tightness in the plantar fascia, metatarsal phalangeal joints, Achilles

tendon, calf, and/or external rotators of the thigh in a cycle of tightness and loss of the stretch that is normally obtained from a straight position during gait. Slight anatomic differences in femoral position usually do not factor in the many degrees of turnout commonly seen, except for major hip pathologies. Toe-out walking imposes a high degree of strain on the feet, ankles, knees, and hips. It contributes to pronation, bunion formation, and the cycle of tightness. It decreases the push-off phase by pressing medially off the big toe rather than the ball of the foot and all toes, reducing speed and jumping ability. Without addressing the cause of deviation in gait, simply forcing parallel gait may lead to other complications. Stretch and retrain gait to keep legs parallel and body weight on the sole, not arches, for standing, walking, jumping, and movement.

Myth: High-top shoes and elastic bracing prevent ankle sprain.

Fact: The main predisposing factors in repeat sprains are disuse atrophy and lack of proprioception and balance sense caused by "supportive" shoes that do not promote stabilizing body weight with ankle and foot postural muscles. Hard stabilizing shoes also contribute to knee and leg pain,[149] and prevent normal foot and fascia stretch. Prevent ankle sprain with balance and kinesthetic retraining for foot and ankle positioning (see Feet and Ankles, earlier).

Myth: Women are more prone to lower body injuries than are men.

Fact: Several studies have identified training, biomechanics, and fitness, not gender, as primary injury risk factors. Data from army recruits showed that those of lower physical fitness had a consistently higher injury rate. When comparing men and women of equal aerobic fitness, rates of injury were similar.[78] In a study of 861 Army recruits, the higher rate of injuries among women "appears to be explained by physical fitness" rather than sex differences.[14] More confirming data came from a 13-year study of 60,000 high school athletes in 18 sports. "What we have here is not a gender issue, but instead a classic combination of training error and [lack of] physical fitness."[133]

Myth: Devices and pills that increase heart rate or blood flow without exercise can improve aerobic fitness.

Fact: Claims are made that head-standing, massage, or lying head-down improves circulation to the head, or that heating the body or holding a yoga stretch increases the heart rate, conferring aerobic benefit. Increased heart rate and local blood flow alone do not benefit cardiovascular status. Situational fright and moving the legs of a person lying in bed raise the heart rate, but are neurogenic rather than cardiogenic increases. Raising the body temperature through a hot shower or tub or sweating in a sauna suit increases the heart rate through skin vasodilation to shed heat. Blood pressure decreases, with consequent increase in the heart rate to maintain pressure. There is no aerobic benefit to overheating or sweating, and caloric expenditure is not raised. Improve aerobic ability through regular moderate-to-high–energy exercise, such as biking, swimming, rowing, skating, dancing, sprinting, and skiing, repeated regularly over time.

Myth: Older people need less exercise.

Fact: Exercise becomes more important and protective with aging. Deconditioning over years is often confused with aging. Regular exercise, functional stretching, and balance practice slow physical decline and can confer gains equivalent to stopping or reversing years of aging. Older people who exercise, move, balance, and stretch have many of the functional characteristics of a chronologically younger person. They can reach, bend, and move easily, negotiate uneven sidewalks and other terrain, and carry their own gear. The antiaging effect of exercise is effective in all age groups. Geriatric populations on exercise programs show improved strength and mobility. Physical gains often eliminate the need for walkers, wheelchairs, and canes, and self-sufficiency returns. Many people do not crouch or sit on the floor because they are too weak to get up. That is not aging, but the need to regain strength to do it. Even critically ill people receiving assisted movement have a shortened recovery time, fewer bedrest-related illnesses, and a reduced need for sedatives. Exercise and skills practice are the keys to independence and retention of physical ability.

PERFORMANCE ENHANCEMENT

PERFORMANCE-ENHANCING DRUGS AND NUTRIENTS FOR EXERCISE AND EXPEDITIONS

Foods to increase physical ability have been sought throughout history. Indigenous and mountain people have long used stimulant plants such as coffee, kola, khat, betel nut, and coca to withstand cold, hypoxia, hunger, and fatigue. Aztec warriors hoped to increase bravery by eating the hearts of brave enemies. Berserkers were Norse warriors legendary for savagery and reckless frenzy in battle; they ate *Amanita muscaria* mushrooms. Dervishes whirled longer by drinking coffee. Before the first Olympic games in 776 BC, athletes used wine to enhance performance by dulling pain; concoctions of wine and substances from strychnine to cocaine were used in later Olympic games. Amphetamines were long given to soldiers to delay fatigue, and were widely used in medical practice until recently. Today, ergogenic aids include stimulants, muscle growth promoters, energy substrates, and oxygen utilization enhancers. They range from healthy to dangerous and illegal.

Methylxanthines

Methylxanthines are a class of stimulant alkaloids found in plants, including coffee, tea, cocoa, guarana, yerba mate, and kola (cola). They may be humankind's most commonly consumed drugs. Animals also seek them out. In South America, animals chew coca leaves, and goats in the Middle East are credited with originally showing the effects of eating coffee seeds to humans. (Although popularly called coffee beans, coffee seeds look like, but are not, true beans.) Methylxanthines are purinergic, acting on purine neurotransmitters such as adenosine.[143] They elevate cyclic adenosine monophosphate in several tissues, including the brain, with stimulant, diuretic, and vasodilator properties.[77] All xanthines have a similar stereochemistry, but each has unique properties. In various products promoted for health and energy, they are often combined (stacked), yielding compound effects.

Caffeine

Caffeine is the primary methylxanthine in coffee and kola nut, from which many cola sodas are made, and is present in smaller amounts in chocolate and tea. It was probably discovered in the Stone Age, and has been widely used ever since for its effects. Caffeine increases endurance and is particularly used for long endurance events.[63] How caffeine helps athletic performance is still studied and debated. Caffeine is thought to help endurance by directly stimulating the central nervous system, increasing plasma epinephrine,[154] which enhances excitation-contraction coupling mechanisms.[158] Some work shows epinephrine-induced enhanced free fatty acid oxidation for fuel,[129] which in turn spares muscle glycogen,[154] whereas others dispute lipid mobilization by caffeine[62,166] and show ergogenic effects of caffeine without an increase in plasma epinephrine.[64,166] Caffeine decreases the perception of effort, perhaps through adrenocortical axis stimulation,[93] which promotes cortisol and β-endorphin release.[42,92] The caffeine molecule is similar to the depressant molecule adenosine. As a competitive antagonist of adenosine receptors, caffeine replaces adenosine.[155] Reported effects on short-duration intense anaerobic activity are inconclusive about whether power or endurance is aided. Positive effects are attributed to increased motor unit recruitment[98] and resistance to fatigue through mobilization of intracellular calcium from the sarcoplasmic reticulum.[158] Although caffeine in isolation increases endurance, some work suggests that the effects do not

extrapolate fully to coffee, perhaps because of components present in coffee that moderate the effect.[63] Caffeine with phenylpropanolamine interacts adversely, increasing the risk of hemorrhagic stroke.[28] Phenylpropanolamine is used as a decongestant and weight-control drug. The U.S. Food and Drug Administration banned this drug combination in 1983. Habitual caffeine users do not derive ergogenic effects from usual amounts of caffeine. Dependence and withdrawal symptoms, often severe, are common.

Theophylline

Theophylline is the methylxanthine in tea leaves, along with a small amount of caffeine and theobromine.[61] Theophylline is a smooth muscle relaxant, diuretic, cardiac stimulant, and vasodilator; it is used to treat asthma and other obstructive pulmonary disease. Theophylline delays skeletal muscle fatigue[102] and is thought to increase aerobic endurance through increased blood glycerol levels without increase in plasma epinephrine.[66] A study of Mt Everest base-camp expeditioners found no evidence that tea acts as a diuretic in regular tea drinkers, even at high altitude where fluid balance is stressed, or that it exerts a positive effect on mood.[144]

Theobromine

Theobromine is the primary methylxanthine in chocolate. Other compounds in cocoa include caffeine, serotonin, histamine, tryptophan, tryptamine, tyramine, phenylethylamine, octopamine, and anandamide.[127] Theobromine is found in smaller quantities in the kola nut. It is a weak diuretic, bronchodilator, and stimulant, and may increase mood and motivation to work.[117] Dark chocolate contains higher levels of theobromine than does lighter chocolate, along with substantial amounts of flavonoids and phenolics, possibly good for the heart. The healthiest way to use theobromine on the trail is in unsweetened cocoa, rather than in sweetened candy.

Guarana

Guarana is made from the crushed seeds of *Paullinia cupana,* a South American vine. It is considered to be as potent as caffeine (often called herbal caffeine), with similar effects.[3] However, guarana may not contain caffeine, but rather, the isomer guaranine.[15] Coffee contains between 1% and 4% caffeine. Guaranine is reported to either contain or be the equivalent of 5% caffeine. It contains lower amounts of the methylxanthines theophylline and theobromine.[132] Guarana is frequently found in herbal and nutritional supplements and has been used for energy and headache relief. Use is linked to unpleasant overstimulation, and withdrawal to weakness and depression.

Yerba Mate

Yerba mate is a South American tea-like beverage made from mate *(Flex paraguariensis),* an evergreen holly. Among other plant substances and vitamins, mate contains a small amount of xanthines, primarily mateine, and smaller amounts of theophylline and theobromine. Mateine is a simple stereoisomer of caffeine, but has distinct effects. Like other xanthines, it relaxes smooth muscle airways and peripheral blood vessels, and is a mild diuretic. Central nervous system effects are disputed.[53] Although the xanthines in mate occur in minute amounts, they attract much speculation regarding possible benefit. Anecdotal claims are that persons with caffeine sensitivities seem able to drink mate for stimulation without insomnia and irritability. The cytotoxic and antioxidant activities of components in mate are speculated to confer a possible anticancer benefit,[128] but at least three studies link mate consumption with oropharyngeal or esophageal cancer.[59,60,148]

CHOLINERGIC STIMULANTS (TOBACCO, ARECA, AND LOBELIA)

Cholinergic agents stimulate nerve cells or fibers that employ acetylcholine as a neurotransmitter. They cause cardiac inhibition, vasodilation, gastrointestinal peristalsis, and other parasympathetic effects.

Nicotine

Nicotine is an alkaloid found in various plants, especially tobacco. It is poisonous, but in small doses is used for its stimulant effects. These effects have long been used to combat hunger and fatigue in various difficult environments, although nicotine has not been specifically found to enhance physical ability. It has mixed effects because it stimulates both the sympathetic and parasympathetic systems.[184] It is used in various forms, usually as chewing or smoking tobacco. Nicotine patches and gum have been used to try to boost alertness.

Betel Nut

Betel nut *(Areca catechu)* is a mild stimulant habitually chewed by many millions of people, primarily in Asia. It contains the alkaloids arecoline and guvacoline. Chewers, known by their reddish black teeth, primarily chew the areca nut wrapped in betel leaf, with mineral lime often added as a catalyst. The lime hydrolyzes the arecoline and guvacoline into arecaidine and guvacine, which are strong inhibitors of γ-aminobutyric acid (GABA) uptake. Aromatic phenolic compounds stimulate release of catecholamines. As a result of complex interactions, betel chewing affects parasympathetic, GABAergic, and sympathetic functions.[39] The dilute plant alkaloids are chewed over hours and slowly absorbed through the mucous membranes of the mouth to furnish a subtle stimulation and not-so-subtle parasympathetic salivation.

Lobelia

This plant, also called asthma weed, wild tobacco, pukeweed, and vomit wort, is another parasympathetic agent used in folk medicine to aid breathing, and more recently as a source of chromium.[99] It is found in several "health" tonics, with side effects reported to be difficulty breathing, rapid heartbeat, low blood pressure, diarrhea, vomiting, dizziness, and tremors.

SYMPATHOMIMETIC STIMULANTS: MONOAMINERGIC SUBSTANCES (AMPHETAMINES, COCA, KHAT, AND EPHEDRA)

Sympathomimetics mimic the sympathetic nervous system and stimulate release of noradrenaline and adrenaline. They enhance alertness and reduce hunger and mental and physical fatigue. Examples are amphetamines, coca, khat leaves, and ma huang (ephedra). Overstimulation is common, with addiction to some resulting in various unhealthy effects.

Amphetamines

Methamphetamine (Methedrine), levoamphetamine (Benzedrine), and dextroamphetamine (Dexedrine) are collectively known as amphetamines. Intense stimulation is followed by withdrawal depression, fatigue, and rebound appetite as neuronal dopamine stores, peaked by use,[38] are depleted in the mesolimbic pleasure center of the brain.[10] Development of amphetamines in the United States was first supported as a substitute for Chinese ephedra. Amphetamines were at one time prescribed to soldiers and widely used in clinical medicine to combat weight loss, asthma, depression, Parkinson's disease, hyperactivity in children, and travel sickness. They have been used for their alerting, enjoyable effects, and to reduce hunger and fatigue. Users may experience abnormally high or irregular heart rates, elevated blood pressure, and, sometimes, mental states resembling paranoid schizophrenia. Abdominal cramps, incoordination, dizziness, dry mouth, nausea, and vomiting may also accompany initial use. Chronic users are found to have structural deficits in several brain areas.[161] Acutely, amphetamines increase the risk of hyperthermia by two mechanisms: increased endogenous heat production and decreased heat dissipation due to peripheral vasoconstriction.[85] Deaths in the heat have resulted in endurance athletes and soldiers,[65,171] and in a 12-year-old

taking appetite suppressants.[85] Amphetamines usually physically and psychologically addict the user after about 12 weeks, with abusers increasing doses from 10 to 1000 times to retain effects. Although amphetamines extend endurance, they are counterproductive to healthful wilderness travel. Over-the-counter (OTC) supplements marketed for weight loss and energy continue to be manufactured with amphetamine-like substances, with periodic reports of injury and death. However, the dependence created is an underreported health and economic concern.

Coca

Leaves of the South American shrub *Erythroxylum coca* contain from 0.1% to 0.9% of the alkaloid cocaine. Cocaine is a powerful cardiovascular stimulant that blocks catecholamine reuptake and prolongs effects of released neurotransmitters.[104] Release of norepinephrine increases blood pressure[163] and arrhythmias.[68] Resulting catecholamine depletion leads to intense depression (cocaine crash).[86] Sudden heart attack may occur in an otherwise healthy person.[91,126,167] Until the early 1900s, cocaine was widely sold OTC in tonics, toothache cures, and patent medicines. Combined with alcohol, cocaine alkaloid yields cocaethylene, a potent reinforcing compound, becoming a popular ingredient in wines such as Vin Mariani. As an export drug, cocaine is extracted in a paste from soaked, mashed coca leaves, often in the form of cocaine hydrochloride salt, with high percentages of cocaine. Addictive and socially and medically unhealthy, cocaine is unsuitable and profoundly unwise for athletic efforts.

Khat

Khat grows in eastern Africa and southern Arabia. It is frequently chewed for amphetamine-like stimulatory effects and to reduce fatigue and appetite. Khat releases catecholamines from presynaptic storage.[83] Leaves of the khat bush contain the alkaloid cathinone, which functions like amphetamine, and a milder form of cathinone, cathine,[173] one of the alkaloids found in ephedra. Cathinone increases blood pressure, heart rate, and psychostimulation.[27] Both cathinone and cathine are controlled substances (cathinone is schedule I and cathine is schedule IV).

Ephedra (Ma Huang)

Ephedra is a plant native to Pakistan, China, and northwestern India. The three ephedra species, *Ephedra sinica, E. equisetina,* and *E. intermedia,* are collectively known by their Chinese name, ma huang. The ephedra plant has two main active compounds: ephedrine (2-methylamino-1-phenyl-1-propanol) and pseudoephedrine.[172] Ephedrine and pseudoephedrine are both sympathomimetic, with effects similar to amphetamine but to a lesser degree. Unlike pseudoephedrine, ephedrine mediates effects through circulating epinephrine[48] and is a bronchial dilator used in treating asthma. Many now-banned "energy" and weight loss products contained one or more of the several forms of ephedra. Ephedrine can have several nervous system effects, such as insomnia, tremors, anxiety, and seizures.[124] Effects do not always depend on the dosage. Ephedra is associated with a small number of cases of cardiovascular toxicities attributed to sympathomimetic adrenergic effects, including myocarditis, arrhythmias, myocardial infarction, cardiac arrest, and sudden death.[119] The hypertensive effect is postulated as a factor in the increased risk of stroke.[112] Ergogenic effects are debated and risks do not seem to show that ephedra is advantageous for wilderness travel. The FDA banned ephedra in December 2003.

OTHER STIMULANTS

Ginseng

Ginseng collectively refers to several different plant species from various countries, each with possibly unique effects. The main active agents are ginsenosides, which are triterpene saponins. It is usually the root that is used, with active agents varying with species of plant, age, location, and method and timing of harvest and processing. Because of ginseng's adaptogen and stimulant qualities, it is used in many candies, pills, and drinks, with numerous claims. Investigations have found that many ginseng preparations contain other stimulating compounds, usually caffeine, and that ginsenoside content varies greatly, with some preparations containing none at all, making interpretation of claims difficult. Although some animal studies show effect, in many human studies there does not seem to be ergogenic effect on oxygen consumption, respiratory exchange ratio, minute ventilation, blood lactic acid concentration, heart rate, perceived exertion,[49,113] exercise time, workload, plasma lactate, or hematocrit.[4] A study reviewing clinical trials showed no beneficial effect on physical performance, psychomotor performance, cognitive function, immunomodulation, diabetes mellitus, or herpes simplex type II infections.[168] Excess may result in diarrhea, nervousness, blood glucose changes, and insomnia. Ginseng may potentiate or interact adversely with caffeine, phenelzine (Nardil),[79] warfarin (Coumadin),[164] and monoamine oxidase inhibitors.[109]

Anabolic Steroids

Anabolic steroids are controlled drugs with growth-promoting and androgenic effects. They improve athletic performance when strength is a primary component, and when used with intense training programs and adequate nutrition. For ergogenic effect, anabolic steroids are taken at 10 to 100 times the therapeutic dose for medical conditions. A large black market exists for controlled medical and veterinary anabolic steroids, such as Trenbolone, which is used to increase the weight of cattle. A related steroid is tetrahydrogestrinone, a designer anabolic steroid derived from gestrinone, a European drug for endometriosis. Several popular steroids have progestogenic activity. Others are aromatizing (synthesize estrogens), including methandrostenolone (Dianabol), boldenone (Equipoise), and to a lesser extent fluoxymesterone (Halotestin). Users seeking to avoid estrogenic side effects or recover depressed testosterone production after a cycle of steroid use may "stack" (combine) antiestrogens (aromatase inhibitors or receptor blockers) such as aminoglutethimide (Cytadren) and clomiphene (Clomid). The pattern of increasing a dose through a cycle is referred to as pyramiding. The risk for injury increases, because tendons and ligaments do not strengthen at the same rate as muscle. Side effects can be common and injurious. One study indicates that reports of hepatotoxicity may be overstated[45]; however, other adverse effects of anabolic steroids seem to be documented, including apoptosis of skeletal muscle,[2] cardiovascular damage,[108] decreased endogenous androgen production and testicular atrophy,[87] thrombotic phenomena such as strokes, myocardial infarctions, and limb loss,[51,52] uncontrolled behaviors,[7] and dependency behavior and withdrawal depression.[84]

ANABOLIC (GROWTH-PROMOTING) NONSTEROIDS

DHEA

Dehydro-3-epiandrosterone (DHEA) is a weak intermediate steroid, the most abundant naturally made in the body. DHEA is manufactured from cholesterol, mostly in the adrenal glands, and to a lesser extent in the ovaries and testes. DHEA converts to dozens of hormones, including estrogen and testosterone in both men and women. DHEA levels wane with age and certain illnesses, leading to the question of whether restoring those levels can mitigate effects of age and disease, even though it is unknown if lowered DHEA causes such problems. Although DHEA is commonly purchased in hopes of enhancing strength, gains are not confirmed in controlled investigation.[81] The estrogenic potential seems to produce results in the laboratory for women to restore lost bone and absent menstrual periods. Before taking DHEA, one should have blood levels checked for deficiency.

Androstenedione

Androstenedione (andro) is made in the body from DHEA. Androstenedione is a precursor molecule (prohormone) of both

testosterone and estrogen. Which hormone pathway it takes depends on several factors, including the percentage of body fat; a high percentage of body fat increases estrogenic potential. Androstenedione is accepted as an aromatizer, being readily converted to estrone. Popularity seems to stem from its status as a precursor to testosterone. For perspective, cholesterol is also a precursor molecule to testosterone, but eating it does not increase testosterone. Reports from gyms and androstenedione manufacturers state that athletic ability is always greatly helped. Studies do not find ergogenic potential.[81] Some studies show increased strength, but no more than in control groups with matched exercise without androstenedione. Another study found no increase in plasma testosterone and no anabolic effect on muscle protein in young men.[130] Supplementation may suppress endogenous production. OTC androstenedione supplements have sometimes been found to contain elements not on the label that can cause a positive drug test for other banned substances.

Creatine

As quickly as ATP is used for fuel in cells, it is rebuilt for more activity using phosphocreatine, stored mostly in skeletal muscle, and a smaller amount of free creatine. Use of supplemental creatine to fuel intense, short efforts is behind sales of creatine monohydrate, the synthetic form of endogenous creatine phosphate. Creatine seems to assist repetitive, high-intensity, short-term efforts with brief recovery.[165] Whether creatine is an important adjunct for extended exercise is debated. Individual variation is wide.[82] Advice to eat steak, fish, and pork, which contain creatine, is misguided because creatine denatures during the cooking process. Creatine (methylguanidine-acetic acid) is an amino acid made in the liver, pancreas, and kidneys from arginine and glycine, which are obtained from balanced meals, including vegetarian meals. The ergogenic effect of creatine supplementation seems to be counteracted by caffeine.[165] Long-term effects of supplementation are not known.

FOODS

Carbohydrates

Ingested and stored carbohydrate is ergogenic, providing fuel and delaying fatigue during intense, long-duration exercise, and aiding recovery after exercise.[174] The larger the body's carbohydrate stores, the longer exercise can be extended before fatigue, depending on the fitness level. Depletion of blood glucose and stored carbohydrate is related to fatigue and reduced athletic ability.[169] Storing muscle glycogen is accomplished by hard physical training and restocking muscles by eating healthy carbohydrate, preferably within the first 30 minutes after a bout of exertion.

Vitamins and Minerals

No evidence supports vitamin or mineral supplementation as ergogenic. Supplementation is useful when nutritional deficiency exists,[177] for athletes in weight-restricted events, or for extended and extreme wilderness travel with inadequate nutrition. However, increasing intake will not improve physical ability with adequate nutrition. Oversupplementation may alter utilization of other micronutrients. Supplementation to offset poor eating habits is not a healthy solution.

Bee Pollen

Bee pollen claims include various effects, from vague vitality to specific athletic improvements. Bee pollen has nutritional components, but it has not been experimentally shown to enhance any aspect of athletic performance[179] or to have any effect on the level of physical stimulation.[76] It may provoke allergic reactions in susceptible people.

WATER

Water is an overlooked athletic ability aid. Although possessing no ergogenic chemical or property, water is a necessary, inexpensive, and easy fluid replacer for healthy functioning, heat balance, and recovery from exercise. Drinking too much will not enhance health, and in extremes, can result in dilutional hyponatremia (see Chapter 89).

Fitness Water, Fitness Carbo, and/or Protein Drinks With "Buzz"

Many packaged "health" and sports drinks contain stimulants of many kinds—ginseng, guarana, and caffeine among them. These are advertised as energy drinks and vitality enhancers. Check the label. Remember that they are stimulants with associated health risks. Also note if they contain refined sugar, hydrogenated fat, dyes, flavors, and fillers.

Alerting and Wakefulness Adjuncts

Products (e.g., nicotine) may increase alertness or stimulation without augmenting the physical ability to do work and thus may be represented as ergogenic without being work-enhancing. Some, such as amphetamines, provide global stimulation but then require recovery sleep, becoming counterproductive in settings requiring good health. Products such as modafinil (Provigil [U.S.] or Alertec [Canada]) and adrafinil aim to focus on wakefulness and vigilance by targeting specific sleep-promoting areas of the suprachiasmatic nuclei,[141] without binding to dopaminergic or adrenergic receptors.[36,97] These drugs are labeled for narcolepsy, with the intended use being wakefulness during an ordinary day, followed by a normal night's sleep. Off-label use as a lifestyle drug, to extend wakefulness for stretches of 40 hours and more without the need for recovery sleep, seems to be increasing among those seeking advantage in an ultramarathon, the military, or a competitive workplace. Prolonged sleep deprivation is known to depress immune function. Animals in experiments and humans deprived of sleep by torture have psychotic effects and die from infections. The effects and safety of these drugs over-extended periods are not yet known.[11]

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CHAPTER 97

Wilderness and Endurance Events

DAVID A. TOWNES AND BRANDEE L. WAITE

Perhaps the earliest record of an endurance event may be traced back to ancient Greece in the 5th century BC. The Persians invaded Greece in 490 BC, landing in Marathon, a small town about 26 miles from Athens. Seriously outnumbered by the Persians, the Athenians sent messengers to cities throughout Greece requesting assistance. Legend has it that after the battle, a man named Pheidippides was sent from Marathon to Athens to bring word of the Greek victory. He covered the 26-plus miles on foot, only to drop dead after proclaiming *"Niki!"* ("victory"). Debate continues among historians about what really occurred. For instance, there is evidence that Pheidippides was actually sent from Marathon to request help and that news of the victory was delivered by a man named Eukles.[35] Although the exact details remain unclear, when the modern-day Olympic games were inaugurated in Greece in 1896, the legend of Pheidippides served as inspiration for the marathon. That first marathon covered a distance of 40 km (24.85 miles), the distance from Marathon Bridge to Olympic Stadium.[36]

During the next 28 years, the marathon continued to evolve. In the United States, the Boston Athletic Association held its first marathon on April 19, 1897, to commemorate the famous ride of Paul Revere on that date in 1775. For the Olympic Games in London in 1908, the marathon distance was changed to 26 miles, the distance from Windsor Castle to White City Stadium, with an additional 385 yards added so that the race would finish in front of the royal family's viewing box. Finally, in the 1924 Olympic Games in Paris, the distance was set at 26.2 miles, establishing the modern-day marathon distance.[36] Today, hundreds of marathons are held throughout the world each year.

The past quarter-century has seen tremendous growth in the popularity not only of marathons but other endurance events, including cycling events, triathlons, ultratriathlons, and ultramarathons. In addition, advances and improvements in outdoor equipment, along with relatively efficient and affordable travel, have allowed increased participation in such activities as adventure travel, backcountry skiing, mountain biking, mountaineering, orienteering, rock climbing, sea kayaking, scuba diving, snowboarding, trekking, and white-water rafting and kayaking.

The growth of these activities, along with continued popularity of endurance events, has led to development of activities that combine aspects of both. Wilderness multisport endurance events, also referred to as *adventure races* or *multisporting,* have soared in popularity throughout the world, with increasing numbers of events and participants each year.

This chapter emphasizes development of a medical support plan for wilderness and endurance events, including adventure races, cycling events, marathons, and triathlons. This information should prove useful for persons charged with provision of medical care for these activities, as well as for those participating in the events.

TYPES OF EVENTS

ADVENTURE RACES

In adventure races or wilderness multisport endurance events, athletes compete over a course that requires performance of multiple disciplines that may include caving, fixed-line mountaineering, flat- and white-water boating, hiking, in-line skating, mountain biking, navigation and orienteering, technical climbing and ropes skills, trail running, and trekking. Races are categorized by duration into sprint (< 6 hours), intermediate (6 to 12 hours), long (12 to 36 hours), and expedition (> 36 hours) length.

Adventure racing began in the early 1980s with the first large, well-organized events, including the Coast-to-Coast, started in New Zealand in 1980, and the Alaska Wilderness Classic, started in 1983. These were followed by other well-known events, including New Zealand's Raid Gauloises and the Southern Traverse, begun in 1989 and 1991, respectively. The Eco-Challenge introduced adventure racing to the United States in 1995. The Primal Quest, started in 2002 in Telluride, Colorado, brought adventure racing more into the mainstream of American sports through network television coverage. In addition to these expedition-length races, there are countless shorter races throughout the world, for example, the Tough Mudder, a 1-day 10- to 12-mile obstacle course held in over 50 locations worldwide in 2015. In the United States, the U.S. Adventure Race Association (USARA), established in 1998, serves as the governing body for adventure racing (see usara.com). The inaugural USARA Adventure Race National Championship was held in 2000 in California. The first Adventure Race World Championship was held in 2001 in Switzerland.

Expedition-length adventure races are competitive team events that require at least one member of the four- or five-person team to be the opposite gender of the other teammates. Teams race together, with each team member completing each discipline along the course. The course may cover hundreds of miles and take up to 10 days or more to complete.

In many expedition-length adventure races, teams are provided maps and the Universal Transverse Mercator coordinates for each checkpoint and transition area (where teams change disciplines) through which they must pass, but there is no set course between checkpoints and transition areas. Unique to these events, it is left to the team to decide the best route between checkpoints, depending on their strengths and weakness. Whereas one team may opt to go around a ridge, another may go over it. In addition, there are no built-in rest periods, and once the race begins, teams may race around the clock. An individual team must strategize if and when to rest.

When teams in expedition-length events are racing on the course, they are governed by a set of instructions called the "rules of travel." These rules dictate multiple aspects of the race, such as where and when a team may travel on paved roads, existing trails, or water. For example, white-water travel is often prohibited at night in the interest of safety. In addition, the rules of travel specify safety equipment that must be used for each discipline, including mandatory use of personal flotation devices while on the water and helmets while riding bicycles.

The rules of travel also dictate several aspects of the event pertaining to medical care that should be included in the medical support plan. They govern use of medications, including performance-enhancing substances, specify penalties for use of medical resources during the race, and outline criteria for medical withdrawal from the event.

A breach of the rules of travel results in a penalty for the offending team. Minor infractions, such as travel on an unapproved section of paved road, might result in additional hours being added to the team's total time at the end of the race. Major infractions, such as not wearing a helmet during a mountain bike section or use of a banned substance, may result in disqualification.

The team to complete the course with the fastest time after all penalties have been allocated is declared the winner. In many events, prize money is awarded to the top teams.

CYCLING EVENTS

Organized endurance cycling events are often noncompetitive group rides or events designed to raise money for charity. These are normally staged, multiday events with participants riding during the day and resting at night. Several investigations have demonstrated that those in charge of medical provision for these rides must be prepared to treat a wide variety of injuries and illnesses. Because many of these events are designed to raise money for charity, the general health and experience of the participants may be more varied than in other endurance events.

USA Cycling, the governing body for mountain biking in the United States, sanctioned more than 3000 cycling events in 2013 (see usacycling.org); however, this represents only a fraction of the events held annually.

In cycling, perhaps more than in other endurance sports, the use of performance-enhancing substances (actual and alleged use) has been a major issue at both the professional and amateur levels. A medical support plan for all events should include a description of the banned substance policy, testing procedures, if any, and rules for disciplinary action for any violation.

MARATHONS AND ULTRAMARATHONS

Marathons are perhaps the most popular endurance events. Standard marathons cover 26.2 miles (42 km), whereas ultramarathons may be 100 miles (160 km) or more. In 2013 there were more than 1100 marathons held in the United States, with approximately 541,000 finishers, compared with approximately only 300 marathons in 2000 (see runningusa.org/marathon-report-2014). In 2012, an estimated 60,000 people finished ultramarathons in the United States, compared with 10,000 finishers in 1990.

USA Track and Field (USATF; see usatf.org) is the national governing body of long-distance running and is a member of the International Association of Athletics Federations (IAAF; see iaaf.org), which sets the rules of competition for all officially sanctioned long-distance running events in the United States and throughout the world. However, the majority of marathons in the United States are non-USATF events.

USATF rules of competition allow for sanctioned medical assistance for participants by authorized official event personnel. Current rules do not stipulate specific penalties or disqualification for acceptance of medical assistance, so long as it does not alter the scheduled time of competition for any athlete, interfere with other athletes in the competition, or incorporate use of illegal or banned substances, technology, or devices that may give the athlete an unfair competitive advantage. A medical official may choose to remove an athlete from competition if the official feels it is medically necessary for safety of the athlete or for safety of other athletes in the competition. Use of intravenous (IV) fluids or other medications during competition (as long as they are not banned substances) are not specifically listed as grounds for disqualification, but they may be subject to review. Additional rules about clothing, shoes, and athlete interactions with race officials, if breached, may result in disqualification (iaaf.org/about-iaaf/documents/rules-regulations).

Although many uncertified events incorporate the same rules, it is imperative that medical providers and athletes familiarize themselves with the rules of a particular event. In general, ultramarathons are not under the governance of the USATF, and rules for these events may be vastly different from those for standard marathons. Some marathons and ultramarathons allow for pacing, in which a noncompeting individual may run alongside a competitor to help the runner keep a certain pace. In other races this is strictly prohibited. Most standard marathons do not enforce time penalties. However, ultramarathons often have rules similar to those for adventure races, where rule infractions may carry time penalties, which are added to the runner's finishing time.

TRIATHLONS

Triathlons, which consist of swimming, cycling, and running, are held in various lengths:

- sprint length: a 400- to 800-m [0.25- to 0.5-mile] swim, a 16- to 24-km [10- to 15-mile] bike, and a 5-km [3.1-mile] run);
- international or Olympic length: 1500- m [0.9-mile] swim, 38- to 43-km [24- to 27-mile] bike, and 10-km [6-mile] run); and
- Ironman, or ultratriathlon: 4-km [2.4-mile] swim, 180-km [112-mile] bike, and 34-km [26.2-mile] run that may last many hours, or days in the case of staged races.

USA Triathlon (USAT) is the governing body for triathlons in the United States (see usatriathlon.org).

The first recorded competitive triathlon was the Mission Bay Triathlon held in San Diego, California, in 1974. It was intended as no more than a break in the normal grind of training for marathons and 10-K races. In 1978, several participants in that first event combined three of Oahu's endurance events (the Waikiki Rough Water Swim, the Around-Oahu Bike Ride, and the Honolulu Marathon) into one race that we now know as the Ironman Triathlon, the most famous event in the sport.

Most triathlons require participants to wear a swim cap and allow goggles, but forbid use of fins, snorkels, paddles, or other devices during the swim. In addition, many allow swimmers to wear wetsuits. To maximize safety during the swim, rescue personnel in boats patrol the water to offer assistance to any swimmer in need. During the bike section, all participants are required to wear a helmet. Regulations about drafting during the bike section vary by event. Most events also have rules about what is allowable and required during the "transition zones," when competitors switch from swimming to cycling, and again from cycling to running.

Most races allow for medical assistance by official event personnel, although rules among events vary and often intentionally leave room for individual interpretation. For example, the rules for the 2014 Ironman Triathlon state that while there is no penalty for receiving a medical evaluation, IV fluid administration results in disqualification (see ironman.com). Although many unsanctioned events use USAT rules as guidelines, medical providers and participants must understand the rules of the specific race in which they are involved. It is often helpful to have medical providers participate in development of these rules.

MEDICAL SUPPORT FOR WILDERNESS AND ENDURANCE EVENTS

With growing popularity of wilderness endurance events has come increasing demand for medical support for these activities. Provision of medical care for wilderness and endurance events represents a unique area of wilderness and event medicine. This chapter reviews the basics of medical support for wilderness and endurance events and suggests strategies for developing a medical support plan for these activities. Although many general aspects of provision of medical support apply to all events, the complexity of certain events (especially adventure races) often warrants additional resources. Adjustments need to be made in anticipation of the type, amount, and severity of anticipated injuries and illnesses. In addition, logistics, communication, emergency medical services, and search and rescue protocols should be tailored to the specific event.

MASS GATHERINGS

Information from the study of mass gatherings serves as a background for the provision of medical support for wilderness and endurance events. A significant amount of variation exists in the literature concerning the definition of a mass gathering. In some cases, it has been defined as an event with more than 1000 participants; in others, an event is not considered a mass gathering unless there are more than 25,000 participants.[8,31]

Provision of medical support for any event begins with development of a medical support plan. Several authors have described this process for mass gatherings.[9,23,27] The basic goals are to provide rapid access and triage, stabilization and transport of seriously injured or ill patients, and on-site care for minor injuries and illnesses.[8] Nine important elements of planning are attendance or crowd size, personnel, medical triage and facilities,

communication, transportation, medical records, public information and education, mutual aid, and data collection.[23]

General recommendations have been made about the location and staffing of on-site medical facilities at mass gatherings. One group of investigators recommends that advanced life support (ALS) units be in place so that the response time from collapse to ALS care is 5 minutes or less for all participants under all conditions.[44] Others have suggested the goals of basic first aid in 4 minutes, ALS care in 8 minutes, and evacuation to a medical facility within 30 minutes.[41] For staffing, it has been suggested that minimum staffing for every 10,000 participants be a two-person team consisting of registered nurses, emergency medical technicians, or paramedics, or a combination of all three.

In terms of on-site medical care provision, events may be divided into four categories, classes, or types. Category I events are those in which spectators remain seated for a set period of time or for the duration of the event. Common examples include stadium sporting events and concerts. In category II events, such as golf tournaments, Mardi Gras or Carnival celebrations, and state fairs, spectators are mobile and may become participants in the events. A large geographic area and participants often outnumbering spectators characterize category III events, which include charity walks, bicycle rides, marathons, and triathlons.[34] In addition, because of the extreme nature and unique challenges in providing medical support for adventure races and similar endurance events, several authors have labeled these events category IV events.[6,51,52,54] In general, categories III and IV events do not meet the participant number criterion of mass gatherings.

Most existing investigations of medical support involve categories I and II events, with a smaller number of investigations of categories III and IV events. Most investigations of categories I and II events include the frequency and type of injuries and illnesses treated, rate of utilization of on-site medical services, and rate of transfer to local care facilities. Their goal has been to determine what factors influence the type and frequency of injuries and illnesses in order to better anticipate needs and establish appropriate guidelines and standards of care. Much information in these investigations is anecdotal and descriptive; several studies have concluded that there is no standard of care for emergency medical services at mass gatherings.[2,8,41,44]

The incidence of true medical emergencies at mass gatherings appears to be relatively small. In one large study, 75% of medical encounters involved respiratory illnesses, heat-related injuries, and minor problems such as sunburn, blisters, and headache. Asthma was the most common reason for required acute medical intervention.[3]

The relationship between attendance (crowd size) and utilization of on-site medical services is unclear. Several studies have found that overall utilization grew with attendance but that the utilization rate did not increase and, in some cases, actually decreased, with larger attendance.[2,9,58] Rate of utilization of on-site medical services varies widely among events, ranging from 0.14 to 90 patients per 1000 participants, with most events reporting 0.5 to 2 patients per 1000 participants.[2,8,44]

Crowd (participant) demographics, event type, and availability of alcohol and drugs may also be used to help estimate utilization of medical resources. Studies demonstrate that when alcohol is readily available, there is an increase in medical problems related to intoxication.[2,31] In contrast, during a Papal visit, one would expect less intoxication but more cardiac-related problems.[27]

Overall, a number of factors may influence the utilization rate and type of medical care required. These include type and duration of the event, weather, availability of alcohol and drugs, and crowd demographics, including average age, density, and mood.[2,3,31]

WILDERNESS AND ENDURANCE EVENTS

Although the basic influence of attendance, temperature, and relative humidity on utilization of medical resources is likely to be similar across all events, caution should be used when applying utilization rates from categories I and II events to categories III and IV events. Compared with categories I and II events, utilization rates of on-site medical resources are likely to be higher for category III events and significantly higher for category IV events.

FIGURE 97-1 Adventure races represent a unique area of wilderness and event medicine because they have no set course and technical search and rescue may be required. *(Courtesy David Townes, MD.)*

Appropriate on-site medical support for wilderness and endurance events is important to help ensure health and safety of participants. As popularity of wilderness and endurance events grows, courses are longer and more demanding, events are held in more remote and exotic locations around the world, and the potential increases for illness and injury.

Wilderness and endurance events often occur in rough and remote terrain where communication may be difficult, transport time to definitive care prolonged, and technical search and rescue required. In some wilderness events, the entire course is set, whereas in others there is no set course between checkpoints and transition areas. In events with no set course, the exact location of each team may be unknown. In addition, many of these events are not staged, resulting in hundreds of miles separating lead teams from the back of the pack (Figure 97-1). Categories III and IV events present additional challenges for provision of medical care and represent a new and important area of event and wilderness medicine.

DEVELOPMENT OF A MEDICAL SUPPORT PLAN

Provision of medical support for any event begins with development of a medical support plan. The importance of early planning, organization, and good communication cannot be overemphasized.[55] For any event, the medical support plan should be based on anticipation of needs. This begins with estimation of number of patients and type of injuries and illnesses that will require treatment in both best-case and worst-case scenarios. It is often helpful to review utilization of medical resources for similar events that have been held.[27]

Development of a medical support plan should be done under direction of the event's medical director. The primary responsibilities of the medical director are the health and safety of participants. The medical director may be a physician, paramedic, emergency medical technician, nurse, or other medical professional. Ideally, this individual should have prior experience as a medical director for similar events and will serve as care provider, planner, advisor, educator, and liaison with the community.[19] It is essential that the director be familiar with the location of the event, including the capability of local emergency medical services (EMS), local health care facilities, and in the case of category IV events such as adventure races, local search and rescue (SAR) system. Medical support plan development should begin

several months to a few years before the event, depending on event complexity.

Development of a medical support plan begins with careful review of the course, including its location, disciplines required, time of year, and climate conditions, including precipitation, temperature, and humidity. In this way, occurrence and type of injuries, illnesses, endemic diseases, and environmental emergencies, such as dehydration, heat and cold illness, and altitude illness, can be roughly anticipated. High temperature and relative humidity can have a major effect on utilization of on-site medical resources. Both of these factors are associated with increases in demand for on-site medical services; however, humidity has a greater effect than does temperature. During mass gatherings, availability of water influenced the incidences of dehydration and heat illness.[2,8,27]

In general, the medical support plan should be comprehensive and outline all aspects of medical support, including a complete list of medical supplies, equipment, and personnel (Box 97-1). Treatment and transfer protocols should be clearly outlined, assigning any penalties for receiving medical care and establishing indications for medical disqualification or withdrawal from the event. It is important that the medical support plan be based on estimates of the type and frequency of injuries and illnesses expected in both best and worst case scenarios.

In some of the locations where these events occur, especially category IV events, there are inherent difficulties in communication, travel, and general logistics. It may be unrealistic to assume that local EMS, health care facilities, and SAR will be able to handle the potential increased burden and demand for services imposed by the event.

The basic goal of the medical support plan should be to provide definitive treatment for minor illnesses and injuries, establish initial stabilization, and facilitate transfer for more severe illnesses and injuries[52] (Figure 97-2). It is fundamental that the medical support plan be based on anticipation of need. For the event medical director, adventure races and other category IV events present the greatest challenge in medical support plan development, often occurring in sparsely populated rural or very remote, rugged wilderness terrain. Although there are resources and even consensus guidelines for some events to assist the medical director in developing the medical support plan, the body of knowledge is still incomplete and anticipating medical needs thus remains a challenge.[24] Available information demonstrates that medical providers should be prepared to treat a wide variety of injuries and illnesses.[15,54]

FIGURE 97-2 In wilderness and endurance events, the basic goal of the medical support plan should be to provide definitive treatment for minor illnesses and injuries and to provide initial stabilization and facilitate transfer for more severe situations. *(Courtesy David Townes, MD.)*

BOX 97-1 Suggested Medical Equipment and Supplies for Wilderness and Endurance Events

Foot Care
Coban self-adherent wrap
Elastikon tape
Hypafix tape
Leukotape
Moleskin
New-Skin

General
Alcohol pads
Blankets
Cotton swabs
Examination gloves (S/M/L)
Flashlight and battery
Hand cleaner, sterilizer, and sanitizer
Instant cold packs
Portable bed or cots
Sharps and needle boxes
Sphygmomanometer
Stethoscope
Syringes and needles (3 mL/22 gauge/1 inch)
Tape (varying sizes)
Thermometer (oral and rectal)
Tongue depressors
Utility towels

Intravenous Fluids
Angiocatheters (18- and 22-gauge)
Fluids: Normal saline (1 L bags)
IV starter kits
IV tubing kits

Medications

Injection
Diphenhydramine (Benadryl)
D50 (dextrose in water)
Epinephrine
Ketorolac
Lidocaine (1% or 2%)
Promethazine

Inhaled
Albuterol

Oral
Acetaminophen
Antihistamine
Hurricaine gel
Nonsteroidal antiinflammatory drugs
Antidiarrheal drugs
Prednisone
Pseudoephedrine (Sudafed)

Topical
Antibiotic or antiseptic ointment
2% lidocaine (Xylocaine) jelly
Hydrocortisone cream
Ophthalmic antibiotic

Miscellaneous
Duct tape
Fans and water sprayers
Foley catheters
Nasal packing
Pregnancy test kits

Orthopedic
Elastic bandages
Cardboard splints
Finger splints
SAM splints

Respiratory
Ambu bags
Laryngoscope and blades
Endotracheal tubes (varying sizes)
Nebulization pipes
Oxygen masks
Oxygen tanks
Oxygen tank regulators
Oxygen tubing

Trauma and Transport
14-gauge angiocatheters
Backboard
Cervical collars
Head immobilizers
Strap kits

Wound
Bandages (varying sizes)
Dressing (4 × 4, rolled gauze)
Masks with eye shields
Needles for irrigation
Normal saline for irrigation (500-mL bags)
Sterile gloves
Steri-strips
Suture kits
Suture (3.0, 4.0, 5.0, 6.0)
Forceps
Wound (tissue) glue

Modified from Townes DA: Wilderness medicine: strategies for provision of medical support for adventure racing, *Sports Med* 35:557, 2005.

FIGURE 97-3 Overnight medical care administered at ultramarathon in the Australian outback, a hot and humid environment. *(Courtesy of Chris Lusher for RacingThePlanet.)*

PERSONNEL, EQUIPMENT, SUPPLIES, AND LOGISTICS

The type, amount, and placement of personnel, equipment, and supplies varies among events. The medical support plan should include clear and comprehensive descriptions of these components for each individual event.

For most endurance events, medical care is administered along the course at medical stations or within medical tents (Figure 97-3). In triathlons and adventure races, medical care is often administered at "transition areas," where racers change from one discipline to another. In adventure races, medical care may also be administered at designated checkpoints along the course where it is anticipated that medical care may be required.

Standard marathons and triathlons often have medical tents positioned every 1 to 3 miles. Ultramarathons normally have medical tents spread further apart, positioned every 5 to 10 miles along the course. During endurance cycling events, medical tents are positioned every 10 to 20 miles. Positioning of medical tents during adventure races is more variable, reflecting terrain variability in the courses. In a typical 400-mile-long adventure race, there may be up to 10 medical stations.

Personnel

On-site medical personnel should be able to recognize and initiate treatment for routine injuries and illnesses, major and minor trauma, environmental conditions, and endemic diseases. Ideally, they should have experience in wilderness and event medicine. Essential skills include patient assessment, establishing IV access, administration of fluids and medications, and packaging of patients for transfer or evacuation. Personnel might include physicians, paramedics, emergency medical technicians, physician assistants, nurse practitioners, and/or wilderness first responders. At a minimum, staffing each medical station should include one or more individuals with excellent patient assessment skills and the ability to establish IV access and administer medications. Because of the high incidence of foot problems among race participants, the authors have found it extremely useful to include personnel with expertise in foot care whenever possible.

Equipment and Supplies

The medical support plan should include a comprehensive list of medical supplies. The list should be available at each medical tent or station so that inventory can be maintained and personnel will not waste time looking for items that are not available. A sample supply list is shown in Box 97-1. Substitutions, adjustments, additions, and subtractions should be made based on the particular event. It is useful to have all supplies packaged in durable carts, with the location of supplies standardized so that each cart is as similar as possible (Figure 97-4). This allows personnel to move from one medical station to another and easily locate supplies. Supplies should be packaged in clear plastic bags and labeled (with an index card inside the bag) to aid in organization, especially when supply carts are moved over rough terrain from one point to another. Equipment and supply needs should be anticipated and adjustments made in the number of supplies at each medical station. Examples include anticipating that foot care supplies will be in high demand after a long trek, but less so after a kayaking section of the course; or predicting that skin lubricant or antifungal creams will be in higher demand during the latter part of the endurance event. Cycling events and mountain biking sections of adventure races events may require more bandaging and wound care supplies due to the higher potential for large abrasions sustained from falls while cycling. Each aid station should prepare a portable "go bag," to be carried in the event that a medical team needs to leave the tent in order to treat a patient in the field.

Thorough and careful review of the course allows a medical director to estimate of the type and number of environmental injuries and illnesses that will require treatment during the event. For example, if the course requires travel at high altitude, the medical support plan should include a protocol for treatment of altitude illness. This might include indications for oxygen, medications such as dexamethasone, and the use and location of a Gamow-type hyperbaric bag.

Even with the best planning, the wide variety and variability of these events—especially adventure races—makes it impossible to precisely predict the injury and illness pattern for any one event. In the authors' experience, there may be significant year-to-year differences in the same event. During the 2002 Primal Quest, a large number of participants developed shortness of breath and wheezing during the event, requiring treatment with β-adrenergic agonists, even though only a few athletes reported a history of exercise-induced asthma. In contrast, during the 2003 Primal Quest, very few athletes required use of these drugs; however, poison ivy on a section of the course rendered prednisone in short supply.

Logistics

One of the biggest challenges in providing medical support, especially for adventure races, is the logistics of equipment, supplies, and scheduling of personnel. Because medical stations will

FIGURE 97-4 Medical supplies should be packed in durable carts that can be easily moved from one location to another. *(Courtesy David Townes, MD.)*

need to be open as the fastest teams reach them and remain in duty until the slowest teams have passed, this is a dynamic process. It is impossible to predict the exact timing before the event and thus important to build sufficient flexibility into the schedule to allow for uncertainty. This should be clearly outlined in the medical support plan with a time schedule and location for all personnel, medical supplies, and equipment. It is important to include packaging, transportation, and set-up time for equipment and supplies. In addition, during adventure races lasting several days or more, personnel should be given mandatory time off.

Ideally, personnel and equipment should include full-time, on-site, ALS-staffed ambulance and helicopter support. Every effort should be made to have an ALS ambulance on site, especially in remote locations where the local EMS response may be prolonged. If a medically equipped helicopter is not available, one option is to ensure that the helicopter used for general transportation and media is also prepared to evacuate and transport ill and injured participants if necessary.

COMMUNICATION

An important challenge in providing medical support for wilderness and endurance events is communication among athletes, race staff, medical staff, and EMS and SAR personnel. Communication is especially important between race participants and medical personnel in the event of an emergency. Given the rugged terrain and remote locations in which some categories III and IV events take place, communication can be difficult and unreliable.

Communication options include cellular phones, satellite phones, and radios. Each system has advantages and disadvantages, and the best modality depends on the individual situation. The advantages of cellular phones include widespread availability and direct, private, person-to-person communication. However, cellular phones are limited by network availability, making them useless in many situations. Satellite phones offer better coverage, but are expensive, relatively large and heavy, and unreliable under certain conditions. In addition, they generally require the caller to remain in one place with an unobstructed view of the sky to minimize the chance of dropping the call. Radios are usually readily available and offer reliable coverage in a variety of conditions. One disadvantage of radios is the need for battery-dependent repeaters to cover large areas. A second disadvantage is lack of privacy during communication.

Global positioning system (GPS) devices have been used to locate teams along the course during several expedition-length adventure races. Teams competing in the Primal Quest carry units that combine a GPS tracking unit with either a radio or satellite phone. In an emergency, teams notify race officials by radio or phone. Through computerized GPS tracking, their exact location can be determined almost immediately. In addition to emergency situations, this tracking system is used to follow progress of the event.

EMERGENCY RESPONSE

The medical support plan should include a protocol for notification of medical personnel of any medical emergency on the course. During standard and ultradistance triathlons, marathons, and cycling events, this is often a relatively straightforward process. A participant with a minor or moderate illness or injury is encouraged to continue or return to the nearest aid station or medical tent for medical assistance. Participants in these types of events generally do not carry phones or radios while they are competing. If the injury or illness is more severe and limits the athlete's ability to continue, he or she must rely on other competitors to notify officials at the nearest medical tent, or be assisted by roving mobile medical personnel or ambulances driving along the course, if this type of medical support is available.

Adventure races present a more complex set of challenges in identification and location of ill and injured participants. In the interest of simplicity, it may be useful to develop and employ a three-part classification system for injury and illness (Table 97-1). Athletes often carry phones or radios during these events and use this system when notifying race and medical personnel of an emergency. The medical support plan should include a protocol for notification of medical personnel of any medical emergency on the course. In one commonly used example, a class I emergency, such as a laceration, requires no evacuation, and the athlete will proceed to the closest medical station for evaluation and treatment. A class II emergency, such as an injured ankle, requires evacuation, but is not life threatening. A class III emergency requires immediate evacuation, as in the case of a head injury.

TABLE 97-1 Emergency Classification for Adventure Races

Emergency Classification	Description	Examples
I	Requires no evacuation; patient will proceed to next medical tent for evaluation	Laceration
II	Requires evacuation; not life threatening	Ankle injury or likely fracture
III	Requires immediate evaluation; life threatening	Head injury

In the event of a medical emergency, athletes are instructed to first notify race personnel of their team number and the emergency classification number. The purpose of this system is to allow athletes to quickly identify themselves and communicate the severity of the situation to medical personnel. It is important to relay information quickly and accurately because communication systems may be unreliable or inconsistent and could potentially break down at any given time. Thus it is crucial to ensure that the most important facts are sent and received immediately; additional details can be provided if communication remains intact.

ACCEPTANCE OF MEDICAL CARE

One area of controversy among medical personnel, event organizers, and athletes involves penalties for acceptance of medical support during an endurance event. Administration of IV fluid is a commonly cited example. If acceptance of IV fluid results in disqualification, athletes may push themselves too hard in an attempt to remain in the event. If IV fluid is administered without penalty, racers may request it at every opportunity to gain a theoretical competitive advantage. The authors and several race directors of both categories III and IV events use an "IV fluid rule" intended to allow fair and safe competition. This should be tailored for each individual event. For example, the IV fluid rule used during the Primal Quest expedition-length adventure race is shown in Box 97-2. As more events are held and investigations about the advisability of IV hydration are undertaken, such rules may be refined.

BOX 97-2 Intravenous Fluid Rule Used During the Primal Quest, 2002 to 2008

Athletes who receive intravenous (IV) fluid are automatically penalized 4 hours. The penalty period begins with the completion of the last liter of fluid.
Athletes requiring more than 2 L of IV fluid at one time (one medical station) or any amount of IV fluid at more than one time (multiple medical stations) will be automatically disqualified from the event.
All athletes who require IV fluid must be evaluated and medically cleared by the race medical director or his or her designee before returning to the race. Return to the race will occur only after the 4-hour penalty has been served.

From Townes DA: Medical support plan: Primal Quest 2002, unpublished.

MEDICAL DISQUALIFICATION

A potential conflict arises when the medical team and an athlete disagree about the athlete's ability to continue to race safely. In adventure races and other team endurance events, one strategy the authors have found helpful in this situation is to explain the concerns to the other seven members of the team (the four crew members and three remaining racers, in the case of adventure races). They will often help convince their ill or injured teammate to withdraw from the race. Sometimes these individuals agree that their teammate should not continue, but are unable or unwilling to convince the athlete to stop. In these cases, the team may look to the medical director for help. The medical director for the event should have the final say about whether an athlete is able to continue the race. This should be clearly explained to all race participants prior to the competition, and they should sign a release form indicating their acceptance of this policy.

EMERGENCY MEDICAL SERVICES AND SEARCH AND RESCUE TEAMS

It is essential to identify local ground and air ambulance services, SAR services, care facilities, and hospitals and trauma centers (and their capabilities) for each location along the course (Figure 97-5). Expedition-length adventure races may cover multiple hospital, trauma center, and EMS and SAR jurisdictions. At each medical station, there should be a folder containing the location and contact information for the resources specific to that medical station. It should also include the location and description of the medical station that will be readily understood by local providers. For example, when requesting a local ambulance, it will be more efficient to describe "Spring Valley Camp Ground, off of County Road 14" rather than "medical tent 5." In this way, any medical personnel, even without local knowledge, are able to quickly request services and communicate accurately. It is also important to determine whether a national emergency network such as 9-1-1 is available and whether it can reached by an out-of-area cellular phone. The importance of working with local providers cannot be overemphasized. It is strongly recommended that a member of the local EMS community act as a liaison between the race and local medical community. This individual is often helpful in determining what EMS, SAR service, or care facility should be utilized.

LEGAL CONSIDERATIONS

Important considerations in development of a medical support plan for any event include licensing, liability, and insurance coverage for medical personnel. The necessary requirements vary depending on location. Because events are held throughout the world, no single set of standards is applicable to every situation. It is essential to understand and adhere to the requirements of the specific location, and it may be beneficial for the medial director and race organization to solicit expert legal advice.

FIGURE 97-5 Medical transport for a wilderness event needs to be predetermined for the entire course. *(Courtesy David Townes, MD.)*

In addition to basic issues of licensing and liability, several questions should be considered. Is the liability different for a volunteer compared with someone who is paid? If medical personnel are covered under the general liability policy of the event, do they require additional insurance? What is the validity of liability waivers signed by race participants? What constitutes the practice of medicine? For instance, does a volunteer who applies a dressing to a blister need to be licensed to do so? Do all medical personnel need to be licensed, or just the medical director? If controlled substances are included in the medical kits, what additional measures are required? The answers to these questions depend on the laws that govern the location of the event.

INJURIES AND ILLNESSES BY EVENT TYPE

CYCLING EVENTS

The most common reasons to need medical care during cycling events include dehydration, heat illness, and soft tissue injuries. During the 1996 California AIDS Ride,[17] heat-related illness accounted for 31% of encounters, followed by pulmonary complaints (12%) and orthopedic problems (9%). During the 2001 Midwest AIDS Ride,[53] dehydration accounted for 35% of encounters, followed by orthopedic problems (27%), skin and soft tissue problems (10%), ophthalmologic problems (6%), gastrointestinal problems (6%), respiratory problems (4%), head and neck problems (3%), allergic reactions (3%), cardiac problems (2%), psychiatric problems (<1%), and other problems (4%). The most common orthopedic problem was overuse injury of the knee, primarily due to iliotibial band syndrome.[17,53] Fortunately, major trauma is rare. This is likely in part because of mandatory helmet use and protection from traffic provided by these events.

Because a large percentage of injuries sustained during endurance cycling events are overuse injuries resulting from inadequate training or conditioning, it may prove useful to send educational material directed at proper training techniques to the participants well in advance of the event.

TRIATHLONS

The overall injury rate for triathlons has been calculated at 13% to 25% of participants.[26] Each of the three disciplines is associated with a fairly unique set of injuries.

The swimming section of triathlon events has the greatest potential for death. It is essential to have sufficient rescue boats with qualified personnel in the water. Fortunately, the swimming section is associated with the fewest overall problems, accounting for only 3% of medical visits in one study.[26] Besides drowning, hypothermia is the greatest risk during the swimming section. Mandatory use of wetsuits may reduce this incidence. Blunt trauma from being kicked in the water and corneal irritation or abrasion from trauma, goggles, and defogging solutions are not uncommon. In addition, jellyfish stings, sea urchin punctures, coral lacerations, and aspiration have all been reported.[48] Leptospirosis has also been described in triathlon participants.[11]

The biking section is associated with trauma, including fractures, sprains, and abrasions, or "road rash." Biking accounts for 7% to 10% of triathlon injuries.[26] Occurrence of significant injury is reduced by rules that require helmet use and do not allow drafting.

The running section at the end of the triathlon is associated with the largest demand for medical assistance. In fact, 75% of medical care is delivered in the last 8 hours of the event, with 75% of this amount delivered at the finish. Many of these injuries and illnesses are due to dehydration and electrolyte abnormalities.[26]

MARATHONS AND ULTRAMARATHONS

In a 12-year study of the Twin Cities Marathon in Minneapolis and St Paul, Minnesota, 90% of medical encounters occurred at the finish line. The most common reason was exercise-associated

TABLE 97-2 Injury and Illness Rates in Multiday Ultramarathon Runners (% of Medical Tent Visits by Diagnosis)

Diagnosis	Marathon	Multistage Ultramarathon	
		Major[a]	Minor
Medical Illnesses			
Exercise-associated collapse[b]	59%	56.5%	3.9%
Altitude sickness	—	0	1%
Serious medical diagnosis[c]	0.14%	1.6%	0.1%
Other medical diagnosis[d]	0.48%	0	2.4%
Musculoskeletal Injuries			
Bursitis	—	1.6%	1%
Sprain	1.3%	3.2%	2.3%
Strain	14.3%	1.6%	2.4%
Tendinitis	—	11.3%	10.3%
Other[e]	0.28%	4.8%	2.6%
Skin Disorders			
Abrasion	1.9%	0	3.9%
Blister	19.9%	16.2%	57.8%
Cellulitis	—	1.6%	0.7%
Subungual hematoma	—	1.6%	9.5%
Other[f]	—	0	2.1%

[a]Major = unable to complete race; Minor = able to continue in race
[b]Hyperthermia, normothermia, hypothermia
[c]Hyponatremia, hematuria, renal stone
[d]Blurred vision, conjunctivits, diarrhea, dyspepsia, epistaxis, hematochezia, insect bite, neuropathy, pharyngitis, upper respiratory infection
[e]Fracture, metatarsalgia, contusion, costochondritis, laceration, splinter
[f]Callus, nail avulsion, rash, paronychia, wart

collapse (59%), followed by skin problems (21%), musculoskeletal problems (17%), and other medical problems (3%).[38] The mechanism of collapse at the end of a marathon may be due to postural hypotension from inadequate venous return secondary to decreased skeletal muscle massage when the competitor abruptly stops running.[33] Sudden cardiac deaths have been reported during marathons, but they are exceedingly rare.[30] About half of these cases occurred in individuals with preexisting cardiac disease.[14] Heat illnesses, including heat exhaustion and heat stroke, occur more commonly in participants who are not properly acclimatized, especially during events in warmer climates. Injury and illness rates during multiday ultramarathon races are shown in Table 97-2.

ADVENTURE RACES

Injuries and illness are common during adventure races. Many are minor, and relatively few result in withdrawal from an event.[5,50,54] Most injuries involve skin and soft tissues.[5,15,54] In a survey of 223 adventure race athletes, 73% reported at least one injury (acute or chronic) during the 18 months before the survey.[15] This is comparable with overall (acute and chronic) injuries reported during orienteering and standard triathlons, although lower than in ultraendurance triathlons, in which injury rates as high as 90% have been reported. In the survey, 44% of advanced, 35% of intermediate, and 19% of beginner racers reported acute injuries. Chronic injuries were more common, reported in 59%, 54%, and 56% of athletes, respectively.[15] Acute injuries are considerably more common during adventure races as compared with triathlons. Some of the difference has been attributed to lower extremity injuries sustained during maneuvering over unstable terrain and the inherent risks of mountain biking. In the survey, the most common site of acute injury was the ankle, followed by the arm and shoulder, knee, and lower back.[15]

In a prospective cohort study of injuries and illness treated during the Primal Quest expedition-length adventure race held in 2002 in Telluride, Colorado, 243 medical encounters and 302 distinct injuries and illnesses were reported among the 248 athletes who participated. Of the 179 (59%) injuries and 123 (41%) illnesses reported, skin and soft tissue injuries were the most common (48%), with blisters on the feet representing the single most frequent reason to utilize on-site medical resources (32.8%).[54] A complete list of injuries and illness by type, number, and frequency is given in Table 97-3.

Although injury was more common overall, illness resulted in more medical withdrawals from the event. Of the 28 athletes who withdrew for medical reasons, 60% withdrew because of illness. Respiratory illness, including upper respiratory infection, bronchitis, and reactive airway disease–asthma, were the most common (32.1%) medical reasons to withdraw, followed by dehydration (25.0%), altitude illness (14.3%), skin and soft tissue problems (14.3%), orthopedic problems (10.7%), and genitourinary problems (3.6%).[5] In a similar study, the only medical withdrawal from a 2-day wilderness multisport event was due to reactive airway disease in the setting of a viral respiratory infection.[5]

Reactive airway disease–asthma appears to be a common cause of illness during adventure races. The relatively high incidence observed may be partially explained by changes in respiratory function in participants. This has been demonstrated by several investigations. In a study of two consecutive years of a wilderness multisport endurance event, measurements of oxygen saturation (Sao_2), forced expiratory volume in 1 second (FEV_1), and forced vital capacity (FVC) were taken before and after the event and at 45-minute intervals during the event. During the event, there was a progressive decline in both FEV_1 and FVC from the starting line to the finish. At the finish, the FEV_1 had declined by 22% to 25% and FVC had declined by 14% to 22% over the 2 years of the study. Changes in Sao_2 were less dramatic.[40] A similar study of 25 adventure race athletes found a mean decrease in FEV_1 of 15.1% and FVC of 13% between the start and finish of the event. Fourteen (56%) of these athletes had a decrease in FEV_1 and FVC of more than 10%, and seven (28%) had a decrease of more than 20%.[39] A decline in respiratory function has been described in other endurance athletes but to a lesser degree.[21,28,29] Possible explanations for these findings include bronchospasm, airway inflammation, muscle fatigue, and pulmonary edema.

Complicating the understanding of reactive airway disease–asthma observed during adventure races is the fact that many events have sections that occur at high altitude. In an investigation of the 2002 Primal Quest, the incidence of altitude illness requiring medical treatment was 14.1%. Most cases were acute mountain sickness (13.3%). Only 0.81% of cases were high-altitude pulmonary edema. The potential role of altitude illness in exacerbating or alleviating other respiratory problems remains a concern.[50]

Previous studies have demonstrated improvement in asthma at high altitude. Explanations offered for this observation include reduction in pollen and pollution, and increase in cortisol levels

TABLE 97-3 Injuries and Illnesses During the Primal Quest, 2002

Type of Injury or Illness	Number of Cases (n = 302)	Percentage of Cases
Skin or soft tissue	145	48.0
Respiratory	55	18.2
Altitude (acute mountain sickness, high-altitude pulmonary edema)	36	11.9
Orthopedic	29	9.6
Dehydration	21	7.0
Gastrointestinal	6	2.0
Head, ears, eyes, nose, throat	5	1.7
Genitourinary	3	1.0
Other	2	<1.0

From Townes DA, Talbot TS, Wedmore IS, et al: Event medicine: injury and illness during an expedition-length adventure race, *J Emerg Med* 27:161, 2004.

at high altitude.[1,7] Other studies have found that exercise at altitude may exacerbate acute mountain sickness.[37] Further studies are necessary to fully understand the interaction between reactive airway disease–asthma, respiratory tract infections, and altitude illness during adventure races.

In addition, injuries and illnesses due to environmental exposure are common during adventure races. A study of Australia's Winter Classic, a 2-day event, found that 21% of participants developed symptoms consistent with exposure.[5] During the Primal Quest in 2003, 25% of medical withdrawals were attributed to dehydration or heat illness.[54]

SPECIFIC INJURIES AND ILLNESSES: ENDEMIC DISEASE

Another potential source of illness during wilderness and endurance events is endemic disease. The literature includes descriptions of everything from isolated cases to widespread infections affecting large numbers of participants.

In the 1997 Raid Gauloises held in Lesotho and Natal, South Africa, 13 French athletes were diagnosed with African tick-bite fever. This rickettsial disease is caused by *Rickettsia africae* and transmitted by *Amblyomma* ticks. Signs and symptoms included fever, headache, multiple inoculation scars, regional lymphadenopathy, and rash.[16]

Another potential infection during endurance events is leptospirosis. Leptospirosis is a bacterial zoonotic infection associated with exposure to water or soil that has been contaminated by wild and domestic animals, which serve as reservoirs and transmit the infection by shedding the causative organism, *Leptospira interrogans,* in urine. The illness is characterized by symptoms that include fever, chills, myalgias, headache, conjunctival suffusion, abdominal pain, vomiting, diarrhea, and rash. This may progress to aseptic meningitis, jaundice, renal failure, hepatic failure, and hemorrhage. The syndrome of fever, meningismus, and renal and hepatic failure is referred to as *Weil's disease.* The incubation period is most commonly 5 to 14 days, but ranges from 2 to 30 days. Mild infections can be treated with tetracycline and severe cases with IV penicillin (see Chapter 34).

The most widely publicized outbreak of leptospirosis occurred during the Eco-Challenge-Sabah 2000 adventure race held in Malaysian Borneo.[12,13,42,48] Of 304 athletes competing, 189 were contacted, of which 80 met the case definition for leptospirosis. No deaths were reported. Risk factors identified were kayaking or swimming in the Segama River, swallowing water from the Segama River, and spelunking (caving). Swimming in the Segama River was the only risk factor independently associated with illness. Of the 20 athletes who reported taking doxycycline for prophylaxis of malaria or leptospirosis, four (20%) developed symptoms of leptospirosis. When this rate was compared with those not taking doxycycline and adjusted for exposure, doxycycline use was determined to be protective; however, the difference was not significant.[42] Leptospirosis infections have also been attributed to participation in an adventure race in Guam, triathlons in Illinois and Wisconsin, white-water rafting in Costa Rica, and an endurance-length "swamp" adventure race in Florida.[10,11,20,47]

Myiasis, infestation of humans by fly larvae, has been reported during an adventure race. In a 2001 race in the Para State jungle region of Brazil, an athlete fell and sustained a wound that was infested with a third-stage larva of the New World screwworm fly *Cochliomyia hominivorax.* Although most cases of myiasis are benign, infestation by invasive species like the screwworm may result in extensive tissue damage, pain, and even death, because the larvae have powerful oral hooks that can invade cartilage and bone.[43]

In 2012, there were 22 cases of *Campylobacter coli* infection (4 confirmed and 18 probable) among participants in a 2-day adventure race in Nevada. A case control study identified inadvertent swallowing of muddy surface water as a significant risk factor.[57]

Wilderness and endurance events are held in a wide variety of locations and conditions. Given the potential for participants to become ill during or after the event, it is essential that the medical director be familiar with endemic diseases for a particular event related to its location, time of year, and current environmental conditions.

MAJOR TRAUMA

Major trauma has occurred during wilderness and endurance events, resulting in significant injuries and death.[25] Fortunately, the incidence is low, but because of potential complications and death, the medical support plan should include equipment, supplies, and personnel to provide initial stabilization and treatment of major trauma. It should also include a protocol for evacuation and transport developed in close conjunction with local EMS and, in the case of adventure races, local SAR personnel. Obtaining appropriate personnel and equipment may require a significant financial commitment by the race organization. The medical director must emphasize the importance of these resources and insist on having them, even though they may go unused. Examples include full-time paramedic-staffed ALS ambulances, helicopters, and other rescue vehicles. Litters and Gamow-type hyperbaric bags can represent a significant expense for some events. The medical support plan should specify the location of these limited resources and their movement during the event. For example, it may be necessary to "leapfrog" ambulances from one location to another during the event to deploy resources most effectively. This planning should be done prior to beginning the event.

FOOT CARE

Foot-related problems (see Chapter 25), particularly blisters, are perhaps the most common reason to seek medical care during wilderness and endurance events (Figure 97-6). In one investigation during an adventure race, foot blisters were the most common reason to seek care, accounting for 53% of medical encounters.[54]

Staffing and supplies should reflect the high incidence of foot-related problems. Ideally, the medical team should include providers with expertise in foot care. At a minimum, all providers should have a basic understanding of foot and blister care (see Chapter 25).

There seem to be as many different techniques for prevention and treatment of blisters as there are feet. Athletes use duct tape, antiperspirants, petroleum jelly, and multiple newer products designed specifically for blister prevention. In a text dedicated to the subject, the authors list 159 ways to prevent blisters.[56] Despite the variety of preventive methods, susceptibility to blisters varies. Although some athletes remain blister-free with little effort, others suffer from blisters no matter what measures are taken.

Treatment of blisters begins before they form. All blisters begin as "hot spots" that should be treated with tape or one of many blister products on the market. If the athlete is no longer

FIGURE 97-6 Self-administered forefoot blister treatment with medical team debridement of deep heel blister in an ultramarathon runner. *(Courtesy of Chris Lusher for RacingThePlanet.)*

FIGURE 97-7 Dehydration and hyponatremia are common in wilderness and endurance events. *(Courtesy Tim Holstrom.)*

continuing in the event, blisters need not be drained unless they are infected. If the athlete plans to continue, however, it may be necessary to drain the blister to allow application of a dressing that will stay in place. The blister can be drained with any sterile sharp object, such as a needle, blade, scissors, or nail clipper. Ideally, a small hole is made in the blister to drain the fluid and the overlying dead skin is left in place. After the area has been cleaned, it should be dressed with tape or a blister care product. Blisters should be monitored closely for infection.

DEHYDRATION AND HYPONATREMIA

Dehydration and hyponatremia are common during wilderness and endurance events, especially marathons and triathlons. Medical team members should be familiar with the recognition, diagnosis, and treatment of these disorders (Figure 97-7). During the Hawaii Ironman Triathlon, dehydration was the most common reason to receive on-site medical care, and hyponatremia the most common electrolyte disturbance. Dehydration with hyponatremia is rare in races lasting less than 4 hours, and becomes more common in races lasting longer than 8 hours.[22]

Hyponatremia is defined as a serum sodium level of less than 135 mEq/L associated with malaise, disorientation, hyperreflexia, nausea, and fatigue. More severe cases may result in seizures, stupor, coma, and death. Seizures have been reported in a triathlete with a serum sodium level of 116 mEq/L, and rapid neurologic deterioration and encephalopathy in ultramarathon runners.[18,46,49]

Hyponatremia occurs when free water intake exceeds free water loss. In the endurance athlete, this is thought to occur in two distinct ways, although there is some debate about the exact cause of exercise-associated hyponatremia. Several authors have suggested that hyponatremia is a result of net water gain during exercise secondarily associated with sodium loss through sweat.[22] Others have attributed it to salt depletion due to massive sweat losses associated with net dehydration.[22] Additional studies have demonstrated that hyponatremia may occur in the setting of dehydration or overhydration.[45]

In a study of 605 participants in the New Zealand triathlon, 58 (18%) were found to be hyponatremic. Of these, 18 were symptomatic, and 11 were severely hyponatremic, defined as having serum sodium of less than 130 mmol/L. The serum sodium concentration following the race was inversely related to weight change during the event. That is, athletes with hypernatremia were dehydrated, but athletes with severe hyponatremia were generally overhydrated. The relationship between mild hyponatremia and hydration status was less clear. Some athletes with mild hyponatremia were dehydrated, but others were overhydrated. It would appear that the mechanisms for mild hyponatremia in the endurance athlete include fluid overload or large salt losses through sweat, or a combination of the two.[45]

Whatever the mechanism, it is important to be aware of both dehydration and hyponatremia in triathlon participants. There are various recommendations to help reduce the incidence of dehydration and hyponatremia. These include (1) athletes should have 0.5 L of fluid intake for each pound (0.45 kg) lost during an event, (2) during races lasting more than 4 hours, athletes should use some form of sodium replacement (1 g/hr), (3) athletes from cooler climates should give themselves a week to acclimatize and should increase salt intake by 10 to 25 g/day, and (4) IV fluid therapy for races longer than 4 hours should be 5% dextrose in normal saline, and for races less than 4 hours, it should be either 5% dextrose in normal saline or 5% dextrose in 0.5 normal saline.[22] Studies of marathon runners have suggested that replacement of sodium at a rate of 20 mEq/hr and potassium at 8 mEq/hr will maintain normal blood levels.[32]

More recently, the Wilderness Medical Society published guidelines for treatment of exercise-associated hyponatremia. These recommendations encourage competitors to drink according to thirst rather than a predetermined schedule in order to avoid overhydration.[4] Additionally, in evaluating a symptomatic competitor, if a blood electrolyte measurement is available on-site and the sodium level is less than 135 mmol/L, the recommendation is to administer an IV bolus of 100 mL of 3% saline, repeated every 10 minutes up to three doses or until neurologic symptoms subside, while preparing for transport to a hospital setting.[4] These guidelines also suggest that if no point-of-care testing is available, one should place an IV line only and give oral hypertonic solution; avoid giving hypotonic solution because of the risk of further lowering the sodium level.[4] Difficulty arises in the absence of point-of-care testing because the symptoms of hyponatremia and dehydration may be similar but different interventions are needed for the two disorders. When in a very remote location (> 4 hours to definitive medical care) without point-of-care testing, one must rely on clinical assessment and judgment to make a diagnosis and treat accordingly. Providers should use caution because there are risks associated with administration of either hypertonic or hypotonic solution in a given context.

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CHAPTER 98

Canyoneering and Canyon Medicine

GIACOMO STRAPAZZON AND GORDON L. LARSEN

Canyoneering (referred to as *canyoning* in Europe) is the term used for a recreational activity involving travel through canyons using a variety of techniques and technical skills. Canyoneering is physically challenging and may require any combination of down-climbing, rappelling down waterfalls, swimming through cold pools and swiftwater, escaping keeper potholes, and using advanced ropework. Navigational skills are essential. This chapter provides an overview of pertinent aspects of canyoneering, namely, canyon environment and potential hazards, progression techniques and necessary equipment, common injuries and illnesses, medical interventions and equipment, and companion rescue and SAR operational considerations. For more information about details of technical rescue, see Chapter 56.

CANYONEERING

HISTORICAL PERSPECTIVE

Canyoneering is at least several hundred years old. Native American cultures (e.g., peoples from Ancestral Puebloan and Fremont) that settled inside natural caves at the base of canyons were likely the true pioneers of canyoneering. Early American explorers and settlers were also reported to have been faced with a maze of canyons in the southwestern regions of the United States.[58] Canyoneering first emerged for recreational exploration in Europe in the late 19th century after the father of modern caving, Édouard-Alfred Martel, explored the Bramabiau cave in France.[14] In 1893, Armand Janet and Lucien Briet became famous due to their explorations in the Verdon region in France and the Sierra de Guara region in Spain.[14] Recreational exploration of canyons was not common during the World Wars, but gained importance again in the 1960s. In 1977, Pierre Minvielle published the first canyoneering guide *Grottes et canyons, les 100 plus belles courses et randonnées*,[32] which marked the beginning of recreational canyoneering in France. Soon the first commission for canyoneering was established within the French Federation of Speleology.[14]

Zion National Park in southern Utah is the most popular region for canyoneering in the United States. Recreational canyoneering in this region began in the 1960s. The term *canyoneering,* as employed to refer to the modern form of recreational exploration in canyons, was not used until the 1990s, when it appeared in the book *Canyoneering: The San Rafael Swell* by Steve Allen.[1] In 1993, two scout leaders were tragically killed on a group excursion in Zion National Park as a result of being caught in hydraulics at the base of a waterfall. The survival story and eventual evacuation of the lone scout group after four cold nights on a ledge in Kolob Canyon in Zion National Park raised public awareness about canyoneering.[3] Over the past decades, canyoneering has become one of the fastest-growing wilderness recreation activities. Development of specialized equipment and techniques has facilitated commercial operations and exploration of increasingly more difficult canyons. The associated increase in rescues led to establishment of specially trained and equipped SAR teams.

Demographics

In the United States, canyoneering is most common in the sandstone slot canyons of the Colorado Plateau, but canyons also exist in the Cascade, Rocky Mountain, San Gabriel, and Sierra Nevada ranges. Canyons are also present offshore on the Hawaiian islands. Over the past 15 years requests for access permits in Zion National Park increased so rapidly that the park services had to develop new usage plans. Remarkably, a 5-year increase in usage of 500% to 1200% in the most popular areas was reported by park officials.[48] Canyoneering seems to attract younger people and more females than other types of wilderness recreation, for example, mountaineering. However, in a web-based survey of 38 members of American and Australian canyoneering associations, almost 90% of respondents were male. Equally, the average level of experience was 6.5 years with 25 canyoneering days per year.[48] These results were based on a small sample of individuals and may not be reflective of a larger population or other regions. In a larger investigation, over a 5-year period in Sierra de Guara, Spain, 8019 canyoneers in 1648 groups were surveyed; 62% of canyoneers were male, with a median age of 32 years (standard deviation 12 years).[5] The majority of canyoneers were in groups of 6 to 10 members, and typically each group had planned the descent before the excursion using canyoneering guides and maps. However, a staggering 73% of those canyoneers sampled were not registered members of a recognized mountain or sport association; nonmembers were reported as less likely to adhere to recommendations regarding individual safety equipment.[5]

Despite any safety concerns, canyoneering has also become popular outside the United States and Europe; for example, in Australia, New Zealand, Japan, and Brazil, as well as on tropical islands (La Reunion Island, French West Indies, and Madeira, Portugal) and in high-altitude mountain ranges (Andes, Himalayas).[4]

CANYON ENVIRONMENT

Of all SAR operations in U.S. National Parks in 2005, the second most frequent rescue location was canyons; only rescues in mountainous terrain above 1500 m (5000 feet) were more common.[22] A *canyon* can be defined as a deep, narrow valley or gorge with steep sides or cliff walls and vertical drops. Canyons can be found as features in mutiple rock types, for example, limestone, granite, sandstone, and basalt (Figure 98-1). They exist on every continent, at any altitude, and in any environment (deserts, rain forests, mountains). The form of a canyon is largely determined by past and present water flow. Over time, action of water and gravel, through erosion, can carve deep channels and other formations in the rock. Water flow over these formations determines the dynamic elements of a canyon. The exact water regime in a canyon depends largely on seasonal trends in climate and geography of the region and tributary catchments. Changes in water flow typically occur during periods of snow melt, glacial melt, and rainfall.

Recognizable features within the canyon environment are important for correctly assessing the mode of safe progression. A *pool* is a deep spot in a streambed. A *pothole* is a bowl-shaped depression in the rock surface that has been carved by swirling actions of stones. A pothole can be dry or filled with water (Figure 98-2). Deep pools, or potholes, are common where the water swirls against canyon walls. A *waterfall* is a place where water flows over a vertical drop, and it is probably the most characteristic feature of wet canyons. A drop over a smooth sloping surface forms a natural *water slide* (or *toboggan*) when wet. An *eddy* is a horizontal reversal of water flow caused by a protrusion from the bank, a turn, or an obstacle (see Chapter 62, Whitewater Medicine and Rescue).[38] An *eddy fence* is the boundary between the downstream water flow and the stalled or reversing water of an eddy. A *hydraulic* is a low-pressure area that draws water from a higher-pressure area downstream.

FIGURE 98-1 **A,** Limestone wet canyon. **B,** Granite wet canyon. **C,** Sandstone slot canyon. **D,** Himalayan canyon. *(Courtesy Erwin Kob.)*

Hydraulics are more commonly associated with rivers, but dangerous hydraulics also exist in wet canyons, typically at the base of a waterfall or water slide (Figure 98-3).

CANYONEERING HAZARDS

The main hazard during descent in a dry canyon is falling, either due to incorrect rope techniques or falling debris. The main hazards in a wet canyon are water and wet surfaces.[44] As water level rises (e.g., in a more narrow section), speed and power of the current increase exponentially. When speed is doubled, the force of the water against an object in the current is quadrupled. Canyoneers are subject to these forces while walking, swiftwater swimming, sliding, and descending under a waterfall. Hydraulics can cause trapping and drowning (Figure 98-4).[44] Canyoneers fixed on a rope can get trapped in a hydraulic. Jammed debris

FIGURE 98-2 A pothole filled with water. *(Courtesy Gordon Larsen.)*

can create a *strainer* (sieve) and may not be visible in dirty water or in a pool or pothole. Pools and potholes can hide water traps, but are avoidable with good navigation techniques. A water trap can be recognized in advance, when the outflow is not equal to the inflow in a pool (see Figure 98-4).[44]

A *flash flood* is the sudden rise of water in a canyon, which may occur within minutes or even seconds. Heavy rainfall in the catchment of the canyon (that could be many kilometers distant) is the most common reason (Figure 98-5). Flash floods can also result if a hydroelectric dam is opened, or a natural dam collapses. Floods can occur in both dry and wet canyons.[44] In one widely publicized incident in 1999, 21 tourists on a commercial canyoneering trip drowned in Saxetenbach Gorge, Switzerland.[46] In another incident, seven adults were killed in a flash flood in Zion National Park on September 14, 2015. The party was in Keyhole Canyon, a popular and short slot canyon, when a fierce afternoon thunderstorm dumped more than an inch of rain over the upper drainage of the canyon in less than an hour. There were no survivors and some of the bodies were found miles downstream. Such incidents can be prevented with knowledge of the forecast and weather conditions. Changes in weather conditions (approaching thunderstorms) and/or water (color, clarity, level, presence of floating debris) may be indicators of a potential flash flood. If any of these signs appear, canyoneers should move to higher ground immediately and stay there until conditions improve. Canyons do not provide sufficient protection from lightning during thunderstorms.

FIGURE 98-3 Hydraulic at the base of a low drop. *(Courtesy Erwin Kob.)*

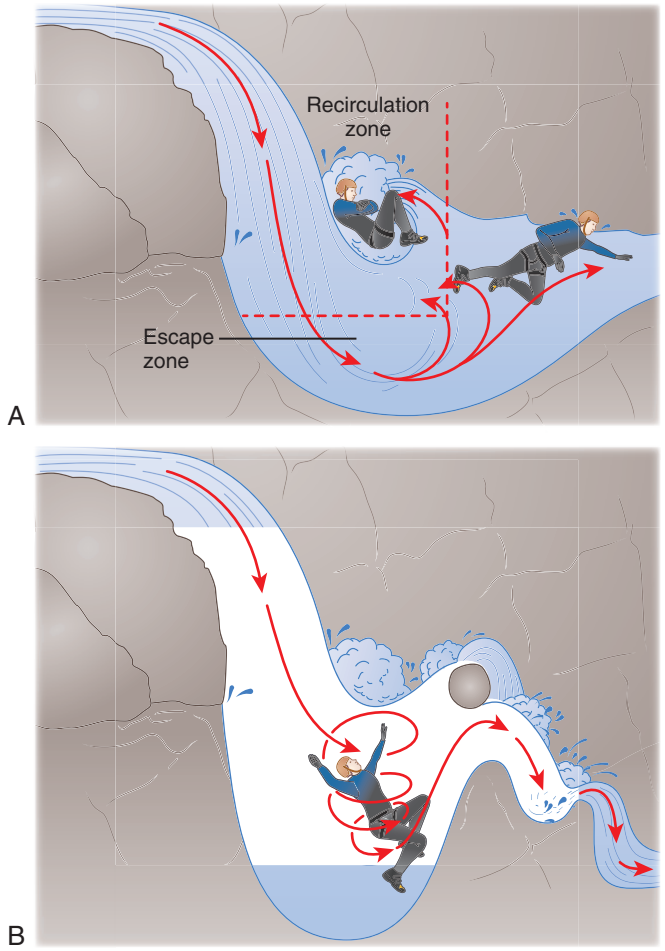

FIGURE 98-4 **A,** Hydraulic with a canyoneer escaping from the pool. **B,** Pothole with a water trap (water outflow is not equal to inflow in the pool).

Environmental risks while canyoneering include accidental hypothermia and heat-related illnesses, potentially even during the same trip. Extreme temperature differentials are possible, depending on sun, water, and wind exposure of different canyon sections. For example, outside temperature can exceed 38°C (100°F), while shaded pools in a narrow slot canyon can be as cold as 6°C (43°F). Hypothermia is a risk regardless of season and is not necessarily recognized by the victim. Immersion in water causes rapid heat loss by conduction/convection that is increased with wind, immobilization, and exhaustion.[11] Risk of immersion hypothermia is present in water colder than 25°C (77°F)[30] and is more severe in water colder than 15°C (59°F). Some technical canyons require extremely strenuous efforts, which can lead to dehydration followed by heat exhaustion, especially if there are alternating wet and dry sections. Heat stroke is an advanced stage of heat exhaustion and can be exacerbated by long exposure and exertion time.[9]

Traveling to and from remote drop-in and exit points can be challenging and risky and requires careful planning. Canyoneers may be exposed to extreme temperatures, thunderstorms, and wild flora (e.g., cacti) and fauna. Venomous snakes, scorpions, spiders, and fire ants can be encountered.[48] Tick-borne diseases may be a risk, especially if skin is exposed while a person is traveling to and from a canyon. Water can be infected by various agents of zoonosis due to deposition by wild animals. Dead animal carcasses are encountered frequently in canyons and can be a source of water contamination. Water can also become contaminated during flooding from upstream human settlements.

FIGURE 98-5 **A,** Normal canyon water flow. A canyoneer can rappel well away from the water flow. **B,** Flash flood. *(Courtesy Erwin Kob.)*

EQUIPMENT

Canyoneering is considerably more damaging to the body, clothing, and hardware than are most wilderness activities (with perhaps the exception of caving). A balance between personal safety and protection and freedom of movement is the most important consideration when choosing clothing for canyoneering. Having the right equipment[7,39,44] and knowing how to use it in progression techniques are essential for personal safety and accident prevention. Existing data show that many groups are not equipped even with minimum personal or safety equipment.[5]

Complete canyoneering equipment includes helmet, shoes specifically designed for canyoneering, wetsuit or drysuit (and personal flotation device [PFD] if necessary), harness, specialized descender, ascender, lanyard, webbing, carabiners, pulleys, slings, whistle, knife for cutting ropes, dive googles and snorkel, headlamp, survival kit (Box 98-1), packs and rope bags, drybags and kegs, canyoneering ropes, and other hardware (Figure 98-6).[7,44] A full description of canyoneering hardware can be found in technical canyoneering manuals[7,26,44] and in Chapter 56, Technical Rescue, and Chapter 108, Ropes and Knot Tying.

Climbing or mountaineering helmets with Conformité Européenne (CE) certification (preferably Union Internationale des Associations d'Alpinisme [UIAA]) should be used. Helmets for canoeing and kayaking without Comité Européen de Normalisation (CE EN) 12492 certification are not considered appropriate equipment for canyoneering.[44] Helmets should be lightweight and adjustable, with a durable shell and expanded polystyrene foam liner for flotation. A helmet adapted to allow attachment of a headlamp is considered preferable.

Shoes specifically designed for canyoneering (e.g., Bestard 0880 Canyon Guide; Five Ten Canyoneer 3) are essential and may reduce the risk of accidents and injuries (primarily falls and lower extremity injuries). In a recent French study, 80% (inexperienced) injured canyoneers were not wearing canyoneering shoes.[13] Appropriate footwear comprises a sole that provides traction on both wet and dry surfaces, good fit with proper ankle and foot support, rapid draining, and narrow profile to permit jamming and close-in edging.

Wetsuits offer whole body insulation via application of a layer of foamed neoprene directly next to the skin, thus allowing reduction in heat conduction away from the body.[38] Full-body wetsuits guarantee better freedom of movement; however, proper fit and adequate stretch are important considerations. Wetsuits that comprise two parts, when worn in conjunction with a set of waterproof overalls and a jacket, are particularly useful in canyons with both dry and wet sections. The disadvantages of wearing a wetsuit while canyoneering are manifold, namely, the additional weight (particularly when wet), volume, and limited protection against

BOX 98-1 Minimum Survival Kit for Canyoneering*

First-aid kit	Replacement batteries
Rescue foil	Hat
Garbage bag	Socks
Duct tape	Gloves
Waterproof matches or lighter	Metal cup
Candle	Food
"Cyalume"	Water disinfectant
Small headlamp	

*Materials are kept in a keg (3.6 L [7.6 pt]).

FIGURE 98-6 Standard personal equipment of a canyoneer in a wet canyon. From top to bottom: helmet with whistle, wetsuit with shears in a chest pocket, descender with multiple braking options, harness with mechanical devices and carabiner slings (also for backup), gloves for hand protection, and canyoneering shoes. *(Courtesy Erwin Kob.)*

FIGURE 98-7 SAR team members wearing drysuits and PFDs during a rescue operation with prolonged water exposure. *(Copyright KONG Italy. Courtesy Michael Kammerer: kong.it/.)*

cold air when wet. Neoprene gloves, socks, and hoods are useful additions for thermal insulation and protection.

Alternatively, drysuits insulate by preventing water from entering via tight seals around the hands, feet, and neck.[38] These are full-body suits comprised of waterproof material and usually worn with thermal undergarments. Drysuits are effective in extreme conditions and commonly used during long operations, or specifically night SAR activities (Figure 98-7). The disadvantage of wearing a drysuit is the additional expense and the fact that they do not function if punctured, protect from impacts, or provide flotation.[38,44]

A canyoneering harness (e.g., Edelrid Iguazu; Petzl Canyon) also requires additional consideration and slight adaptation compared to most climbing harnesses. There should be a reinforced attachment point, positioned high and horizontally, for enhanced canyoneering specific functionality. The vertical configuration of the belay loop on a climbing harnesses tends to twist the rappel device 90 degrees to the intended angle of use, making rope handling more awkward.[44] A removable and replaceable seat cover can protect the wetsuit and harness from abrasion.

Descenders have multiple braking options and can be placed on the rope without removing it from the harness. The Petzl Pirana is formed as a figure-eight but tends to prevent a lark's head hitch around the body. The Petzl Pirana also reduces rope twisting without decreasing the braking friction. The Sterling ATS and Kong OKA are rappel devices similar to the Petzl Pirana, but provide additional friction and can be used for rescue maneuvers. The Black Diamond ATC-XP is popular in the United States; it should be avoided in wet canyons with hydraulics and waterfalls. At least one member of a canyoneering group should bring mechanical ascenders, and every canyoneer should carry a few slings (usually made of Kevlar), to make soft cams such as Prusik, Klemheist, or Bachmann knots. Slings (and other mechanical devices for ascent and descent) are necessary when there is a knot in the rope or in emergency situations.[44] Whistles are used for communication during progression and ropeworks (Table 98-1). Whistles should be attached to the helmet or PFD. Only whistles that function if wet are suitable; avoid whistles with a cork ball. Carry knives or shears attached to the harness or in a

TABLE 98-1 SUDOT Whistle Signals for Canyoneering Communication During Ropework

Command	Whistle Signal	Meaning or Action
Stop!	One blast	Stop all movement until further instruction is provided
Up	Two blasts*	Often used to signal that the rope is too long
Down	Three blasts*	Often used to signal that the rope is too short or that a person is stuck on the rope
Off rope/ rope free	Four blasts*	Canyoneer is clear of the rope and it is available
Trouble/help!	Continuous blast	General emergency signal

Modified from ASTM F1768-97(2014): Standard guide for using whistle signals during rope rescue operations, ASTM International, 2014, West Conshohocken, Pennsylvania: astm.org.
*In Italy, commands are codified in a different way.

chest pocket. A throw bag should be carried in canyons with swiftwater (see Chapter 62, Whitewater Medicine and Rescue).[38] PFDs that provide mobility and comfort (e.g., type III PFD worn by paddlers) are suitable.[38]

PROGRESSION TECHNIQUES

Canyoneering has been referred to as the decathlon of wilderness activities. A typical progression scenario includes squeezing by or scrambling over lodged boulders, navigating deep potholes or swiftly moving streams, and rappelling down waterfalls up to 30 m (98.5 feet). Special techniques have been developed from climbing, caving and swiftwater swimming, and are important for personal safety and accident prevention. The correct use of standardized equipment and techniques ensures a balance between rapid descent and controlled progression and risk management.

Progression Without a Rope

Progression without a rope includes many techniques, namely, scrambling, climbing, sliding, jumping, swimming (also in swiftwater), and deep wading (Figure 98-8). Scrambling is common in sections with debris or rough terrain. Standard climbing techniques (often adapted or improvised) are often used to enter and exit a pothole, down-climb a chimney, or reach an emergency evacuation point. Jumps and slides are part of the attraction of canyoneering, but a pool or pothole should always be assessed first for hazards. Jumps are done in a vertical position with the arms close to the body and knees slightly bent.[44] This position prevents typical canyoneering injuries, such as shoulder dislocation, vertebral compression fracture, lower extremity injury, and head trauma. Jumps can be useful to avoid hydraulics and other dangerous situations. To pass a hydraulic when the eddy fence is too far in advance to jump over it, jump into the turbulence (whitewater) and move downstream of the hydraulic (see Figure 98-4). If passing a hydraulic, a group member should be positioned with a throw bag or be prepared to use other swiftwater techniques for companion rescue. Sliding is done in a crouched position with the back elevated from the rock, legs straight, toes up, and arms close to the body or crossed on the chest. Packs are usually thrown in advance to reduce the impact in shallow pools or potholes. Floating and wading techniques are used to move with or across the main flow of water and during rescue.[38] The position for floating is with feet downstream if there are undercut rocks, or upstream if there are strainers.

Progression With a Rope

Standard rope techniques for progression use releasable rappels. Rappel and rope techniques used by climbers and canyoneers have many similarities and differences (Figure 98-9). Rappelling in a dry canyon can be comparable to rappelling in traditional climbing. The rope is threaded through the anchor and rappelling is done on both strands with a descender and a secondary conditional self-belay (e.g., autoblock knot, Petzl Shunt) as a backup. This method should be avoided in wet canyons because there is an increased risk that the canyoneers will encounter hazards, such as drowning, hypothermia, and suspension syndrome, if they become stuck on the rope in a waterfall feature (Figure 98-10). In wet canyons, rappelling is commonly done on a single strand, without a secondary conditional self-belay as a backup. A knot block (or a blocked figure-eight descender) is placed against the rappel metal ring and secured with a carabiner.[44] The

FIGURE 98-8 Progression without a rope. **A,** Scrambling in a wet area with debris (tree). **B,** Sliding on a water toboggan with arms crossed on the chest. **C,** Jumping in a clear pool feet first (correct) with one arm too far from the body (incorrect). **D,** Swiftwater swimming in a hydraulic. *(**A-C** Courtesy Erwin Kob; **D** courtesy Oskar Piazza.)*

FIGURE 98-9 **A,** Rappelling on a double strand in a dry slot canyon (with high risk of falling debris and skin abrasion). **B,** Rappelling on a single strand in a waterfall (with the risk of being stuck and of hypothermia). *(Courtesy Gordon Larsen [A] and Erwin Kob [B].)*

first strand is used for descent and the second strand is usually brought down by the last person. This allows rope retrieval and is important in case of self-rescue or companion rescue. Ropes should be positioned in a way to reduce friction and rope damage. Ideally, the rope should be kept above the water where possible. Equally, it is important to avoid use of a final knot, as this could become trapped in hydraulics at the base of a waterfall or a slide.[44] There are several other special considerations for rappelling, such as guided rappels to avoid obstacles during the descent, or a single strand blocked on a figure-eight descender controlled by a companion to reduce rope damage (Figure 98-11). Complete details about progression techniques can be found in technical canyoneering manuals.[14,44]

Large potholes are common in many canyons and especially in sandstone slot canyons. *Keeper potholes* are large, circular potholes too deep to scramble out of and with water too deep to stand in. There are several improvised systems designed to allow escape from keeper potholes, including hooks attached to long poles to aid climbing and weighted bags that are thrown over an edge.[7]

FIGURE 98-10 **A,** Incorrect rappelling on a double strand with an autoblock knot in a wet canyon with a pack on the shoulder. **B,** Correct rappelling on a single strand blocked on the anchor and with a pack attached to an equipment loop with a carabiner-on-carabiner technique.

Ascending techniques are similar to those used in caving but are not that common in canyoneering. They are used when backtracking to exit the canyon, when releasing a stuck rope, or for self-rescue maneuvers.

CANYON CLASSIFICATION AND MAPPING

Canyons have varying levels of difficulty. However, to date, classification of canyoneering routes has been widely discussed but with little consensus. There is general acceptance that a classification system must contain several key considerations of equal importance, such as location, access routes, and required

FIGURE 98-11 Rappelling on a single strand controlled by a companion with a Petzl Pirana descender to reduce rope damage on rocks. *(Courtesy Oskar Piazza.)*

TABLE 98-2 American Canyoneering Association Classification of Canyons

Terrain and Technical Ropework	Water Volume and Current	Time and Commitment (Optional)	Risk and Seriousness (Optional)
1, Canyon hiking, no rope	A, Dry or wading up to waist, no swimming	I-II, Half day	G-PG, General audiences or parental guide suggested
2, Basic canyoneering, scrambling	B, Swimming in still water; wet disconnects; no current	III-IV, Full day	R, Risky (not recommended for beginners; solid technical skill required)
3, Intermediate canyoneering, rappelling	C, Currents and waterfalls	V-VI, Multiple days	X-XX, Extreme or double extreme (serious injuries or death if error in techniques or judgment)
4, Advanced-expert canyoneering, advanced ropework, and problem solving	—	—	—

Modified from Haro JL, Samsó L: Les cotations: Les cahiers de l'EFC [serial online] 1:20-26, 2010: fedme.es/salaprensa/upfiles/675_F_es.pdf.

technical knowledge. Additional considerations include seasonal topographical water volume and meteorological influence within the canyon environment. Canyon conditions and rated difficulty of progression can vary significantly, especially with changes in water flow. In 2005, the French Federation of Mountain Climbing, with support from the French Federation of Speleology plus other national commissions, adopted a multifactorial canyon classification. This system was based upon the degree of interest in the canyon (local [*] to international [****]), combined with the degree of technical difficulty, overall exposure risk, and progression length.[15] The degree of exposure or length of canyon route is classified on six levels (I to VI). This classification is dependent on length of time required to traverse the chosen section or sections and ease of exit strategy throughout the canyon route. Classification of the degree of difficulty of canyon progression is determined under optimal canyon conditions, i.e., during the season where the least extreme environmental factors are reported and the canyon is considered most accessible. Level of difficulty describes both technical (vertical) difficulty and water (aquatic) difficulty. Vertical ("v") and aquatic ("a") difficulty are described in seven classes. This class system ranges from very easy (1) to extremely difficult (7). Since its inception in 2005 by the French, this classification in its entirety has subsequently been adopted by most canyoneering associations in Europe.[19] A similar classification proposed by the American Canyoneering Association is currently used in both Zion National Park and the Colorado Plateau region. This classification places emphasis on two main considerations, plus two optional factors for enhanced interrogation of the canyon route. Primary considerations are related to canyon terrain and the corresponding level of technical ropework proficiency needed. Secondary considerations are focused on canyon water volume and current presence. Finally, the optional factors for consideration include progression time, commitment, and risk assessment (Table 98-2).[7,19] For example, Mystery Canyon in Zion National Park is classified as *** III v3 a1 or as 3B III, and Imlay Canyon in Zion National Park as **** IV v5 a3 or as 4B IV R (according to French and American classifications, respectively).

Reaching a canyon may require navigational skills in remote or extreme environments; it is critical to know GPS coordinates of drop-in and exit points. It is also important to record time of access, descent, and exit; number of rappels; maximum length of a rappel (and presence of a re-belay); suggested rope length; and other information specific for the route (e.g., special technical and personal equipment, possible escape points). Canyoneering maps show a longitudinal section of the canyon with waterfalls, slides, pools, and other important progression elements (Figure 98-12).

CANYON MEDICINE

EPIDEMIOLOGY OF INJURIES AND ILLNESSES

Injuries to the lower extremities are common, mainly because progression without ropes involves jumps or slides and walking or scrambling on wet surfaces. Data show that fractures (lower extremities and spine or thorax) followed by sprains (mostly to the lower extremities) and dislocations (mostly to the upper extremities) account for the majority of injuries requiring a SAR operation. In a 10-year (1999 to 2009) retrospective analysis of canyon rescues in Aragon, Spain, traumatic injuries were reported in 419 (81%) patients.[45] Isolated injuries of extremities were more common than spine or multiple injuries. The most common injury location was the lower extremity (74%) (Table 98-3).[45] Similar data were obtained from 362 patients rescued in canyons in France between 1998 and 2001; the most common injury location was the lower extremity (50%, of which 72% were fractures and 24% were sprains). Injuries to the spine, thorax, and abdomen accounted for 16%, whereas upper extremity injuries accounted for only 10% (57% dislocations, 38% fractures).[42] Similarly, in Zion National Park between 1999 and 2002, the most common injury location was the lower extremity.[48] Between 1997 and 2002 in La Reunion Island, France, a popular tropical canyoneering region, the most common injury location was also reported to be the lower extremity.[10] Regional discrepancies in injury patterns may be due to differences in environmental factors, type of rescue included in the sample (companion rescue and/or SAR operations), and changes in equipment and progression techniques over time.

Medical and environmental illnesses were reported in 49 (9%) patients in Spain (see Table 98-3)[45] and 25 (12%) patients in

TABLE 98-3 Type of Injury and Illness in Canyoneers (n=520) Rescued in Search and Rescue Operations in Aragon, Spain, from 1999 to 2009

Injury or Illness	n	Type	n (%)*
Traumatic injury	419		
		Head/face	5 (1.1)
		Spine/back	39 (9.2)
		Upper extremity	51 (12.6)
		Lower extremity	310 (74.0)
		Thorax	2 (0.4)
		Abdomen	1 (0.2)
		Pelvis	2 (0.4)
		Multiple	9 (2.1)
Medical or environmental illness	49		
		Drowning	16 (32.7)
		Heat-related illness	25 (51.0)
		Hypothermia	1 (2.0)
		Medical illness†	7 (14.3)
Uninjured	50		
Total	518‡		

Modified from Soteras I, Subirats E, Strapazzon G: Epidemiological and medical aspects of canyoning rescue operations, Injury 46(4):585-589, 2015.
*% refers to each category of injury or illness.
†Anaphylaxis (n=1), anxiety (n=1), coronary syndrome (n=2), dizziness (n=1), exhaustion (n=1), seizures (n=1).
‡Data were missing for two cases.

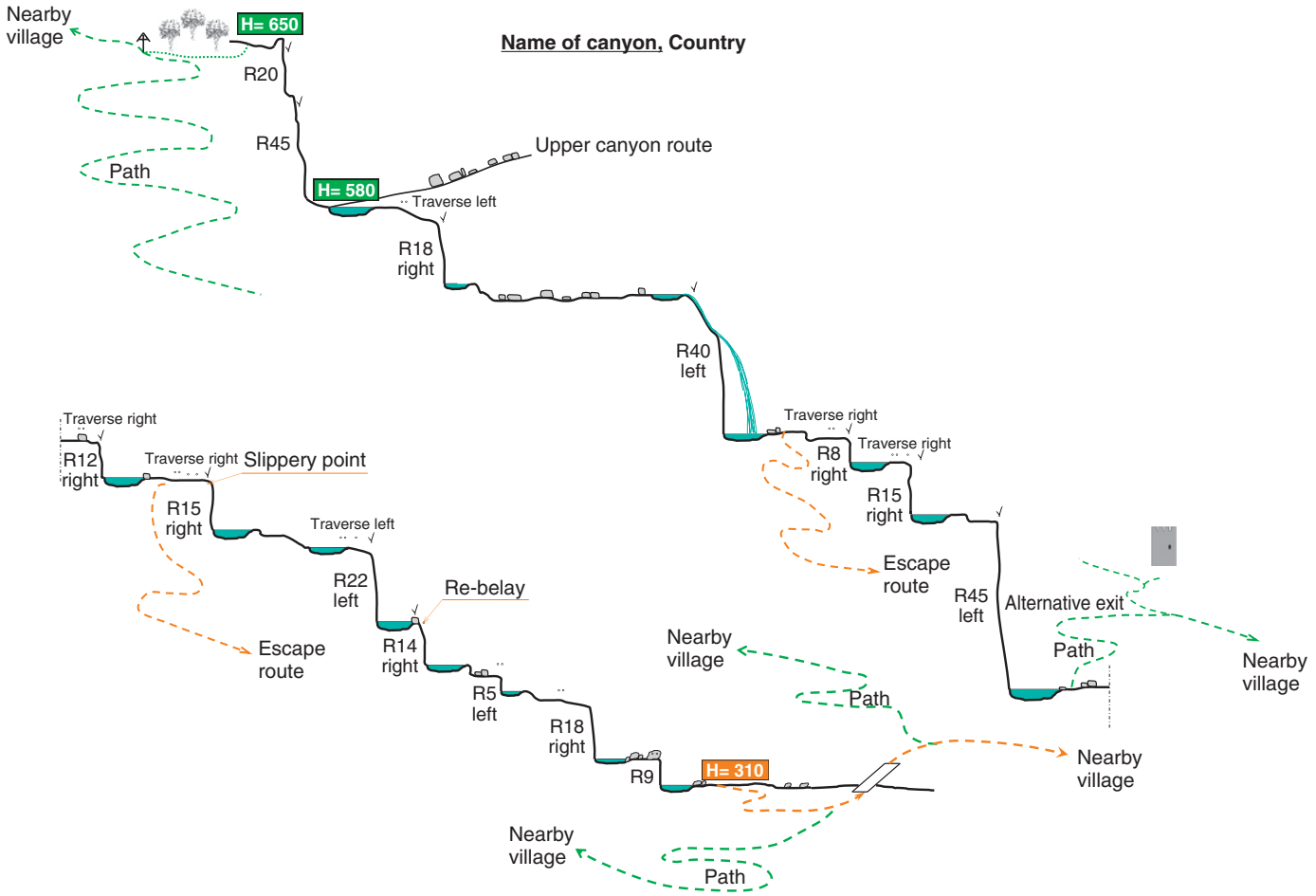

FIGURE 98-12 Longitudinal section of a canyon. H, altitude above sea level (m); R, rappel (m). *(Modified courtesy Erwin Kob.)*

France.[42] In Spain, heat-related illnesses were the most common illness (51%), followed in descending order by drowning (33%), medical illnesses (14%), and accidental hypothermia (2%).[45] Similarly, in La Reunion Island, heat-related illnesses were the most common, followed by accidental hypothermia, drowning, and medical illnesses.[10] In general, most patients rescued from canyons probably have mild to moderate accidental hypothermia or heat injury, but the incidence remains unknown because most cases are unreported. A web-based survey of American and Australian canyoneers[48] compared with European canyoneers[42,45] showed a higher frequency of environmental illnesses resulting from both warm and cold exposure. In European data, accidental hypothermia was reported in only a minority of cases, though it is probably present but not documented in many patients with traumatic injuries. The prevalence of accidental hypothermia in canyoneering patients with traumatic injuries is likely similar to that in other trauma situations (e.g., car accidents). In Germany, secondary hypothermia (defined in this study as core body temperature < 36° C [96.8° F]), occurred in nearly 50% of trauma patients and in 98% of entrapped patients rescued by a helicopter emergency medical service.[23] Other reported medical illnesses included cardiac arrest and thermal shock, anaphylaxis, panic attack, seizures, syncope, and infectious diseases.[10,18,25,31,42,45,51]

Medical and environmental illnesses are reportedly less frequent than are traumatic injuries, but are often more severe. The same web-based survey of American and Australian canyoneers found a higher frequency of severe environmental illnesses compared with traumatic injuries, reported as the average incidence of the injury or illness seen or suffered in a canyoneering career (6.5 years, with 25 days per year of canyoneering).[48] Equally, in Spain, the percentage of patients in SAR operations with a potential or actual life-threatening injury or illness (i.e., predefined as a National Advisory Committee for Aeronautics [NACA] score ≥ 4)[8] was reportedly higher for medical and environmental illnesses than for traumatic injuries (96% vs. 47%).[45] Within those patients, approximately 95% were classified as having a Glasgow Coma Scale score of 15.[45] Nevertheless, the patient's clinical status may worsen with prolonged exposure and a long alert or delayed evacuation. Potential or actual life-threatening injuries (NACA: 4 to 6), were found in 28 (5%) patients.[45] Correspondingly in France, a similar survey revealed that head trauma and multiple injuries were more severe in the majority of the reported cases.[42]

Fatalities occurred in 3% to 5% of canyon rescue operations.[10,42,45] Drowning and traumatic injuries were considered the primary causes of fatalities in France, Spain, and tropical regions.[10,42,45] In Spain, 19 (4%) patients were pronounced dead at the scene (NACA: 7): 9 patients from traumatic injuries, 8 from drowning, and 2 with cardiac arrest due to coronary syndrome. The causes of death were similar in France and tropical regions.[10,42] In comparison, the cause of death is not commonly reported in the United States, but unpublished data from Zion National Park demonstrate similar trends in reported fatalities.

MECHANISM OF INJURIES AND ILLNESSES

Errors in progression techniques or negligence cause most injuries and illnesses in canyoneering (Figure 98-13). In France, for example, 70% of SAR operations reportedly involved an incident directly caused by errors in progression techniques, whereas the remaining 30% where considered a result of negligence alone.[42] In correspondence, research related to the incidence of accidents in canyon environment in Italy indicated that the majority of requests for SAR assistance are due to inexperience.[17] Data from a 5-year survey in Sierra de Guara, Spain, showed that only 69% of canyoneering groups had at least one technically proficient canyoneer.[5] The most common mechanisms that cause canyoneering incidents are jumps, falls and slips, and rappelling. In France, jumps reportedly caused 35% of incidents, followed by falls and slips (32%) and rappelling (13%).[42] Incident reports

FIGURE 98-13 **A,** Navigation and technical skills are essential. **B,** Canyoneer can avoid getting stuck or losing control of the rope when crossing the water flow while rappelling. *(Courtesy Erwin Kob.)*

from La Reunion Island demonstrate similar determinant mechanisms of injury.[10]

Falls, Jumps, and Other Traumatic Mechanisms

Jumps, and falls or slips caused moderate to severe traumatic injuries in 13% and 25% of cases, respectively.[42] Table 98-4 shows some of the most common errors in progression technique, and the associated mechanism of injury and possible injury. For example, calcaneal, tibial plateau, acetabular, and vertebral compression fractures are possible after incorrectly estimating the depth of a pool prior to a jump. Knowledge of the mechanism of injury is helpful for on-site diagnosis and decision making during a rescue.

Abrasions, blisters, and lacerations are common minor injuries caused by impacts during sliding and jumping and not wearing appropriate clothing, such as gloves, long-sleeved clothing, shoes, and neoprene socks. Abrasions due to flora and cacti have also been reported in approximately one in three canyoneers per year of activity.[48] Other common traumatic injuries include damage to the outer ear due to helmet-related mechanical strain incurred while jumping; bruised testicles from water impact after high jumps (especially with poor jumping technique); and several minor orthopedic problems from errors in ropework. Burns on the fingers and palms may occur in canyoneers who grab ropes after losing control on rappels without a secondary conditional self-belay (e.g., autoblock knot) as a backup.

Barotrauma in canyoneering is a consequence of quick pressure changes during jumps. Without equalization of pressure, it can occur at depths of approximately 1 m (3.3 feet), which is possible with a jump from approximately 6 m (19.7 feet). Damage is caused by pressure differences between air- or gas-filled spaces in the body and incompressible structures. Barotrauma is covered in detail in Chapter 71, Diving Medicine. Pain can develop in the ear during ascent because of pressure from expanding gas that is not released through the eustachian tube. It can result in clinical symptoms, including vertigo and tinnitus. The sinuses are the second most common site of barotrauma.

Environmental Exposure

Heat loss in water is 25 times greater than in air, and heat loss by conduction increases as thermal gradients increase in cold water. Several experimental studies have found significantly faster cooling rates for healthy human volunteers wearing wetsuits or drysuits in rough or turbulent water compared with calm water (see Chapter 8, Immersion into Cold Water).[47] Decreased heat production due to exhaustion or immobilization increases cooling, even in healthy canyoneers. Decreased heat production from immobilization and/or impaired thermoregulation from injuries (e.g., central nervous system trauma) should be suspected in all injured canyoneers. The hazards of cold water are independent of the season or ambient air temperature.

Drowning primarily occurs when a person is trapped underwater, but can also occur after a person jumps into a cold pool. Mistakes while swimming or rappelling are common causes. Prolonged exposure to cold water affects neuromuscular activity.

TABLE 98-4 Canyoneering-Specific Mechanisms Associated with Particular Traumatic Injuries

Errors in Progression Technique	Mechanism of Injury	Possible Injury
Jump in a pool or pothole without checking the depth or for debris	Landing flat on the feet from a height	Calcaneus, tibial plateau, acetabulum, vertebral compression fractures
Jump in a pool or pothole	Fall on the outstretched arm	Posterior dislocation of the shoulder
Fall on a wet surface	Fall, landing on the outstretched arm or with the elbow beneath the body	Fracture of the radial head
Fall on a wet surface	Fall on the outstretched arm	Posterior dislocation of the shoulder
Fall on a wet surface	Forced dorsiflexion of the wrist	Fracture of the scaphoid, lunate dislocation, perilunar dislocation, Colles fracture
Slip on a wet surface	Ankle inversion force	Fracture of any of the three malleoli, fracture of the base of the fifth metatarsal
Slip on a wet surface	Rotatory ankle force	Fracture of any of the three malleoli, disruption of the anterior tibiofibular ligament with proximal fibular fracture (Maisonneuve injury)
Slip on a wet surface	Inversion or medial or lateral stress to the forefoot; axial load on the metatarsal heads with the ankle plantarflexed	Midfoot dislocation (Lisfranc injury)

Modified from Menkes JS: Initial evaluation and management of orthopedic injuries. In Tintinalli JE, editor: Tintinalli's emergency medicine, 7th ed, New York, 2011, McGraw Hill, pp 1783-1796.

There is initially decreased sensation in the hands and fingers and decreased coordination of gross and fine motor control, followed by loss of muscular power. In France, 25% of reported fatalities were due to incorrect execution of rappelling technique, which left canyoneers trapped in the flow of a waterfall (e.g., incorrect positioning of the pack can cause rotation backward under the water) (see Figure 98-10).[42] When an unconscious patient is found in a waterfall, drowning should be differentiated from severe hypothermia and/or suspension syndrome.

Staying longer than planned in a canyon can increase the risk of being caught in a flash flood. Flash floods on the Colorado Plateau have been concomitant with several drowning fatalities and associated trauma incidents.[3] Similarly, flash floods were responsible for 50% of fatal accidents in France between 2004 and 2008.[35]

Immersion in pools and potholes, especially with low or no water flow and in summer months, poses a risk of zoonosis. Outbreaks of leptospirosis have been reported after canyoneering in tropical and subtropical regions.[25] Giardiasis and other zoonoses can occur. Water exposure can worsen an infection or cause infections of the eyes and other mucous membranes. A case of anterior uveitis was reported in a patient after canyoneering in the French West Indies.[31] Heavy rainfall and flooding may increase human exposure to contaminants and waterborne pathogens.

A recreational hand dermatitis called *canyoning hand* may result from repeated water immersion with subsequent periods of drying and contact with abrasive rock.[12] Prolonged skin wetting causes destruction of the stratum corneum and cutaneous erosions. Skin lesions are found only on the fingertips and palms, and include erythema, punctate erosions, and edema on the fingertips and thenar and hypothenar eminences (Figure 98-14). This condition can be prevented by wearing gloves. Otitis externa (swimmer's ear) is a common but poorly documented skin injury related to water exposure. This can usually be resolved by limiting further exposure to water and/or treatment with topical antibiotic solutions (see Chapter 76, Aquatic Skin Disorders).

There are no reported cases in canyoneering of severe nonfreezing cold-induced injuries, such as trench (immersion) foot.[33]

FIGURE 98-14 Canyoning hand, showing erythema and erosions on the fingertips and thenar and hypothenar eminences. *(From Descamps V, Puechal X: "Canyoning hand": a new recreational hand dermatitis.* Contact Dermatitis *47:363-364, 2002.)*

However, severe nerve damage associated with nonfreezing cold-induced damage in other settings has been seen after prolonged exposure.[54] The combination of cold and wet over prolonged periods could lead to similar skin damage in canyoneering; the lower the water temperature, the faster a nonfreezing cold-induced injury could occur. This can be prevented by wearing specific canyoneering shoes, waiting in a dry place if stranded, and staying active to promote blood flow to the feet.

Heat-related illnesses due to heat injuries, dehydration, and strenuous physical effort are possible and may be exacerbated by drysuits and wetsuits. A case of exertional rhabdomyolysis complicated by mild acute renal failure has been reported from a canyoneering environment. Associated clinical signs and symptoms included progressive weakness in the extremities, myalgia, cramps, and gross pigmenturia.[49] Neoprene allergic dermatitis due to chemical additives used in rubber processing has been described in divers and therefore may be anticipated in canyoneers.

MEDICAL MANAGEMENT

Recommendations and protocols for patient assessment and emergency care in canyons are based on standard principles of wilderness trauma care. Safety evaluation and risk assessment are equally important to companion rescuers and SAR teams, both to prevent accidents and carry out rescue operations. Basic management steps are to (1) control the situation and assess the possible risk for SAR team members and/or companions; (2) obtain an overview of the patient situation; (3) move the patient to a safe and stable place; (4) perform a primary survey; (5) resuscitate the patient if necessary; (6) perform a secondary survey; (7) make a definite plan; and (8) package the patient for evacuation.[2,6,41] These steps may have to be adapted or improvised depending on the environment and situation. Care should be appropriate and sustainable throughout a rescue. Medical monitoring is critical. The U.S. Department of the Interior, National Park Service, underlines that "Medical personnel should be educated […] to the realities of patient care limitations in the technical environment."[39] Table 98-5 shows proposed medical interventions according to rescue technique and environment.[39] The most common on-site medical interventions in all Spanish SAR operations over a 10-year period are shown in Table 98-6.[45] Splinting or immobilization and analgesia were the most common on-site medical interventions (71% and 34% of rescued canyoneers, respectively). Reduction of dislocations was done in 7% of patients. Vascular access was obtained in 6% of patients and followed by fluid administration in most cases. Chest tube insertion was never performed. Oxygen was administered in 4% of patients, but no advanced airway control was executed despite the presence of a physician in all cases. Cardiopulmonary resuscitation was performed on four patients, but vasoactive drugs and defibrillators were not used. Medical interventions were reportedly similar in La Reunion Island.[10] Specifications for canyon rescue are described in detail within the following paragraphs to promote a comprehensive understanding of treatment limitations within this difficult environment.

Risk Assessment and Safety

During canyon rescue, risk assessment primarily refers to risks imposed by water (Figure 98-15).[57] If a canyoneer becomes stuck and falls unconscious while rappelling down a waterfall, there is immediately a high risk of drowning and the priority is a pickoff (not resuscitation). In this scenario, if the risk is unacceptable for rescuers, the patient should be lowered using a second rope with a "cut and lower" procedure. Similarly, if an unconscious canyoneer becomes trapped in a hydraulic, the personal safety of the rescuer entering the water is the priority, followed by quick recovery of the patient and subsequent effective treatment. If the patient did not fall from a height, the reported incidence of spine injury in drowning is low (0.009%).[56] However, when removing the patient from the water, immobilization of the patient remains critical, where rescue is not impeded. On removal from the water, and if possible, the patient should be transferred to a safe and stable place and insulated fully from cold and water

TABLE 98-5 Medical Interventions According to Rescue Technique and Environment That Can Be Found in Search and Rescue Operations in Canyons

Intervention	Low-Angle Maneuvers*	High-Angle Maneuvers†	Helicopter Short-Haul or Hoist‡	Water or Swiftwater Rescue
BLS airway	R	T	R	T
BLS vital signs	R	N	N	N
Splinting or bandaging	R	T	R	T
Tourniquet	R	R	R	R
Spinal immobilization	R	N	R	R
Medication IN, IM, or PO	T	T	T	T
Medication IV or IO	T	N	N	N
Chest decompression	T	T	T	T
ALS airway	T	T	T	T

Modified from Thompson J: Medical considerations. In Phillips K, editor: Technical rescue handbook, 11th ed, U.S. Department of the Interior, National Park Service, 2014, pp 230-243.
ALS, advanced life support; BLS, basic life support; IM, intramuscular; IN, intranasal; IO, intraosseous; IV, intravenous; N, not practical in this setting; PO, oral; R, recommended skill; T, training strongly recommended.
*Rough terrain or debris with an angle less than 20 degrees.
†Terrain with an angle greater than 20 degrees to vertical.
‡Technical maneuvers with no complex ground rescue.

(Figure 98-16). Under these conditions, hypothermia can result within a short period, even within a neoprene suit.[57]

Drowning Management

Drowning incidents in canyons can be different than in other bodies of water (see Chapter 69, Drowning and Submersion Injuries). Victims are usually found floating or entrapped in hydraulics or in a waterfall, and high-impact injuries are more common. Once the patient is out of the water, immediate ventilatory support and early chest compressions result in a better prognosis and outcome in patients in cardiac or ventilatory arrest.[55] It is advisable to be in a dry place when defibrillating and to first dry the chest.[55] Advanced treatment by the SAR team can be further complicated if oxygen and/or continuous positive airway pressure are not available. Vomiting is a common complication for rescue breathing or chest compressions[29] and therefore continuous clinical monitoring is required. Rapid cooling due to immersion in cold water may offer a protective benefit and prolong the time after which resuscitation can still be successful. This is particularly qualifiable in cases where the patient cooled before becoming hypoxic (caused by closure of the glottis or after inhalation of water into the lungs).[55]

Patient Assessment

Debris and steep or rough terrain can make physical examination difficult. In this scenario, the patient should be placed in a horizontal position by being positioned perpendicular to the slope. The patient should be insulated from the ground. It is possible to layer ropes, canyoneering packs, aluminum foil, and garbage bags to make a comfortable and insulated surface (and improvised spinal immobilization). The medical examination may be more difficult if the patient is wearing a wetsuit, but the first assessment should be as complete as possible. A vertical incision in the wetsuit provides access for examination (or intervention)

TABLE 98-6 On-Site Medical Interventions in Canyoneers (n=520) Rescued in Search and Rescue Operations in Aragon, Spain, from 1999 to 2009

Intervention	n	%
Oxygen administration	19	3.7
Airway management	0	0.0
Intravenous lines	31	6.0
Analgesics*	175	33.7
Intravenous fluid administration	27	5.2
Vasoactive drugs†	0	0.0
Basic life support	4	1.5
Reduction of dislocations	35	6.7
Splinting or immobilization	370	71.2
Hypothermia prevention	10	1.9
Antibiotics	0	0.0

Modified from Soteras I, Subirats E, Strapazzon G: Epidemiological and medical aspects of canyoning rescue operations, Injury 46(4):585-589, 2015.
*Morphine or analogs (n=81), nonsteroidal antiinflammatory drugs (n = 74), pyrazole derivatives (n = 41), tramadol (n = 19), ketamine (n=4).
†Epinephrine, ephedrine, atropine.

FIGURE 98-15 Risk assessment and safety in rescue operations includes knowing where you are going, how to get there, and what understanding safety is. **A,** Safety in rappelling. **B,** Safety in swiftwater. *(Courtesy Oskar Piazza.)*

FIGURE 98-16 Principles of patient assessment. **A,** Removal from the water (and immobilization in trauma) is the first priority. **B,** Find a safe and stable place. Keep the patient insulated from the ground. *(Courtesy Inigo Soteras.)*

and can be closed afterward with bandages or duct tape. This limits the degree of exposure of the patient. Pulses and other vital signs should be sought for at least 60 seconds when hypothermia is suspected.[11] On-site differentiation of drowning, severe hypothermia,[11] and/or cardiac arrest related to suspension syndrome (if the patient was rescued from a rappel)[34] can be difficult.

Hypothermia Prevention

All patients should be assessed for accidental hypothermia, because measures to prevent development or exacerbation of hypothermia are critical to patient prognosis and should be taken immediately. Removing the patient from the water is the first priority. Subsequently, wind chill can cause further cooling of the patient by evaporation of moisture. Early application of adequate insulation on-site is crucial to limit heat loss. Removal of wet clothing is generally suggested, but can be difficult in the canyon environment. A study demonstrated that mean skin temperature in healthy persons wearing wet clothing increased with addition of a vapor barrier under an ordinary ambulance blanket at an ambient temperature of 5°C (41°F; wind speed of 3 m/s [7 mph]),[52] conditions that are similar to those in the bottom of a canyon. A vapor barrier can be easily fashioned from a garbage bag (Figure 98-17), which when combined with a dry insulating layer is more effective than bubble wrap or other rescue foils (see Figure 98-17). This method is effective even when the patient is still wearing wet clothing.[24,52] Cold exposure can be reduced by moving the patient into a tent and insulating him from the ground. In the interim, a neoprene hood or cap can be used to minimize heat loss from the head. However, if the patient is in cardiac arrest, a hood or heating the head is not appropriate. High-calorie food and warm, sweet fluids should be given to a conscious patient. A 10-point scale has recently been developed to evaluate thermal discomfort in conscious patients.[28]

Pain Management

Analgesia administration should be a priority when moving the victim to a safe and stable environment after a water rescue or pickoff from a waterfall. A nasal Mucosal Atomizer Device (MAD) may be useful to administer analgesia (e.g., ketamine) and other

FIGURE 98-17 Hypothermia prevention is a priority. **A,** Insulation with a garbage bag. **B,** Insulation with bubble wrap. *(Courtesy Inigo Soteras.)*

FIGURE 98-18 Administration of analgesia with a MAD device. **A,** Materials required. **B,** Administration. *(Courtesy Inigo Soteras.)*

drugs rapidly. The technique can be used in a patient in any position, but may be less effective if the nasal passage is obstructed. To use this device, a syringe (3 mL) is filled and the MAD is attached to the tip of the syringe; the syringe is pretested before insertion into one nostril and depressed with sufficient force to atomize the medication (Figure 98-18).[43] Up to 1 mL per nostril per dose is suggested (the dose should be repeated in the other nostril if giving more than a single dose). One possible side effect is choking. It is important to first check for nasal obstruction and adjust dosage if the patient is hypothermic. Moreover, it is important to be informed about specific drug doses when using an "alternative" pain management route. Regional nerve blocks are a valuable option for analgesia, but require special expertise due to environmental and logistical factors (e.g., limited monitoring options and long evacuation times).[16]

Alternative Routes for Fluid Administration

It can be difficult to obtain vascular access on-site in a hypothermic and/or hypovolemic patient. Intraosseous access may be used as an alternative route for drug and fluid administration. Intraosseous access can be placed manually or via a driver and needle set (EZ-IO). Common sites include the proximal tibia, distal anterior femur, and proximal humerus; fractured bones or contaminated sites should not be used.[43] The manual equipment includes a 16- or 18-gauge intraosseous needle, 5-mL syringe, 60-mL syringe, and intravascular fluid. Appropriate insertion sites include (1) the proximal tibia 2 cm below and medial to the tibial tuberosity (with a rope or a pack under the knee); (2) the distal anterior femur 3 cm above the patella on the anterior midline above the knee; or (3) the humerus slightly anterior to the lateral midline of the arm at the greater tubercle (with the patient supine and the arm adducted, elbow bent, and hand on the umbilicus). After cleaning the skin, the needle is angled respective to the site as follows: (1) perpendicular to the humerus; (2) slightly superior on the anterior femur; or (3) slightly inferior on the tibia. For manual insertion, the needle (stabilized in the palm with the index finger on the skin) is inserted with a twisting motion until there is a decrease in resistance and a crunching sound (the distance is usually > 1 cm). Thereafter, the stylet should be removed. Proper placement is confirmed by one of the following: the catheter stands at a 90-degree angle to the skin and is firmly seated; blood is seen at the hub of the catheter; or fluid flows freely with no evidence of extravasation.[43] Once placed, the needle needs to be secured and checked. Flushing with lidocaine 2% (0.5 mg/kg) over 1 minute should be considered prior to fluid infusion and medication administration. Systemic analgesia, such as fentanyl, is a good drug for intraosseous infusion. In the field, a practical method is to give fluids and drugs as boluses using the 60-mL syringe before moving the patient. During patient transport, the intraosseous site should be checked for fluid extravasation every 30 minutes, as well as before and after every drug administration. An intraosseous needle should be replaced with an intravenous line as soon as possible. Intraosseous infusions prolonged beyond 24 hours are associated with increased risk of osteomyelitis.

Hemorrhage and Wound Care

Management of severe bleeding does not differ from that undertaken in other wilderness settings (see Chapter 21, Wound Management). There is always increased risk of infection in an aquatic environment. Preventing infection is fundamental, even with minor scratches and abrasions. Wound irrigation is crucial for optimizing wound healing, as long as there is sufficient pressure and volume. Use irrigation volumes of approximately 100 mL/cm of wound length, using sterile or potable water, except if the bleeding is profuse. Antibiotic prophylaxis should be administered for severe wounds if the expected time from injury to definitive care is greater than 2 hours.[43] Interestingly, despite this recommendation, this practice seems to be uncommon in established practice; for example, antibiotic prophylaxis was never administered in a 10-year period of SAR operations in Spain.[45] Before evacuating the patient, if there is risk of water contact, where possible all dressings and bandages should be covered with plastic wrap (Figure 98-19). The patient should be reassessed for comfort, distal circulation, sensation, and motor function in affected extremities.

Splinting and Reduction

Reduction and splinting maneuvers on-site may be appropriate when evacuation is difficult (Figure 98-20). Reduction is indicated for any suspected fracture or dislocation with a decreased distal pulse, or a deformity affecting the ability to adequately splint and/or transport (in particular for a long transport).[43] The dynamics of the accident should be evaluated in each case to assess the risk of associated fractures. However, on-site reduction, especially of shoulder dislocation, is usually safe and should be done immediately. Medical personnel should use the technique with which they are most familiar, but should also be up to date and proficient in alternative procedures used in difficult situations or terrain. As with wound care, the splinted area can be covered in plastic wrap to create a waterproof seal (Figure 98-21). Duct tape can also be used on the dressings for additional protection, taking care not to place it circumferentially. Once the splint is applied the patient should be reassessed regularly for comfort, distal circulation, sensation, and motor function in affected extremities.

Patient Packaging

It is important to package the patient before evacuation. This includes stabilization, immobilization, and preparation for transport (Figure 98-22). To guarantee correct packaging: (1) place the stretcher horizontally and close to the patient; (2) open the waterproof bag and straps; (3) place the patient in the stretcher; (4) close all straps gently (starting from the thorax and moving

FIGURE 98-19 Improvised wound care dressings. **A,** Plastic wrap can be used as an outer layer. **B,** Waterproof wrapping is essential during water transport. *(Courtesy Inigo Soteras.)*

toward the feet) and adapting to injuries; (5) rotate the stretcher vertically and recheck that the straps are secure; (6) close the waterproof bag and external straps; and (7) confirm that the float valve is working.[44] Packaging is considered correct if it prevents further injuries and ensures patient comfort during evacuation.

MEDICAL EQUIPMENT

First-Aid Materials for Canyoneers

Every canyoneering group should have at least one first-aid kit and be prepared and trained to use it. A web-based survey of American and Australian canyoneers found that nearly 90% of respondents carried a first-aid kit, mostly containing wound care materials and analgesics.[48] Space is limited in canyoneering packs, but it is advisable to also include SAM Splints, duct tape, aluminum foil, and garbage bags; these simple additional materials are adequate for most minor injuries and hypothermia prevention. A first-aid kit should be kept in a keg with the survival kit (Figure 98-23).

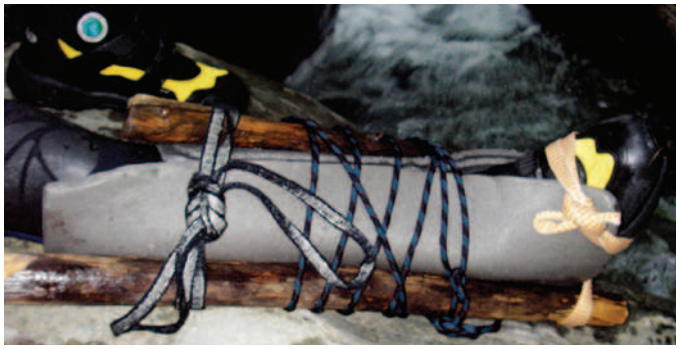

FIGURE 98-20 Improvised splint of an ankle injury with slings, sleeping mat and wood. *(Courtesy Erwin Kob.)*

Medical Equipment for Search and Rescue Teams

There are some general recommendations for technical medical kits for canyon rescue, although the exact contents may differ based on personal or institutional preferences. The International Commission for Mountain Emergency Medicine (ICAR Medcom) suggests that equipment be stored and transported in floatable canyoneering packs. Specialized containers (drybags or kegs) can be used to ensure that all materials are kept dry; in addition, sterile equipment should be stored in sealed individual plastic bags that are checked and changed regularly.[27] Water damage is the main risk for medical equipment and materials. Backup packaging with sealed individual plastic bags is important to minimize this risk. Medical-kit bags are generally divided by application: airway management and ventilation, circulation with hemorrhage control, analgesia and medication, and splinting and immobilization (ikar-cisa.org/ikar-cisa/documents/2011/ikar20111027000798.pdf).[27] The airway management and ventilation bag should specifically contain a handheld suction device to clear airways, extension tubing with an interposed bacterial filter for ventilation maneuvers, nasogastric tube to empty the stomach in case of drowning, and other standard materials and backup devices. A cost-effective solution to extend oxygen use and minimize weight is the Oxymizer oxygen conserver with a B(M6) aluminum oxygen cylinder, or the Trek S portable aerosol system.[39] Intraosseous infusion systems should be included in the bag. The medication bag should contain antibiotics in case of wound contamination by water or long rescue times. Benzodiazepines and antiemetics should also be routinely carried, because they are the second most commonly used drug in canyon rescue (after analgesics).[45] SAM Splints are a valuable addition to the bag for splinting and immobilization; they are lightweight, reusable, and versatile, and can be formed into an improvised cervical spine collar. Neoprene splint kits usually contain 5 aluminum-bar–coated neoprene splints, which are malleable and allow quick immobilization; however, weight and volume can limit their use in ground rescue operations. Elastic bandages are preferred to adhesive tape because they work when wet. The Kendrick Extrication Device is a valuable immobilization device that can be used for spine immobilization during pickoff from a waterfall, or moving the victim to a safe and stable environment. A special harness that encloses both the patient and the Kendrick Extrication Device is used for hoist evacuations.[37]

Electronic devices should be avoided, although a portable pulse oximeter and heart rate monitor may be useful. Materials to prevent hypothermia are important. A thermometer for core temperature measurement is essential to accurately assess severity of hypothermia.[50] A drybag containing a monitor and automated external defibrillator should be available when managing critically injured patients.

Organization of Equipment Packs

SAR team members involved in the first response should have one pack for medical assessment and treatment and two packs for rope and swiftwater progression (Figure 98-24).[44] The medical pack should be organized according to the modality of assessment and treatment. Equipment for trauma care, hypothermia prevention, nutrition, and splinting and immobilization should be carried.[40]

The technical rescue medical kit should also be modular, and is carried by medical personnel of the SAR team. The National Park Service adopted a similar organization of medical equipment in which bags with basic and advanced materials are brought to the site depending on the level of care needed. The usefulness of routinely carrying advanced airway management equipment

FIGURE 98-21 Splinting of an ankle injury in canyon rescue. **A,** Bandage wrap can be used to secure the splint. **B,** Plastic wrap can be used to cover the splint. **C,** Duct tape (not placed circumferentially) gives additional protection. **D,** Waterproof wrapping improves flotation. *(Courtesy Inigo Soteras.)*

FIGURE 98-22 Patient packaging. **A,** Kong 911 Canyon stretcher placed horizontally. **B,** Open waterproof bag with straps inside. **C,** Dummy placed inside and fixed with straps. **D,** Waterproof bag and external straps closed. *(Copyright KONG Italy. Courtesy Michael Kammerer: kong.it/.)*

FIGURE 98-23 Canyoneering survival kit items should be kept in kegs, and equipment should be stored in sealed plastic bags. *(Courtesy Giacomo Strapazzon.)*

has been debated. It may be reasonable to have it available when there is an advanced life support provider.

Canyon Stretcher

Canyon stretchers should have the following features: (1) buoyancy; (2) ability to keep the patient dry; (3) ability to protect the victim from impact or collision; (4) suitability for sliding transport; and (5) suitability for rope transport. Some models use a removable float on a standard mountain-rescue stretcher to make a floatable stretcher that maintains the head of the supine patient above the water.[44] These models are not ideal in swiftwater or waterfalls because they do not guarantee sufficient protection for the patient. Other models are based on inflatable systems; the advantage being that they can be used in larger rivers with big pools, with the disadvantage being the risk of puncture and lack of rigid head protection.[38] A model developed with the Italian National Technical School for Canyoneering Rescue (CNSAS-SNaFor) can be positioned at an angle to adapt to the terrain, is buoyant, and has a built-in waterproof bag to keep the victim dry. The Kong 911 Canyon stretcher is designed to fully enclose the patient and has a float valve for water-based transportation (see Figure 98-22). This model has an aluminum-and-fiberglass shell to protect the victim from impact or collision, and has a transparent shield made of polycarbonate to protect the head.[44] Although the watertight seal is designed to allow relatively easy access to the patient, it can induce claustrophobia and prevent continuous communication. Medical personnel and stretcher attendants should continuously monitor the patient through the transparent shield and maintain radio communication. When using this model it is particularly important to open the bag and reevaluate the patient periodically, ideally every 10 minutes or less.[44] Internal webbing on stretchers helps secure the patient quickly and enables low- and high-angle operations. There are special accessories for stretchers for hoist evacuations. Similar to cave stretchers, many models can be disassembled into two pieces for easier transportation.[44]

EVACUATION

Evacuation Planning

Reaching the exit point of a canyon with an injured or ill patient can be a challenge. In Spain, 63% of SAR operations required technical proficiency over terrain with some grade of difficulty, mainly for incidents in a site with moderate to extremely difficult access. Six percent of SAR operations were done by ground rescue without air-based rescue, either due to adverse weather conditions (e.g., low clouds, rain, strong wind) or during night operations.[45] Data from France and La Reunion Island are similar.[10,42] Risk assessment is important in planning an evacuation strategy. The weather forecast should be continuously monitored during the rescue. It is preferable to transport without a stretcher if possible and plan a dry evacuation with alternative transport, unless the rescue time is largely reduced with water transport (Figure 98-25). Artificial high directionals or hoists are techniques to evacuate an injured patient from a cliff wall. Technical details on canyon evacuations are covered in Chapter 56, Technical Rescue. If an advanced life support intervention is necessary for the patient's survival, risks versus benefits of the intervention are evaluated by the medical and technical leaders of the operation. It is usually preferable to avoid a night rescue (when the patient is not critically injured), if the operation can be suspended and resumed in the morning. When the canyon is located in a remote area, an external health post can provide valuable logistical and emergency support to emergency medical services teams.

Medical Considerations in Evacuation

The patient must be placed correctly in the stretcher before evacuation and transport (Figure 98-26). It is important to take measures (e.g., pillows and medications for prevention of decubitus lesions) to prevent complications associated with prolonged transport. Fluid and medications are given as boluses before transport. During evacuation, monitoring for possible complications or deterioration of clinical status is critical and should be done using all available means. Do not rely only on electronic devices. Medical personnel are not always within monitoring distance (e.g., when transporting the patient over a highline or

FIGURE 98-24 Organization of the first-response equipment according to standards of the Italian CNSAS canyon rescue team. **A,** *Left to right:* two packs for rope and swiftwater progression and one pack for medical assessment and treatment. **B,** Contents of a medical pack. *(Courtesy Giacomo Strapazzon.)*

FIGURE 98-25 Transportation of a canyon stretcher in a waterfall by a SAR team member. *(Courtesy Erwin Kob.)*

in a waterfall) (see Figure 98-25). Continuing measures to prevent hypothermia are important, as is documenting information on the rescue and medical interventions.

Technical Materials for Evacuation by Search and Rescue Teams

Complete rescue equipment in Italy includes specific packs for rescue rigging (one pack for highline installation, one pack for drilling, and two packs for rope and swiftwater progression) and for evacuation with a stretcher (one pack for stretcher management, two packs with ropes for stretcher progression, and two packs for rope progression of the rescue team).[44]

FIGURE 98-26 Assessment for correct placement of a patient in the stretcher before transport. Stretcher attendants should take care that the patient is not hit by carabiners and slings during the operations. *(Courtesy Oskar Piazza.)*

FIGURE 98-27 Communication of rescue orders during a SAR operation using a whistle. *(Courtesy Oskar Piazza.)*

Communication Equipment During Evacuation

Communication equipment is essential in canyoneering rescue. Standard whistle signals (Figure 98-27; see Table 98-1) and swiftwater hand signals are also used in canyoneering.[38] A SAR team member will commonly be posted in the canyon as a "radio relay" with one or more handheld radios. Waterproof field radios allow communication between different SAR team members in the canyon and between air and ground support teams. Radios should have at least an international protection level against liquid ingress (retain function after immersion for 30 minutes at a depth of 1 m).[44]

RESCUE

Companion Rescue

Companion rescue refers to management of an incident by fellow group members. Companion rescue can be lifesaving; wilderness basic life support and first-aid training should be included in canyoneering courses. Companion rescue is quite common, occurring in up to 50% of cases in a web-based survey of American and Australian canyoneers.[48] Incident management by companions is not well documented, although management of minor injuries, such as minor cutaneous and orthopedic injuries, seems to be common (Figure 98-28).

FIGURE 98-28 Companion rescue of a team member with an improvised splint. *(Courtesy Erwin Kob.)*

ICAR Medcom published recommendations on minimal requirements for medical training for professional guides (ikar-cisa.org/ikar-cisa/documents/2011/ikar20111027000798.pdf).[57] These recommendations should be considered basic principles for any group leader, even those without professional certification. Canyoneering guides must be technically competent and have specific knowledge of water and helicopter rescue in canyons. Guides must also be familiar with the local SAR organization and proficient in delivering expected standards of patient care in the wilderness. In brief, emergency extrication of a person stuck on a rope is possible with a few additional carabiners and slings, and emergency rescue from swiftwater is possible with a throw bag if canyoneers have proper technical knowledge.

Companion rescue has particular importance in drowning incidents. The chance of successful resuscitation decreases with time; thus, prompt care by companions is crucial. Immediate ventilatory support and early chest compressions result in better prognosis and outcome in patients in cardiac or ventilatory arrest, but should be started when the patient is out of the water.

Search and Rescue Operations

Demographics of Search and Rescue Operations. Canyoneering incidents accounted for 2% of SAR operations in U.S. National Parks in 2005 (mountaineering also accounted for 2%). However, this proportionately small percentage of rescues belies the fact that the number of responses to canyoneering incidents doubled between 2003 to 2004 and 2005 to 2006.[20] Canyoneering incidents account for an even higher percentage of SAR operations in popular canyoneering regions (Figure 98-29). For example, it is one of the most common reasons for SAR operations in Utah's National Parks (up to 50% in Zion National Park and 27% in Glen Canyon National Recreation Area between 2001 and 2005).[21] In Italy and Spain, there was a concurrent reported increase in canyon rescue operations and higher percentage of SAR operations in popular canyoneering regions.[17,45]

SAR operations show seasonal peaks that reflect trends in recreation. In Zion National Park and surrounding regions, most incidents occur between May and November, with the highest peaks at the end of summer and beginning of autumn. At higher latitudes, most operations occur in July and August (canyoneering incidents accounting for 50% of cases in Spain; approximately 67% of cases in France).[42,45] In La Reunion Island, rescues are most common when canyoneering conditions are best and during the most popular vacation period.[10] Tourists and locals are equally involved in these incidents; for example, on La Reunion Island, one-third of all SAR operations involved tourists, one-third involved locals, and one-third were unknown.[10] In Spain, the demographics of rescued canyoneers reflect the entire population of canyoneers in that region; there is not a particular demographic category that has a higher frequency of incidents.[5,45] However, 23 (5%) patients were under the age of 16 years. Data from France were similar.[42]

Comparatively, most emergency calls involve nonguided groups as opposed to guided groups (nonguided groups accounted for ~ 80% of calls in France and on La Reunion Island).[10,42] Alerts made by nonguided groups involved both a higher percentage of major injuries and illnesses and a person or group trapped in difficult terrain with limited evacuation options.[42]

Duration of Search and Rescue Operations. A typical scenario in Zion National Park is an incident occurring in the early afternoon. Cellular phone service is limited, and the narrow slot canyons also limit reception for satellite phones. A group member or another group often has to complete the canyon route and hike out to inform the park rangers. A first SAR team of rangers is sent to the incident site to assess the situation. At this time, darkness is usually approaching, and unless the patient is critically injured, rangers spend the night with the patient in location awaiting daylight and a full rescue team to complete evacuation. If the victim is critically ill or injured, the rescue and evacuation operation continues through the night, despite the potential risk to the SAR team.

Data from European SAR groups demonstrate similar rescue procedures and concurrent rescue durations. In France, mean rescue duration from the incident to admission to an acute care facility (or evacuation of uninjured patients) was 170 minutes (range, 35 to 1140 minutes).[42] Long SAR operations were either due to delay in response time or prolonged rescue effort at the scene of the incident. The mean time to the emergency call was 83 minutes (range, 1 to 980 minutes). Similar to the scenario described in Zion National Park, in many cases delays incurred during response to an incident and subsequent rescue efforts were due to problems with electronic communication, lack of group proficiency, and long exit routes. Understanding the challenges of the canyon environment, alternative escape routes, and contact strategies with the local SAR organization can speed up rescue operations. The time from the incident to the emergency call for nonguided canyoneers was nearly double that for professionally guided groups.[42] The mean scene time was 104 minutes (range, 10 to 725 minutes) and approximately 86 minutes with the

FIGURE 98-29 Transport of a stretcher by a SAR team. A, High-angle terrain in a wet canyon. B, Highline in a dry canyon. *(Courtesy Oskar Piazza [A] and Gordon Larsen [B].)*

exclusion of extreme values. In Spain, the median time from emergency call to admission to an acute care facility (or evacuation for uninjured patients) was 90 minutes (range, 10 to 860 minutes).[45] Almost 50% of SAR operations in Spain involved ground rescue with or without air rescue support.[45] Helicopter-supported rescue can reduce this time. Successful hoist operations during canyon rescues have been reported.[36] Helicopters that are equipped with a hoist or a short-haul can transport the SAR team with all necessary rescue and medical equipment directly to the site or to the nearest possible access site.[53] In France and on La Reunion Island, air rescue was also common (alone or in combination with ground rescue), but up to 20% of SAR operations involved only ground rescue.[10,42] Despite the observation that most of the injuries in canyoneering are of mild to moderate severity, duration of the potential rescue scenario probably justifies on-site presence of an emergency medical technician, paramedic, or physician.

Financial Costs of Canyon Rescue. Financial costs of canyon rescue are high. The Zion National Park Service was among the U.S. National Park Service units with the highest total and average SAR operation costs in 2005.[20] Many U.S. National Parks have introduced permits for technical canyoneering trips to reduce the number of incidents. Although Zion National Park does not charge for SAR operations, ambulance transfer and hospital care are expensive. Personal health insurance is strongly recommended for canyoneers.

Education of Search and Rescue Teams for Canyon Rescue. In the United States, SAR operations in slot canyons usually involve the National Park Service. Occasionally local agency rescue teams, usually county-based teams, are called to support a rescue. There are no specific canyoneering courses or guidelines used in the United States or by the National Park Service, but rescue teams working in regions with canyons have become familiar with canyon rescue. In France in the 1990s, the mountain rescue organization implemented specific training and rescue protocols for SAR teams involved in canyon rescue operations. In 2005, the Italian mountain rescue founded the CNSAS SNaFor with certified national instructors and specific training for rescuers as standard.

SAR team members (and companions) should be able to perform patient assessment and treatment at the basic level of an emergency medical technician. The ICAR Medcom developed specific recommendations for use of medical equipment.[27] The National Park Service developed emergency medical protocols for SAR teams in the United States.[39,43] Rescue personnel are trained in basic emergency medical technician care, and many National Park rangers complete a rigorous emergency medical services course similar to that completed by paramedics.

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CHAPTER 99

Cycles, Snowmobiles, and Other Wilderness Conveyances

TODD W. THOMSEN

MOUNTAIN BIKES

The sport of mountain bicycling began in the 1970s when cyclists looking for new challenges began riding 1950s-era bikes (complete with balloon tires and coaster brakes) down the rocky trails of Mt Tamalpais in Marin County, California. Recognizing the need for better equipment, Joe Breeze is credited with building the first mountain bike with 26-inch knobby tires in 1977.[31] The popularity of mountain biking has grown quickly.[15] Mountain bikes accounted for 25% of all bicycle sales over the past decade. Today, sanctioned races are held in a variety of disciplines, ages, and skill levels.[38,75,97,131] Mountain biking became an Olympic sport in 1996 and achieved full Olympic status in 2000.[99,121] Approximately 40 million Americans participate in the sport annually.[74,119]

Most enthusiasts ride recreationally for fun and exercise. Mountain biking has distinct categories. *Cross-country cycling* involves traversing varied terrain, including uphill sections, and requires a great deal of aerobic fitness (Figure 99-1). Cross-country races may last several hours.[76] Participants often perform at 90% of maximum heart rate during the entire race.[75] *Downhill riding* involves high-speed descents on trails with varied terrain (Figure 99-2). Jumps and other acrobatic stunts are common and increase risk of injury.[21,35] Downhill races may last only minutes, but speeds of up to 70 miles per hour (mph) can be achieved by experts.[38] *Freeriding* focuses on tricks and jumps of downhill riding (Figure 99-3).[38] Mountain biking parks use ski lifts to carry riders up mountains. They have numerous terrain features used for jumps.[141] *Four-cross* and *dual-slalom races* are head-to-head racing events on downhill courses (Figure 99-4).[38,121] *Endurance races* last more than 6 hours. *Stage races* are long-distance events over the course of several days.[15,110]

EQUIPMENT

Mountain bike frames can range from heavy, inexpensive steel models to lightweight and expensive carbon fiber frames. Frames made of aluminum and titanium can be crafted to suit particular types of riding (e.g., cross-country and downhill).

Many mountain bikes have a front suspension fork that reduces trail vibrations and improves steering and control. Some bikes also feature rear suspensions. This increases riding efficiency and decreases trail vibrations to the rider (Figure 99-5).[58,122,149] Riders of full-suspension bicycles may experience fewer injuries.[14,121] Fat bikes have large (> 4 inches in width) low-pressure tires that allow riding in "soft" conditions (e.g., on sand or snow) (Figure 99-6).

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FIGURE 99-1 Cross-country mountain bike racer. Cross-country riding involves cycling over varied terrain, and often includes extended uphill sections.

Mountain bikes often are equipped with powerful disk brakes that allow braking in wet conditions and may reduce the incidence of rider injury.[121] Clipless pedal systems allow the foot to lock onto a pedal until a twisting motion of the foot releases the cleat. Clipless pedal systems increase pedaling efficiency. Failure to disengage the foot during a fall may lead to rider injury.[128]

PROTECTIVE GEAR

The majority of mountain bikers wear helmets.[14,35,38] Bicycling helmets made of expanded polystyrene foam are most commonly used.[25] Downhill and freeride cyclists frequently use full-face helmets to provide additional protection.[14] Other protective gear includes neck braces, padded thoracic jackets, padded cycling shorts, and pads for shoulders, elbows, knees, and shins (Figure 99-7).[21] Cycling gloves decrease injuries.[14] Mouth guards are rarely used, but may provide protection against dental trauma.[15] Use of protective gear should be guided by the type of riding pursued. At a minimum, a helmet, gloves, and protective eyewear should be worn.

FIGURE 99-2 Downhill mountain bike racer. Downhill riding consists of cycling down steep hills at high speeds. Natural and man-made trail features and obstacles are commonly encountered. *(Courtesy Dr. Steven J. Wolf.)*

FIGURE 99-3 Freeriding is similar to downhill biking. Jumps and acrobatic stunts performed at high speeds are the focus of this discipline. *(Courtesy Dr. Steven J. Wolf.)*

MECHANISM OF INJURY

Falling Over the Handlebars

Falling over the handlebars (colloquially referred to as an *endo*) is the most common mechanism of injury in mountain biking (Figure 99-8).[35,94] This occurs when the front tire makes impact with an immobile object or when the front brake locks the front wheel and the rider continues to rotate around the pivot point of the front axle. Over-the-handlebar incidents are typically more severe than sideways falls and associated with distinct injuries that include head, neck, facial, and dental trauma.[15,38,45,95,121] If the abdomen strikes the handlebars, injury to the liver, spleen, and diaphragm may occur.[15] Fractures and dislocations of the shoulder, elbow, forearm, and wrist are common.[21,35,84,121]

Falling Sideways

The other common mountain bike injury is falling to the side (Figure 99-9). Bicycles are inherently less stable at lower speeds, which can lead to sideways falls when riding uphill over technical terrain. High-speed cornering or jumping over obstacles during descent can also lead to sideways falls. These falls tend to injure the lower extremities, although upper extremity injuries may occur if the fall is on an outstretched hand.[21,38,45]

FIGURE 99-4 Four-cross racing involves head-to-head racing on downhill courses. High-speed crashes and collisions with other riders are ever-present possibilities.

FIGURE 99-5 Modern mountain bicycles are highly specialized pieces of equipment. This bike has front and rear suspensions, disk brakes, and clipless pedals. Such features are common on today's bikes. *(Courtesy Dr. Steven J. Wolf.)*

Pedal-Related Injuries

On bikes with clipless pedal systems, if the rider fails to disengage the foot from the pedal during a fall, lower extremity injuries (e.g., soft tissue injury, femur and acetabular fractures) may result.[128] Riders using traditional flat pedals (i.e., platform pedals) are also at risk for pedal-related injury. If the foot slips, the pedal may forcefully hit the shin, causing a laceration or avulsion injury.

EPIDEMIOLOGY OF MOUNTAIN BIKING INJURIES

Injury Rates

Reliable estimates of injury rates experienced by mountain bicyclists are limited. Such injuries are likely to be underreported.[15]

In the United States, approximately 15,000 patients are treated annually for injuries related to mountain biking.[121] Common injuries are fractures, soft tissue injuries, and lacerations. Five percent of patients are hospitalized. Overall, accidents declined by 56% between 1995 and 2007. No fatalities were reported. In one study, trauma center admissions for mountain biking injuries increased threefold from 1992 to 2002.[89]

FIGURE 99-6 Fat bikes are increasingly popular versions of mountain bikes. Fat bikes have massive low-pressure tires that allow for riding in unconventional cycling environments, such as through snow and sand. *(Courtesy Anthony DeLorenzo.)*

FIGURE 99-7 Protective gear. This downhill racer is wearing a full complement of protective gear. Note the full-face helmet, goggles, neck brace, arm and leg pads, and gloves. Using such equipment decreases risk of injury. *(Courtesy Dr. Steven J. Wolf.)*

Some studies define the rate of injuries from mountain biking in terms of injuries-per-hour-of-biking or injuries-per-biking-exposure. Recreational riders experience 1.54 injuries per 1000 biker-exposures (one biker-exposure equals one person riding a mountain bike on 1 day).[14] If one injury occurs per 1000 hours of mountain biking, that equals a risk of injury of 0.6% per year.[65] Similar results are described in a pediatric population.[15]

Mountain biking may present a higher risk of injury than other common outdoor activities. In a review of a college outdoor program, mountain biking resulted in 7.5 injuries per 1000 participant days, a higher rate than for mountain climbing, backpacking, kayaking, hiking, cross-country skiing, and snowshoeing.[64]

Age and Gender

Most mountain bikers are young men, 20 to 39 years old), and they suffer most of the injuries.[18,35,38,45,84,89,121]. Female riders may be injured at higher rates than men.[121] In a study of a large off-road race, 0.77% of women sustained injuries, versus 0.44% of men.[96] Women were 1.94 times more likely to be injured, and 4.17 times more likely to sustain a fracture.

Older patients may be at higher risk for more severe injuries than their younger counterparts. Patients more than 40 years old are more likely to suffer dislocations or to be hospitalized.[121] Patients between the ages of 14 and 19 years sustained more traumatic brain injuries (TBIs) than did all other age groups combined; this may be secondary to decreased helmet use by these riders.

Types of Injuries

Most mountain biking injuries are minor. The appendicular skeleton is more likely to be injured than is the axial spine. Hospitalization rates of injured mountain bikers are poorly documented; in one series, the rate was 16%.[14]

Minor injuries (e.g., abrasions, contusions, and lacerations) are the most commonly reported conditions and account for more than 50% of injuries. They are usually of little clinical consequence.[21,94] Fractures of the upper extremities occur in 10% to

FIGURE 99-8 Over-the-handlebars mechanism of injury. **A,** Over-the-handlebar crashes occur when the front tire comes to an abrupt stop, usually after striking an immobile object or locking up the front brake. The momentum of the bike continues forward and rotates around the front axle. There is potential for substantial head, cervical spine, thoracoabdominal, and upper extremity injury. **B,** This cyclist also crashed over the handlebars. Note how the use of protective gear (full-face helmet, torso protector, and arm and leg pads) shields the biker from injury. (***A** courtesy Anthony Lorenzo; **B** courtesy Dr. Steven J. Wolf.)*

20% of U.S. emergency department cases.[45,84] Lower extremity fractures occur less frequently.[21]

In a review of mountain biking injuries requiring trauma center admission in Vancouver, orthopedic injuries (46%) accounted for the majority of cases, followed by head and spine (12% each), chest (10%), abdominal (5%), and genitourinary injuries (2%).[89] Sixty-six percent of these admitted patients required operative intervention. Only one fatality was reported during this 10-year period.

Injury Rates for Different Types of Riding

Although studies of mountain biking injury rates have focused mainly on racing environments, the vast majority of injuries occur in recreational riders.[84]

Downhill mountain biking is more dangerous than cross-country riding. In two studies, downhill rates of injury were 16.8 and 43.4 injuries per 1000 hours of exposure, a rate significantly higher than the rate for cross-country riding, at 3.7 and 12 injuries per 1000 hours of exposure.[38,21] Downhill riding rates of injury decrease as rider experience increases; more injuries are sustained during competition than during practice.[21]

Cross-country racing may be more dangerous than endurance or stage racing. Lareau found that 7.2% of cross-country riders were injured during a race versus 4.7% of endurance race riders.[97] Cross-country races last about 2 hours; endurance races last longer than 6 hours. These differences may be due to the greater intensity of cross-country racing or the greater experience of endurance riders. Most injuries in the endurance and stage racers were minor (e.g., abrasions, contusions, strains, and blisters).[110]

Mountain biking has been reported to be more dangerous than road cycling. Palmer reported that mountain bikers suffered 14.4 accidents per 100,000 km cycled; city cyclists suffered 1.7 accidents per 100,000 km. Touring cyclists suffered 11.5 injuries per 100,000 km.[127] Mountain bikers are more likely to sustain fractures, dislocations, and concussions than are their road-riding counterparts.[131] Although the mechanism of injury often differed between road and mountain cyclists (e.g., being struck by another vehicle versus falling during a jump), similar types of injuries were encountered (e.g., head injury, facial trauma, and extremity injury).[140]

Causes of Mountain Biking Injuries

Rider error (e.g., poor judgment, excessive speed, and overestimation of ability) is the most common cause of injury.[21,65,94] Factors external to the rider (e.g., irregular terrain surfaces, bad trail conditions, unforeseen obstacles, and equipment failure) also are frequently blamed for crashes leading to injury.[21,94]

ACUTE MOUNTAIN BIKING INJURIES

Craniofacial, Brain, and Cervical Spine Injuries

Craniofacial injuries often occur in over-the-handlebar crashes (see Figure 99-8A). Mountain bikers are more likely to sustain facial injuries (e.g., facial bone fractures, dentoalveolar injuries, and facial soft tissue injuries) than are road cyclists.[38] One survey found that 30% of riders had suffered or knew a rider who had sustained either a dental fracture or an avulsion.[117] Most of the respondents were not aware that avulsed teeth could be reimplanted. Education about self-reimplantation in the field and routine use of mouth guards was suggested.

Rare facial injuries include a degloving injury of the oral mucosa in a cyclist who crashed during performance of an aerial stunt.[138] In one report, a foreign body perforated the tympanic membrane during a fall, resulting in trans-tympanic facial nerve injury and facial palsy.[116] Wearing a full-face helmet would likely prevent many of these injuries, especially when descending at high speed (Figure 99-10).

FIGURE 99-9 Fall-off-the-side mechanism of injury. Riders falling off the side of the bike are at risk for lower extremity injuries. Falls on outstretched hands, as depicted above, can lead to scaphoid fracture, distal radius fracture, and posterior elbow dislocation. *(Courtesy Dr. Steven J. Wolf.)*

FIGURE 99-10 This mountain biker sustained facial contusions, a mild concussion, and a shoulder contusion after falling over the handlebars of her bike. The accident was caused by overzealous application of the front brake during descent. She was wearing a helmet and escaped serious injury. *(Courtesy Cynthia Froning.)*

Brain injuries (e.g., concussions and other TBIs) occur at a much lower frequency than does extremity trauma.[15,45,84,121] Intracranial hemorrhage is even more rare.[15,121] Use of full-face helmets (as compared with traditional cycling helmets) is not associated with decreased incidence of TBI.[14]

One series describes patients with symptoms consistent with benign positional paroxysmal vertigo occurring several hours after a mountain bike race.[168] Frequent vibratory impacts, repeated acceleration and deceleration, and increased gravitational forces experienced during jumping and landing were theorized to cause displacement of otoconia, leading to benign paroxysmal positional vertigo–like symptoms. All riders recovered without sequelae.

Cervical spine injuries are relatively rare. Vertebral fractures, dislocations, and spinal cord trauma (with resulting paraplegia) have been described.[15,38,84] In a review of mountain bike–related axial spine injuries evaluated at a regional spine referral center, 95% percent of patients were male. The mean age was 32.7 years.[56] Forty percent sustained spinal cord injuries; two patients remained dependent on a ventilator at the time of discharge.

Thoracoabdominal Injuries

Rib fractures are the most commonly reported thoracic injury in mountain bikers.[14] More severe chest trauma is rare; however, reports exist of these injuries, such as hemopneumothorax requiring tube thoracostomy.[84] Ortega reported a series of 11/11 cyclists with elevated cardiac troponin (cTnI) levels after a 95-km race.[125] None experienced cardiovascular symptoms. The clinical significance of this finding is unclear. Piniewska-Juraszek reported the case of a 41-year-old male cyclist who suffered ventricular fibrillation cardiac arrest during a 32-km mountain bike race.[134] The patient was successfully defibrillated in the field and ultimately diagnosed with acute anterior wall myocardial infarction due to left anterior coronary artery occlusion.

Abdominal injury is much more common than thoracic injury in mountain bikers. A common mechanism of injury is blunt force trauma from the handlebars.[15,38] The abdominal wall should be examined for a *handlebar bruise* as a sign of intraabdominal injury[57] (Figure 99-11). Solid-organ injuries (e.g., liver and spleen laceration or hematoma) are the most commonly encountered intraabdominal injuries.[15,38,120] Hollow viscus injuries (e.g., small bowel hematoma and jejunal rupture) occur less frequently.[38,148] Rare intraabdominal injuries include diaphragmatic rupture, pancreatic transection, and small bowel evisceration.[38,102,105]

Infectious gastroenteritis outbreaks after mountain bike races have been reported.[69,86,160] In these outbreaks, the race course passed through muddy fields and *Campylobacter jejuni* was identified as the source. Mud contaminated with animal feces (the source of *C. jejuni*) likely splashed onto the riders' faces or was transmitted from dirty water bottles. Rider education, provision of clean water, and attention to food hygiene at aid stations are recommended.

Genitourinary Injuries

Blunt abdominal trauma may cause renal contusion and fracture.[14,84] Traumatic arterial priapism has been reported, usually from a direct blow to the perineum by the bicycle's top tube.[53,66,77] Selective arterial embolization was required to achieve detumescence. A case of spontaneous intracavernosal hematoma in a long-distance mountain cyclist has been reported.[177] Chronic genitourinary maladies in cyclists are more common and are discussed later in this chapter.

Appendicular Skeleton Injuries

Upper Extremity Injuries. Extremity fractures are much more common than are axial injuries.[14] Upper extremity fractures occur when one falls onto an outstretched hand or uses the arm to protect the face during a fall.[15,38] Clavicle fractures are extremely common, and often incurred with a fall over the handlebars.[84] Distal radius fractures, scaphoid fractures, and elbow dislocations result from falling onto an outstretched hand[38,84] (Figure 99-12). Radial head fractures, metacarpal and phalangeal fractures, and dislocations are common.[35,136] Soft tissue injuries are also extremely common[15,35] (Figure 99-13).

Lower Extremity Injuries. Lower extremity fractures occur less frequently than do upper extremity fractures. Femur and acetabular fractures have occurred in riders falling sideways with feet still engaged in clipless pedals.[154] Tibia and femur fractures have been documented.[15,38,84] Callaghan reported a rider who sustained a Lisfranc fracture-dislocation after failing to disengage from a clipless pedal. This is reminiscent of the original 19th century description of Lisfranc injury in a soldier who fell from his horse with his boot still caught in the stirrup.[36] Soft tissue injuries of the leg are extremely common. The shin is particularly susceptible to soft tissue injury secondary to blunt trauma by rocks, undergrowth, and bicycle pedals.[15,38] Shin and knee protectors decrease incidence and magnitude of these injuries.

FIGURE 99-11 Handlebar bruise. Patients who go over the handlebars should be examined for a handlebar bruise. This finding indicates substantial impact between the anterior abdominal wall and the handlebars, and raises suspicion for liver or splenic injury. Hollow viscus injuries are less common.

FIGURE 99-12 Distal radius and scaphoid fractures. This patient fell off his bike onto an outstretched hand. Distal radius fracture *(long arrow)* and scaphoid fracture *(short arrow)* are common injuries in this type of accident.

Electrolyte Disorders

Exercise-associated hyponatremia (EAH) is commonly seen in endurance athletes; up to 22% of marathon runners may be afflicted. Mountain bikers competing in long-distance events may be similarly at risk.[88] EAH (i.e., water intoxication) results from fluid consumption in excess of losses during prolonged exercise, and can occur up to 24 hours after the event.[44] EAH risk factors include slow pace, duration of exercise greater than 4 hours, low-body mass, preexercise hydration, use of nonsteroidal antiinflammatory drugs (NSAIDs), and extremely hot or cold environments.[44] Symptoms are nonspecific (e.g., nausea, vomiting, confusion, and headache); more severe cases present with seizures, pulmonary and cerebral edema, and death.[44] Mountain cyclists competing in endurance events often carry one or two 24-oz water bottles, and may also use a backpack hydration system that can carry up to 100 oz. Aid stations offer water or other fluids. Remaining hydrated during exercise is a great concern, but avoiding overhydration is equally important.[91] Because EAH is not chronic hyponatremia, rapid correction with hypertonic saline is considered to be safe and does not risk central pontine demyelination.[88]

Despite the apparent risk of endurance mountain cyclists developing EAH, multiple reviews in the literature have failed to document its occurrence.[44,90,91,142] The reason for the low incidence in endurance cyclists versus other endurance athletes is unclear.

EAH is prevented by avoiding overconsumption of hypotonic fluids. A recommended starting point for hydration is consumption of 0.4 to 0.8 L of fluid per hour; electrolyte-containing sports drinks are likely preferable to water.[147] In the studies above, drinking to the dictates of thirst was a successful strategy.

FIGURE 99-13 Soft tissue injuries, such as this abrasion, are among the most common maladies encountered in mountain biking.

Severe and Fatal Injuries

Severe and fatal mountain biking injuries are rare. Intracranial hemorrhage, cervical spine injuries, hemopneumothorax, blunt abdominal trauma, and fatalities have been reported in small numbers.[15,84] In a 12-year review of U.S. emergency department visits for mountain biking injuries, no fatal injuries were identified.[121] Aitken reported no fatal injuries in a review of Scottish mountain biking injuries.[14] Media reports exist of individual fatal mountain biking accidents.[37,164,173]

CHRONIC MOUNTAIN BIKING INJURIES (OVERUSE SYNDROMES)

Mountain cyclists are at risk for chronic injuries (i.e., overuse syndromes) caused by body positions sustained over extended periods while riding over rough terrain surfaces (e.g., roots, rocks, and ledges). Overuse syndromes may afflict up to 90% of competitive racers and 46% of recreational riders who cycle on a regular basis. The cervical and lumbar spine, buttocks, knees, and hands are commonly involved.[99]

Mountain bicycles for cross-country or endurance riding often have the saddle at a high position (to allow extension of the leg during pedaling) and the handlebars at the level of the saddle. Riders flex at the waist over the front of the bicycle and extend the neck (see Figure 99-1). Cervical strain and spasm frequently result.[15] Lower back strain is also common because prolonged lumbar spine flexion leads to spinal extensor muscle spasm and lumbar disk stress.[99]

Patellofemoral pain syndrome (PFP) is a common cycling-related overuse injury. Symptoms include anterior knee aching pain behind the patella, exacerbated by knee flexion and extension.[47] Risk factors for PFP syndrome include patellar misalignment (e.g., patella alta or valgus deformity of the knee).[15] PFP is theorized to be caused by microtrauma and inflammation, as well as cartilage stress.[47] Poor cycling biomechanics (e.g., inexperienced or fatigued riders) impart additional stress to the patellofemoral joint, as does riding in a gear that is too high (i.e., requires increased muscular effort). PFP syndrome may be prevented by appropriate conditioning exercises to prevent fatigue during riding and adjusting the bicycle to properly fit the rider. Consultation with a professional bike fitter may be beneficial for riders suffering from PFP.

Iliotibial band (ITB) syndrome is another common overuse injury.[15] Symptoms include lateral knee pain exacerbated by repetitive motions (e.g., cycling). ITB syndrome may be due to friction of the ITB against the lateral femoral condyle, compression of soft tissues under the ITB, and chronic inflammation of the ITB bursa.[159] Causes may include inadequate stretching, poorly fitted bicycles, and riding in too high a gear. As with PFP, prevention strategies include conditioning exercises and proper bike fitting.[15]

Hands are frequently afflicted by overuse syndromes. Both medial and ulnar nerve palsies are more common in mountain bikers than in road cyclists.[129] Ulnar neuropathy results from ulnar nerve compression within the canal of Guyon. Median

neuropathy results from median nerve compression within the carpal tunnel. Both motor and sensory symptoms can result, with pain and numbness in the fingers being most common.[15] The risk can be decreased with proper bike fitting, frequent changes of hand positions during riding, use of cycling gloves, and not gripping the handlebars too tightly.[129] For more severe cases, rest, splinting, and NSAIDs may be helpful.[85] *Hypothenar hammer syndrome* (i.e., ulnar artery occlusion) results from repetitive compression of the superficial branch of the ulnar artery as it crosses the hypothenar muscles.[10,15,38] Symptoms include hand and finger numbness, tingling, cold insensitivity, discoloration of fingertips, and hypothenar pain.[10] Prevention is similar to that discussed to avoid ulnar nerve compression.

Common maladies due to bicycle seats include chafing, perineal folliculitis and furuncles, and urethritis.[15] Erectile dysfunction was described in 4.2% of mountain cyclists after a 320-km race.[54] Perineal numbness and paresthesias are common, and likely due to compressive neuropathy.[38,53] Genital ultrasonography of mountain bikers has revealed numerous abnormalities, many of uncertain clinical significance. Findings of scrotoliths, spermatoceles, epididymal calcifications, hydroceles, varicoceles, and torsion of the appendix testis have been described.[15,62,113] Battaglia reported five cases of clitoral microcalcifications; none experienced sexual dysfunction.[19] In a review of professional cyclists, hemorrhoids, anal fissures, perianal abscesses, and higher sphincter pressures and sphincter hypertrophy (which could lead to defecation disorders) were documented.[146] Prevention of chronic perineal conditions may prove difficult. If a rider is experiencing perineal complaints, alternative saddles should be tried. Regular use of padded bicycle shorts is recommended. Products to reduce chafing (e.g., Body Glide antichafe balm, chamois cream, or diaper rash products such as Desitin) can help prevent and treat local irritation and saddle sores.

INJURY PREVENTION

Risk-taking activity (e.g., riding beyond ability) often leads to injury.[15,84] Mountain biking injuries might be decreased by educational programs, especially at high-risk locations (e.g., downhill mountain bike parks).[15,21] Instruction on bike handling, braking, basic bike maintenance, proper protective gear, and trail selection should be included. Riders who self-report fast riding are at higher risk for severe injury. Efforts to encourage riding at controlled speeds might reduce injuries.[141] Attention to trail design and maintenance, including removal of unsafe obstacles and modification of trails to limit the opportunity to achieve full speed, may provide additional benefit. In commonly used public lands, separation of hiking and bicycling trails can lessen the chance of injury to both hikers and bikers.[21]

Individuals can reduce risks by maintaining equipment; improperly adjusted equipment or fatigued components can lead to injury.[15] Improper bike adjustment may lead to overuse syndromes. Proper protective gear is required during mountain biking. Helmets, gloves, and protective eyewear should be worn. For downhill riders and freeriders, full-face helmets, arm and leg protection, and neck and thorax protectors should be considered. Riders experiencing symptoms of overuse syndromes should be evaluated by a professional bike fitter.

Rider fatigue is a common contributing factor to mountain bike crashes. Fatigue compromises performance, leads to loss of control, and increases susceptibility to injury.[15] Structured aerobic and anaerobic fitness training is beneficial to help the rider sustain a high workload.[158] Increased core muscle strength (i.e., trunk and abdomen) can reduce lower back overuse syndromes. Hip extensor and abductor strengthening programs can help prevent chronic knee injuries.[99] Adequate hydration and nutrition can reduce rider fatigue.[147] Adequate caloric and carbohydrate intake (1 to 1.2 g/min) optimizes performance.[83] Carbohydrate loading in the days prior to an endurance event increases muscle glycogen stores, reduces fatigue, and improves performance.[106] Protein intake while cycling is thought to prevent body mass loss, enhance thermoregulatory capacity, and improve competitive exercise performance.[23,40] Sports drinks, energy bars, and energy tablets are helpful to maintain proper fluid and caloric intake during riding. Adequate hydration and nutrition regimens are important because decreased fatigue during riding can prevent accidents.[137]

BOX 99-1 Key Steps in Planning Medical Coverage for a Mountain Biking Event

- Select a medical director. The medical director will be in charge of all planning activities, as well as medical activities during the race.
- Review the course. Identify areas where injuries are more likely to occur.
- Map out shelters, evacuation routes, landing zones for helicopters, and trailhead access for ambulances and other rescue vehicles.
- Plan for anticipated weather conditions at the time of the race (such as extreme heat or cold).
- Consider pre-event medical screening for participants.
- Plan for the number of caregivers required at the event. Consider not only the total number of participants and anticipated injury rates but also the geographic aspects of the course.
- Formulate protocols for evacuation.
- Plan for and acquire necessary medical equipment.
- Obtain communications equipment, and formulate communication protocols with local agencies and rescue personnel.
- Provide medical staff with easily identifiable uniforms (e.g., T-shirts, jackets).
- Establish a plan to keep accurate records of all medical encounters during the event.

Data from Burdick TE: Wilderness event medicine: planning for mass gatherings in remote areas, *Travel Med Infect Dis* 3(4):249-258, 2005.

MEDICAL COVERAGE AT MOUNTAIN BIKING EVENTS

Medical support at organized wilderness endurance events is covered in Chapter 114; the key point is an organized plan, formulated well in advance of the event. Box 99-1 reviews steps in formulating this plan. The race event plan itself deserves great attention. Mountain bike injuries are 10 times more likely to occur on downhill sections. Aid stations should be strategically located near these areas.[34] Stage races, which cover long distances over remote areas, often leave rescuers with limited access to injured athletes.[110] Ensuring that sufficient medical personnel are available to reach injured parties in a reasonable amount of time, as well as *a priori* coordination with local rescue agencies, is of paramount importance. Protocols should be developed detailing who can be treated on site and who requires evacuation to a hospital.[110] Large events in remote locations can potentially strain local emergency medical services, rescue, and hospital resources; prior coordination with these agencies is necessary.[39] The number of health care workers required for an event is a function of the number of participants, anticipated injury rates, and layout of the course.[34] Events covering large distances require more caregivers. Equipment at aid stations should reflect the anticipated injuries and illnesses (Box 99-2).[97] Soft tissue injuries and fractures are likely to occur. Common illnesses include gastrointestinal disorders, flu-like malaise, and environmental conditions. Aid stations should be stocked accordingly. Supplies that include intravenous fluids, antiemetics, antidiarrheals, and over-the-counter analgesics should be in adequate supply. Although more catastrophic injuries or illnesses are unlikely to be encountered, being prepared for them with advanced equipment is required, especially if operating in remote environments with limited access to emergency medical services or local hospitals.

SNOWMOBILES

The first snowmobile was introduced in 1923 by Joseph Armand Bombardier. It was intended as winter transportation for hunting and fishing. Snowmobiles have been used as school buses, ambulances, and war-time vehicles.[135] Snowmobiling is a popular recreational activity in North America and northern Europe. Two

BOX 99-2 Recommended Equipment for Medical Stations at Mountain Biking Events

First-Aid Equipment
- Adhesive wound bandages
- Gauze pads
- Adhesive tape
- Elastic rolled bandages
- Pressure dressing
- Splints
- Arm slings
- Ice packs and cold packs
- Alcohol pads
- Water
- Soap
- Antiseptic solution
- Eye wash
- Antibiotic and antiseptic ointment
- Insect bite relief preparation
- Tweezers
- Scissors
- Sunscreen
- Safety pins
- Gloves

Drugs
- Aqueous epinephrine (1:1000)
- Aspirin
- Diphenhydramine
- Nitroglycerin
- Glucagon
- Dextrose
- Oxygen
- Albuterol

Advanced Equipment
- Bag-valve-mask device
- Automated external defibrillator
- Cervical collar
- Backboard
- Glucometer
- Intravenous fluids and equipment for administration

Adapted from Lareau S, McGinnis H: Injuries in mountain bike racing: frequency of injuries in endurance versus cross country mountain bike races, *Wilderness Environ Med* 22(3):222-227, 2011.

million snowmobiles are registered in the United States and Canada; 100,000 machines are sold annually in these regions.[78,133,162] The average snowmobiler is 44 years old and rides more than 1600 miles per season.[78] More than 3000 snowmobile clubs in North America provide safety and training programs, represent the snowmobile community in political issues (e.g., land access), and groom and maintain local trails.[12,42]

North America has 225,000 miles of groomed snowmobile trails. Riders also explore the backcountry on both private and public lands.[78] Snowmobile racing is popular. There are many types of racing, such as cross-country racing, drag racing, hill climbing, and snocross).[79] Extreme snowmobiling is the newest sector of the sport. As in motocross, riders jump and perform tricks with their vehicles over obstacles, sometimes at great speeds.[104] The risk of injury is high.

EQUIPMENT

Snowmobiles range from basic entry-level machines to high-performance vehicles (Figure 99-14). The engine size ranges from 250 to 1000 cc, and speeds up to 100 mph can be reached.[43] Snowmobiles can weigh in excess of 600 lb, which puts riders at risk for serious injury from rollover accidents.[51,133] Several categories of snowmobiles are manufactured:[7,8]

- Trail snowmobiles (i.e., entry-level snowmobiles) are ideal for riders new to the sport. They are lightweight, easy to maneuver, and moderately powered (60 to 70 horsepower [hp]).
- Performance snowmobiles have larger engines (usually over 85 hp), are heavier, and have more aggressive handling characteristics. They are less forgiving when maneuvered improperly. Use should be reserved for experienced riders.
- Touring snowmobiles are designed for two riders. Comfort takes precedence over performance. They tend to be larger and heavier than trail or performance machines.
- Mountain snowmobiles are designed for backcountry and mountain riding. They are high-horsepower machines designed to perform well in deep powder, on steep terrain, and at high altitude.
- Utility (or working) snowmobiles are designed for commercial applications (such as ski resorts, or search and rescue efforts). These machines are wider and heavier than are recreational vehicles, and perform well on trails and in heavy snow.
- Youth-specific models are designed for riders 8 years of age and older. They are lightweight, low-horsepower machines and are easy to handle. The top speed is often limited by a governor.

PROTECTIVE GEAR

With any high-speed wintertime sport, proper protection against the elements is mandatory. A traditional layering approach is ideal. Next-to-the-skin layers should be made of wool or synthetic material that can wick away moisture. Cotton should not be used. Midlayers of woolen or synthetic fabrics can be chosen according to local weather conditions.

Outer layers provide warmth and protection against wind and precipitation. They must allow for unrestricted freedom of movement and not interfere with vehicle operation. Snowmobile-specific suits, or jacket and bib pants work well. Skiing outerwear or similar items may also be worn. Outer shells made from Gore-Tex or other similar synthetic fabrics that are waterproof and windproof provide the best protection. Outerwear with built-in buoyant foam insulation (e.g., Ice Rider Jacket from Mustang Survival, Bellingham, Washington) is available, and can be life-saving in a fall through the ice.[3] Avalanche airbag systems (e.g., ABS Backpack, ABS Avalanche Rescue Devices, Inc., Langley, British Columbia) can be helpful safety items in avalanche-prone terrain (see Figure 99-14).

Helmets should always be worn, and in many states are required by law.[13] Full-face helmets designed specifically for snowmobilers are ideal. They not only protect the head and face but also provide warmth and have antifog visors to protect eyes

FIGURE 99-14 The modern snowmobile. Today's snowmobiles are high-performance machines, can weigh more than 600 lb, and can reach speeds above 100 mph. They are thrilling to ride but can cause injury or death. Note the full complement of protective gear worn by the rider: helmet, goggles, snowmobile suit, boots, and avalanche airbag system. *(Courtesy Polaris, Medina, Minnesota.)*

and increase visibility. Motorcycle-style helmets may be worn but often require use of goggles.[157] A review of snowmobile injuries at three trauma centers in Minnesota found that only 35% of victims were helmeted.[22] A review of traumatic injuries in Alaskan children found a similar 33% rate of helmet usage.[155] Helmets are effective at preventing central nervous system injury (odds ratio [OR] 0.28, 0.18 to 0.44), and are associated with a lower likelihood of death or permanent disability (OR .026, 0.01 to 0.67). Other studies report similar findings.[92] Potential barriers to helmet usage include discomfort, inconvenience, and lack of perceived risk.[155]

Water- and wind-resistant gloves and waterproof winter boots are required. Gloves should not be so bulky as to interfere with operation of the snowmobile. Silk, wool, or synthetic glove liners can be worn to provide additional warmth. Boots should be warm and comfortable and have rubber-lugged soles to provide traction.[157] Riders should pack a gear bag that includes personal items, safety equipment, tools, and an emergency first-aid kit[157] (Box 99-3).

MECHANISM OF INJURY

On snowmobiles, drivers are injured more frequently than are passengers.[161] Driver inexperience and poor judgment are the leading causes of accidents.[43,133] Drivers' unfamiliarity with local terrain may contribute to crashes; visitors have injury rates approximately four times higher than do local riders.[176] Excessive speed was found to be a factor in 64% of fatalities in New England in the early 2000s.[22,43] Inattentive operation (e.g., driving on the wrong side of a trail, jumping over barrier embankments, and negotiating curves improperly) also contributes to snowmobiling injuries.[43]

Collisions with fixed objects (e.g., trees, rocks, snowdrifts, and ice) constitute the most common mechanism of injury in snowmobile accidents.[22,26,51,82,139,162,167] These collisions occur more frequently after sunset.[43] Rollover accidents are common, and given these machines' weight, can cause significant trauma[51,82,139,162,167] (Figure 99-15). Less common mechanisms include collisions with other snowmobiles or other vehicles, driver or passenger ejection, passenger injuries while being pulled behind snowmobiles (on inner tubes or sleds), and "clothesline" accidents.[139,162,167] Clothesline injuries tend to occur in open fields, when an unexpected fence is encountered at high speed.[67] This can result in devastating facial and neck lacerations, airway trauma, and cervical and thoracic spine injuries.[51] Fall-through-the-ice accidents occur when a person is snowmobiling over insufficiently frozen bodies of water. These accidents may lead to hypothermia or drowning, and are discussed later in the chapter.[51,82,139,162,167]

Snowmobilers are at risk for environmental injury (e.g., frostbite and hypothermia). Cold ambient temperatures and high-speed wind exposures contribute. Frostbite on exposed skin is not uncommon.[123] Skin and body temperatures decrease by several degrees Centigrade after 2 hours of snowmobiling.[169] Review of specific snowmobile-related cold injuries follows later in this chapter.

FIGURE 99-15 The most common mechanism of injury during snowmobiling is colliding with a fixed object. Rollover accidents, such as depicted here, are also frequently encountered and can lead to substantial injury, given the weight of the vehicle.

BOX 99-3 Recommended Snowmobiling Gear

Personal Items
- Driver's license
- Snowmobile safety certification card (if required by state law)
- Money
- Medications
- Cell phone
- Water
- High-energy food

Safety Equipment
- Compass and map
- Waterproof matches, candle, fire starter
- Flashlight and spare batteries
- Extra ignition key
- GPS unit
- Small shovel
- Probe and avalanche beacon (if traveling in avalanche-prone regions)
- Strobe light or flares
- Ice picks, kept readily available in outer pockets (if traveling over a frozen body of water; used to aid in self-extraction in case of falling through the ice)

Tools
- Spare sparkplug and sparkplug wrench
- Other wrenches for general repair
- Screwdrivers
- Pliers
- Knife
- Electrical or duct tape
- Bungee cords
- Tow rope

First-Aid Kit
- Bandages
- Gauze pads
- Adhesive tape
- Elastic wraps
- Thermal or "space" blanket
- Scissors
- Antiseptic solution

Data from *Safe Riders: Snowmobile Safety Awareness Program*, 2014: saferiderssafetyawareness.org.

EPIDEMIOLOGY OF SNOWMOBILING INJURIES

Studies of snowmobiling injuries are flawed by methodologic variability. Underreporting is likely. Approximately 10,000 to 14,000 patients are treated each year in U.S. emergency departments for snowmobiling injuries.[133,153,162] The Consumer Products Safety Commission (CPSC) estimates 110 deaths per year in the United States; other sources estimate approximately 200.[133,162] Rates of all injuries are between 2.8 and 5 injuries per 1000 registered snowmobiles per year.[133,161] Fatality rates in northern New England states have been estimated at between 1 and 1.7 deaths per 10,000 registered snowmobiles.[43]

Young men (15 to 35 years of age) account for the vast majority of snowmobiling accidents and fatalities.[24,26,60,82,135,144,153,161] In a 20-year review of accidents in Canada, males accounted for 89% of snowmobile fatalities and 81% of seriously injured persons.[167] In a similar review in Minnesota, 85% of snowmobile accident patients were male.[22] Male predominance is likely due to young men's higher participation rate and risk-taking behavior.

Most snowmobiling injuries or deaths occur during recreational activity, often on weekends. Many accidents occur after sunset, when visibility is reduced.[82,162] Injuries in the workplace (e.g., livestock herding and military exercises) are less common.[82] A review of injuries during organized snowmobile competitions

(e.g., speed racing or snocross) has not been published, but accidents are common. A professional competitor died from injuries sustained in a crash during an aerial stunt in the 2013 X-Games.[30] This "best trick contest" has been dropped from X-Games motorcycle and snowmobile events.[28] Although snowmobiling activity is typically off road, one study found that 11% of snowmobile crashes occurred on roadways.[167]

Alcohol and Snowmobiling Injuries

Alcohol use is strongly associated with snowmobiling injuries and deaths. A Canadian study found that 67% of fatally injured snowmobilers tested positive for alcohol, and 80% of those had a blood alcohol level greater than 0.08% (80 mg/dL).[167] U.S. studies reveal similar findings; 44% to 64% of injured snowmobilers had consumed alcohol.[22,162] Rowe compared snowmobile-related fatalities with age- and sex-matched automobile and motorcycle fatalities; snowmobilers had a fourfold greater use of alcohol.[144] Males were more likely to have consumed alcohol.[167] Programs aimed at decreasing alcohol use when snowmobiling would likely decrease morbidity and mortality rates.

TYPES OF SNOWMOBILING INJURIES

Snowmobile accidents can be thought of as cold-weather, off-road analogs of motorcycle accidents. Riders may suffer substantial multisystem injuries, which may not be apparent on initial evaluation. Clinical management is the same as that of any multisystem trauma patient.

Head injuries are among the most commonly reported injuries; in one series, 35% of patients were reported to have sustained head injuries.[22,41,51,82,135,139,162] Head injuries may include concussion, traumatic subarachnoid hemorrhage, subdural hematoma, parenchymal contusion, and skull fracture.[153] Helmets had been worn in less than 30% of cases. They should be routinely worn.[92,155]

Extremity fractures occur in two-thirds of snowmobile crash victims.[22,167] Lower extremities are the most frequent sites of injury.[26,41,51,87,133,135,161] No fracture patterns have emerged as specific to snowmobiling. Soft tissue injuries (e.g., anterior cruciate ligament tear and acromioclavicular separation) have been reported.[87] Extremities should be splinted in the field if potential for fracture exists. A high index of suspicion for significant occult injury must be maintained.

Axial skeleton injuries are less common than are extremity fractures. Eighteen percent of injured Minnesota snowmobilers had spinal injuries.[22] In a similar review from New York, 6% sustained hip or pelvis fractures.[135] A 14-year-old boy fractured all his cervical vertebrae in a high-energy snowmobile accident.[100] He suffered no neurologic injury and was successfully treated using a halo device.

Snowmobile accidents can cause substantial thoracoabdominal trauma. In one series, thoracic injuries included pneumothorax and hemothorax (19%), pulmonary contusion (16%), rib fractures (29%), clavicle fractures (11%), and scapula fractures (3%).[135] Intraabdominal injury was less common, and included spleen (12%), liver (4%), and renal injuries (2%). A Minnesota cohort had similar injury patterns: 29% of patients sustained thoracic injury and 15% abdominal trauma.[22]

Chronic and overuse injuries related to snowmobile use are not described in the medical literature, save for a single report by Anttonen regarding *white finger syndrome*. This condition is a form of Raynaud's syndrome caused by continuous vibration to the hands.[17]

FATAL SNOWMOBILING INJURIES

The most frequent risk factors for fatal injury are male gender, alcohol use, and excessive speed.[126,139,162] Other risks include inattentive or careless vehicle operation and inexperience.[43] In northern New England, 82% of fatalities were a result of blunt trauma to the head, chest, and/or abdomen; 7% from drownings, 4% from medical causes, and 7% from unknown causes. Blunt traumatic injuries leading to death are most frequently caused by striking a fixed object.[51,139,162] Deaths are more likely to occur on weekends and after sunset.[43,126]

PEDIATRIC SNOWMOBILING INJURIES

Many snowmobile enthusiasts consider snowmobiling to be a family sport. The majority of snowmobile owners are married with children.[139] Children may be injured while operating the vehicle or riding as a passenger.[51,118] Size, weight, and speed of modern snowmobiles predispose young riders to injury. Passengers towed behind a snowmobile (more likely to be children than adults) are at high risk for injury.[139,162]

As with adults, male children and adolescents are much more likely to be injured in a snowmobile accident than are females.[51,118,139] In a study of Norwegian youth snowmobilers, boys were more likely to adopt peer-group conformity than were girls, and were less likely to identify potential risks in snowmobiling activities.[111] Whereas girls were more likely to focus on risks and how to avoid them, boys were more focused on testing their limits while driving. Such differences likely contribute to the increased injury rates in boys.

Injury patterns are similar in pediatric victims of snowmobile injuries, compared with adults. Orthopedic injuries are most commonly reported, but blunt head, thoracic, and abdominal trauma are common.[51,118,139] Helmet use among pediatric patients ranges from 53% to 68%.[51,118] In response to concerns regarding pediatric injuries and deaths from snowmobiling, the American Academy of Pediatrics has published recommendations regarding safe use of snowmobiles[9] (Box 99-4).

FALLS THROUGH THE ICE WHEN SNOWMOBILING

Driving snowmobiles across a frozen body of water (e.g., river, lake, or ocean) is inherently risky. Falls through the ice and drowning account for between 4% and 38% of snowmobiling deaths[139,162] and are frequently reported by local media.[1,5] "Skimming" (i.e., attempting to ride a snowmobile over a section of open water) is an activity pursued by some. This activity is extremely dangerous.[43,150]

Of 307 falling-through-the-ice events in Alaska, more than 50% involved a snowmobile.[60] Sixty-eight percent of the incidents led to search and rescue operations; 35% were fatal. Most victims were men, with a mean age of 33 years. Falls through the ice occurred most frequently on rivers. Overflow conditions (i.e., water from a high tide, rain, or snowmelt that collects above surface ice and subsequently partially refreezes) was a factor in 11% of cases. The author posited that these events may become

BOX 99-4 American Academy of Pediatrics: Snowmobiling Recommendations

- Children younger than 16 years old should not operate a snowmobile.
- Children younger than 6 years old should not ride as a passenger on a snowmobile (they lack the stamina and strength to stay on).
- Snowmobile manufacturers should avoid advertisements directed toward children.
- Graduated licensing programs should be put in place for operators 16 years and older.
- Travel at safe speed should be encouraged.
- Speed governors should be used for inexperienced riders.
- There is absolutely no alcohol or drug use.
- Proper gear, including helmets, is mandatory at all times.
- Always travel in groups of two persons or more.
- Avoid ice unless its condition and thickness are known.
- No more than one passenger rides on a snowmobile.
- Never tow a passenger recreationally behind a snowmobile on any conveyance.
- Ensure that the snowmobile is properly maintained.

Data from American Academy of Pediatrics: Snowmobiling hazards, *Pediatrics* 106(5):1142-1144, 2000.

more common in Alaska due to global warming with a shortened ice travel season. In a Minnesota review, an average of 6.3 deaths occur annually as a result of falling through the ice; half of victims were on snowmobiles.[115] In a review of 246 snowmobile-related deaths, the Canadian Red Cross concluded the majority of immersion deaths were preventable.[49]

The best way to avoid falling through the ice is to avoid crossing frozen lakes or rivers. Ice thickness can vary widely.[156] Ice thickness and quality must be evaluated before driving onto ice. Riders should not assume that tracks from prior snowmobiles ensure safe passage. The burden of establishing safe passage rests with the individual.

Evaluation of ice conditions begins before starting out. Check with local authorities, who may have knowledge of local ice conditions and routes to avoid. Ice should be qualitatively assessed before embarking. Only clear, hard ice is recommended for travel.[156] Ice that is slushy, on or near moving water, has thawed or refrozen, or is layered due to sudden temperature changes, must be avoided.[2] Ice covered by snow may be weakened because snow acts to insulate the water and may retard ice formation and growth.[2] If no apparent qualitative deficiencies are noted, the next step is to measure ice thickness.

The Minnesota Department of Natural Resources has developed ice thickness guidelines (Figure 99-16).[114] These guidelines are intended for new, clear ice only. White ice or "snow" ice is less than half as strong; thickness guidelines should be doubled for travel on white ice. These are general guidelines only. Other environmental factors may cause ice to be unsafe.

To measure ice thickness, an ice chisel, auger, or cordless drill can be used to make a hole.[114] Insert a tape measure into the hole, hook it on the bottom edge of the ice, and measure the thickness. The Minnesota guidelines recommend checking ice thickness every 150 feet. Although this may be feasible for ice fishermen, it is unreasonable to assume that persons on snowmobiles will start and stop at these intervals. Regardless, ice conditions can change rapidly over short distances. The rider choosing to travel over ice must use common sense, recheck the ice thickness as local conditions warrant, be willing to acknowledge an inherent risk of falling through, and be prepared for such an accident.

The first step in responding to falling through the ice is to remain calm. Outer clothing layers should remain on; their insulating layers trap air and can provide buoyancy. The victim should then turn and face the direction from which he or she came; ice in that direction is known to be solid enough to support a snowmobile. Ice in any other direction is of unknown thickness and quality. Place hands and arms on the surface of the ice. Screwdrivers, ice picks, or other similar objects, if kept in easily accessible outer pockets, can be used to dig into the ice and help the victim pull himself or herself out of the water (Figure 99-17). Without such devices, self-extraction may prove almost impossible because of the lack of traction. Kicking with legs while using the ice picks can aid propulsion out of the water and onto the ice surface. Once the person has been extracted, the person lies flat on the surface and rolls away from the hole. Standing up may concentrate too much weight on a minimal surface area and result in ice breakage. Once the person is safely away from the water, efforts to seek shelter, remove wet clothing, and rewarm need to be urgently pursued.[6]

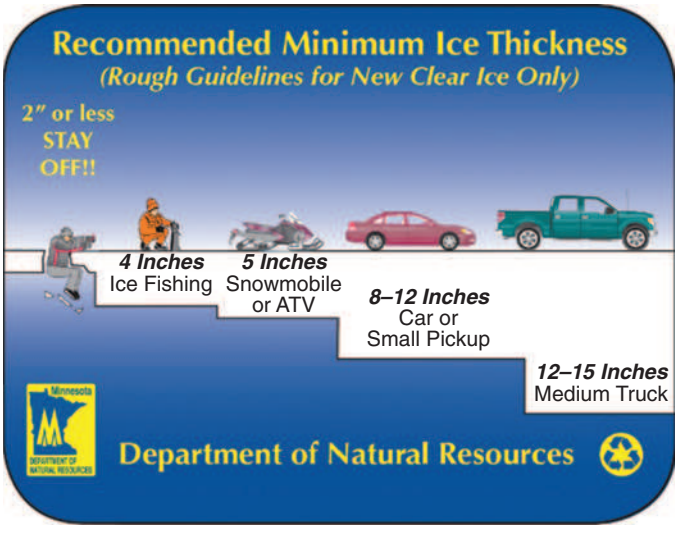

FIGURE 99-16 Ice thickness guidelines. *(Courtesy Minnesota Department of Natural Resources.)*

FIGURE 99-17 Falling through the ice. **A,** Self-extraction from the water up onto the surface may be difficult, if not impossible, given the slippery nature of the ice. **B,** Ice picks, long industrial nails, or screwdrivers may be used to dig into the ice to pull oneself up and out of the water. Commercially available ice picks designed specifically for this emergency are ideal and should be kept in a readily accessible outer pocket. *(**A** courtesy Angel-Guard Products, Worcester, Massachusetts.)*

Witnesses to fall-through-the-ice accidents also need to remain calm and carefully formulate a rescue plan. A call for emergency assistance should be made as soon as possible. "Preach, reach, throw, row, go," an adage familiar to lifeguards, is also sage advice in this situation:[4]

- Preach: Let the victim know you are there to help; encourage the person to fight for survival.
- Reach: If the victim is reachable from shore, extend an object such as a ladder or long pole.
- Throw: Try to toss a rope or buoyant object (such as a personal flotation device) to the victim. Encourage the victim to tie the rope around himself or herself before the victim is too weak to grasp it.
- Row: Push a light boat across the ice to the edge of the hole, get into the boat, and pull the victim in over the bow.
- Go: As an absolute last resort, and if no other possibilities for rescue exist, consider approaching the victim while lying down on the ice. Nonprofessionals without extensive preparation and specialized equipment who attempt this type of rescue are at substantial risk of themselves becoming victims.

Please see Chapters 7 to 10 for details on hypothermia, frostbite, and immersion into cold water.

SAFETY AND RISK REDUCTION IN SNOWMOBILING

Safety rules and regulations vary greatly by jurisdiction. In Maine, there are no speed limits for snowmobiles; riders are simply mandated to "operate at a reasonable and prudent speed for conditions." In New Hampshire, the speed limit is 45 mph unless otherwise posted, and in Vermont, it is 35 mph on public lands and "reasonable speeds" on private lands.[43] Not all states have helmet laws; some require helmets only for riders less than 18 years of age.[139] Given that excessive speed and lack of helmet use are associated with snowmobiling injuries and deaths, legal and educational efforts to limit speed and mandate helmet usage appear reasonable.

Safety courses vary by jurisdiction. Many states offer free safety training courses; many do not require them. Maine does not require a safety course; New Hampshire does for persons under the age of 18 without a driver's license, and Vermonters are required to take a class if they were born after July 1, 1983.[43] Training would likely increase safety. Topics might include proper operating procedures, risks of high speed, safety gear (including the use of flotation devices), and ice safety and rescue procedures. Given the extremely high percentages of accident victims who are impaired by alcohol at the time of a crash, alcohol-related education should be investigated.[144] Targeted programs for young men (15 to 35 years old), focused on risk-taking behavior and appropriate risk-reduction strategies, may yield positive results.[135]

Safety improvement for children should include adherence to recommendations of the American Academy of Pediatrics regarding snowmobiling (see Box 99-4). Local interventions (e.g., trail maintenance programs and removal of fixed objects that may be struck) and restrictions against towing passengers might also be considered.

ALL-TERRAIN VEHICLES

All-terrain vehicles (ATVs) are popular off-road vehicles. Approximately 10.2 million ATVs are in use in the United States, with almost 700,000 new units sold each year.[61] Of ATV users, 81% are male, and 40% are less than 30 years old. ATVs specifically designed for youths are popular and make up 40% of total U.S. ATV sales.[61] In a 2001 study, approximately 7.2 million children less than 15 years of age had ridden an ATV at least once. Young ATV riders are particularly prone to injury.

ATVs are used in a wide variety of settings. In the United States, approximately 80% are used solely for recreational purposes; the remainder are used in commercial environments or in tasks as varied as farming, police and government functions, patrolling of park lands and beaches, and search and rescue operations, and as a primary mode of transportation in remote regions.[61,98] ATVs are well suited for farming and property maintenance because they are able to maneuver in rough terrain, can be fitted with accessories (such as racks, plows, and winches), and can carry larger loads and travel much faster than can a person on foot. Recreational ATV enthusiasts enjoy their vehicles on public and private lands, including designated ATV parks and trail systems (e.g., the Hatfield-McCoy Trails in West Virginia).[52,61]

EQUIPMENT

ATVs are powerful machines propelled by gas engines and capable of achieving speeds of up to 100 mph. They have high-volume, low-pressure tires, narrow wheelbases, short turning radius, and high center of gravity. These characteristics make ATVs ideal for off-road travel, but render them unstable and prone to rollover.[27] Instability is pronounced when an ATV is operated at high speeds on paved roads because it is not designed to be used in such a manner.[52] Most ATVs are intended for a single operator. Elongated straddle seats enable the user to "actively" operate the vehicle (i.e., enable the driver to shift the body weight in order to steer, climb, descend, and maintain control), a requirement for safe operation. If a passenger joins the driver on an ATV designed for one person, active control of the vehicle is compromised.[52] Original ATVs had three wheels. These were discontinued in the 1980s for safety reasons. Nearly all ATVs in use today are four-wheeled models.[48]

FIGURE 99-18 All-terrain vehicles (ATVs). A wide variety of ATVs are available, including sport, utility, and youth models. Children should never be allowed to operate adult-sized vehicles. They lack the strength, coordination, and judgment required to operate these vehicles safely. Many authorities believe children under the age of 16 years should not be allowed to operate any ATV, regardless of the child's size. These riders are properly equipped with helmets, protective eyewear, riding jacket, long pants, gloves, and sturdy boots.

Multiple types of ATVs are available[61] (Figure 99-18). Sport models intended for recreational trail riding have engines that range from 90 to 1000 cc, and weigh 300 to 700 lb. Utility models are similar to sport models, but are equipped with a variety of accessories (e.g., cargo and/or gun racks) that improve utility (e.g., for farming, patrol and policing operations, camping, and hunting). Youth models are designed to make the vehicles safer for young riders; engines are less than 90 cc, and vehicle weight is less than 300 lb. Youth ATVs are equipped with governors that limit top speed to 10 to 15 mph. Transition models are available for adolescents and teenagers. Although they are larger and more powerful than youth models, these ATVs are lighter and less powerful than full-size ATVs.

PROTECTIVE GEAR AND HELMETS

Proper protective gear is mandatory when operating an ATV (see Figure 99-18). Full-length pants, long-sleeve tops, and gloves help prevent soft tissue injuries. Sturdy boots with rugged nonslip soles are required. Protective eyewear (e.g., goggles or safety glasses) should always be worn. A review of ocular injuries (e.g., eyelid lacerations, traumatic cataracts, and corneal abrasions) sustained by ATV riders found that 100% of victims were not wearing protective eyewear.[107] Protective gear and pads designed for ATV use are readily available; they include riding boots, chest and back protectors, elbow and wrist guards, goggles, kidney belts, knee and ankle guards, neck braces and supports, shoulder pads, and protective undergarments. The protective benefit of such equipment seems obvious, but studies have not been performed to evaluate efficacy.

Helmet use is supported by robust research. A properly fitting helmet approved by the Department of Transportation should be worn whenever a person is operating an ATV. Despite numerous safety campaigns, helmet usage remains low. Eighty-three percent of ATV-related fatalities in the United States involved victims who were not wearing helmets, according to recent government statistics.[61] Numerous other studies of injuries and deaths related to ATV use document similar noncompliance with helmet use.* Rates of helmet usage range from 0% to 46%; no report documents a usage rate of more than 50%.[151,152,174] Studies from New Zealand and Canada show similar results.[20,50,174]

*References 20, 27, 50, 55, 107, 112, 130, 143, 151, 152, 155, 163, 165, 174.

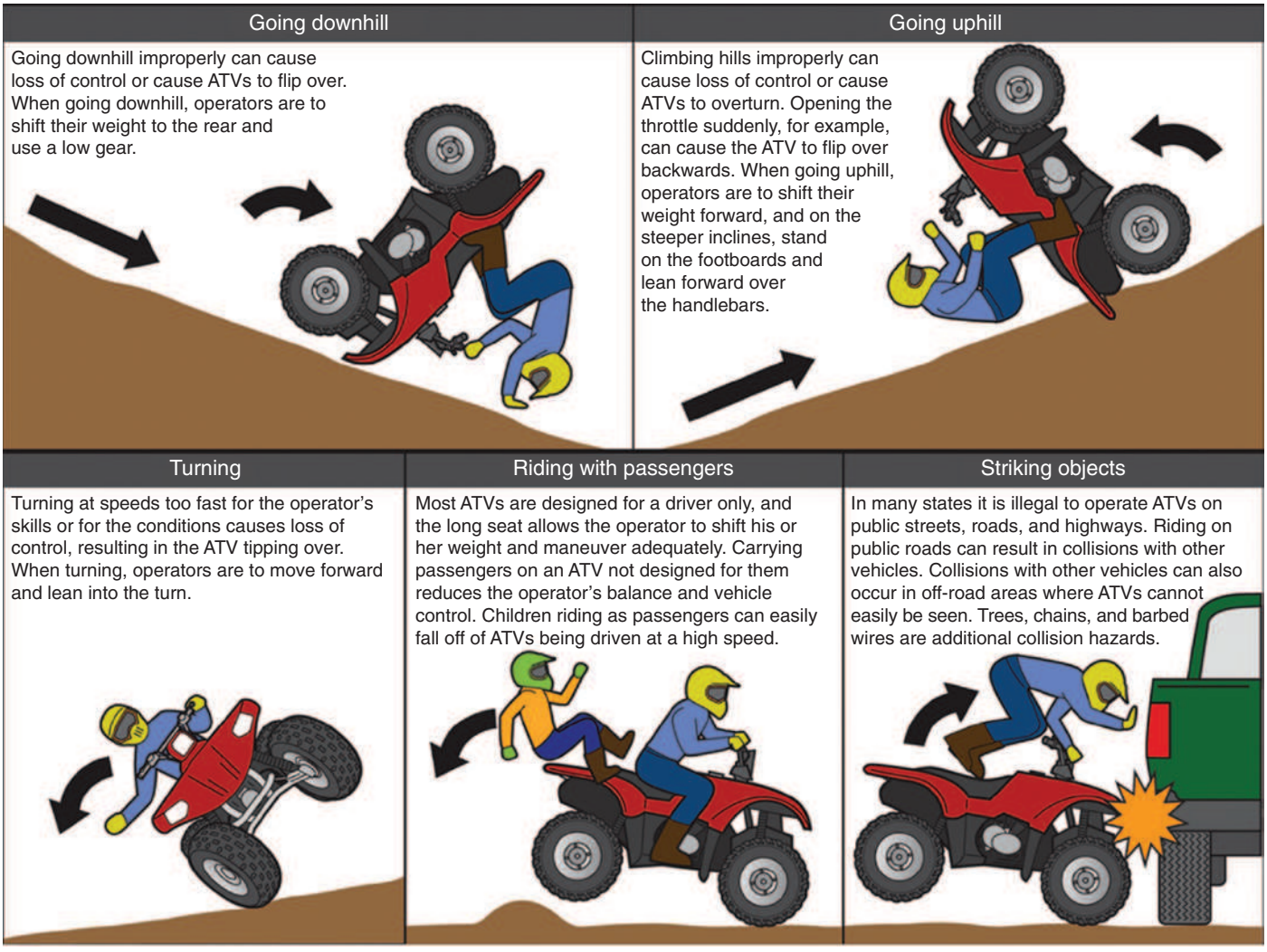

FIGURE 99-19 Mechanism of injury in ATV accidents. *(Courtesy U.S. Government Accountability Office.)*

Data on helmet-use risk reduction are compelling. Helmets save lives and prevent injuries to the head, face, and neck.* Data on ATV crash victims in West Virginia illustrate the point.[112] Unhelmeted riders were significantly more likely to suffer head and neck soft tissue injuries (81% versus 56%), concussions (60% versus 38%), intracranial hemorrhages (22% versus 6%), facial fractures (21% versus 12%), and skull fractures (19% versus 9%). Unhelmeted riders were less likely to be discharged home from the emergency department (33% versus 45%). A review of CPSC fatality data indicates that helmets reduced likelihood of head injury among fatal crash victims by 58%.[52] A study of Alaskan children involved in ATV accidents found that helmets significantly reduced risk for central nervous system injury (OR 0.28, 95% confidence interval [CI] 0.18 to 0.44), as well as risk for death or permanent disability (OR 0.26, 95% CI 0.10 to 0.44).[155]

MECHANISM OF INJURY

Several distinct mechanisms of ATV injury cause the majority of injuries and fatalities (Figure 99-19). Collisions with fixed objects (e.g., trees, rocks, or embankments) are the leading causes of death and injury. U.S. and Canadian government statistics reveal these collisions cause 48% to 52% of fatalities.[61,167] A rollover crash is the second most common cause.[27,61,108] (Figure 99-20). An innovative review of YouTube videos and real-world ATV

FIGURE 99-20 ATVs are prone to rollover crashes, given their high center of gravity. The vehicles may roll over even at low speeds. The rider here is particularly susceptible to head injury because he is not wearing a helmet.

*References 52, 59, 63, 72, 93, 109, 112, 130, 143, 145, 155, 165, 174.

rollover events found that ATVs rolled sideways in 47% of events, rearward in 44%, and forward in 9%.[166] Most rollovers occurred at low speeds: 86% at 10 mph or less and 53% at less than 3 mph. Seventy-nine percent of riders were uninjured, 16% sustained injuries secondary to contact with the vehicle, and 5% sustained injuries unrelated to the ATV (e.g., striking the ground). Attempts to actively dismount at the time of rollover occurred in 63% of cases; 72% of these attempts were successful. Fifteen percent of dismounters sustained injury, while 32% of riders who remained on the ATV were injured. The author concluded that active rider movements, including separating from the vehicle in the event of a rollover, were important in determining outcomes of an ATV crash. Less common mechanisms include ejection from the vehicle, unexpected terrain changes, and *clothesline injuries,* which occur when a rider runs into a wire fence at high speed (as they do with snowmobiles).[27,59,61,98]

ATVs are designed for off-road use. Their high center of gravity and low-pressure tires perform poorly on hard surfaces at high speeds. Operating these vehicles on paved roadways is a dangerous endeavor. CPSC data reveal that 60% of all ATV fatalities between 1985 and 2009 were a result of roadway crashes and accidents.[52] ATV crashes on the road are more likely to involve ATV passengers, and so have multiple fatalities. On-road ATV victims are more likely to be intoxicated and less likely to wear helmets than their off-road counterparts. Fatality Analysis Report System data regarding on-road ATV deaths provide additional insight.[172] Of 1701 reported fatalities, 1482 were drivers and 210 were passengers (the rider status was unknown in several cases). Half were teenagers or younger; 90% were male. Helmets were worn by only 13% of drivers and 6% of passengers. Forty-three percent had a blood alcohol content of more than 0.08%. Speeding was implicated in 42% of single-vehicle crashes. The most common mechanism was striking a fixed object; rollover events were common. ATVs should not be operated on roadways. Other risk-laden activities (e.g., not wearing a helmet, carrying a passenger, speeding, and consuming alcohol) further increase the risk for death.

EPIDEMIOLOGY OF ATV INJURIES

Nonfatal Injuries

In 2011, 107,500 patients were treated in U.S. emergency departments for ATV-related injuries.[48] Eighty-seven percent were treated and released. Twenty-seven percent were less than 16 years old. In 2009, the rate of injury in the United States was 37.9/100,000 riders, and was highest in the 13- to 15-year-old age group. The mean age of ATV crash victims is 27 to 30 years old. Males are involved in 70% to 80% of crashes.[29,32,55,93,145,167]Rural inhabitants are much more likely to be injured on an ATV than are their urban counterparts (227/100,000 versus 7.3/100,000); ATVs are used primarily in remote environments.[32]

Fatal Injuries

The CPSC reports 11,688 persons died from ATV accidents between 1982 and 2011.[48] Twenty-five percent were less than 16 years old, and 10% less than 12 years old. Deaths per year have increased over time; the Government Accountability Office (GAO) reported 816 fatalities in 2007, a 53% increase in 8 years.[61] ATV use tripled in the same time period. Males account for 80% to 90% of fatal accidents, and the average age is approximately 30 years old.[46,61,73,101,167] In the United States, the rate of death from ATV accidents is 0.32/100,000.[73] The death rate for males is sixfold higher than for females (0.55 versus 0.09/100,000). In Canada, the overall death rate is similar to that in the United States, at 0.3/100,000.[167] The CPSC database for 1982 to 2007 includes deaths from all 50 states in the United States, with California (504), Texas (478), Pennsylvania (459), West Virginia (444), and Kentucky (419) leading the list.

Pediatric Injuries and Fatalities

Pediatric injuries and deaths related to ATV use merit special attention. Children make up 14% to 18% of riders but 20% of ATV deaths and 33% of injuries.[61,98] Between 1996 and 2005, 320,700 children sustained an ATV-related injury; 1154 were killed.[48] The annualized injury rate is approximately 56/100,000.[152] Injured youths are 75% to 80% male; their injury rate is twice as high as that of females.[98,152,170] An ATV operator less than 16 years old has a 33% chance of sustaining an ATV-related injury during the vehicle's lifespan.[27] Child passengers are at greater risk of death or serious injury (particularly head and neck injuries) than are child drivers.[152]

Pediatric riders figure prominently in injury and death statistics for many reasons. Most children (≈ 90% in the GAO and CPSC databases) are killed or injured while riding adult ATVs.[48,61,108] Children do not have the judgment, skill, strength, or endurance to maneuver an adult-sized ATV weighing over 700 lb. Children may not weigh enough to counter the rotational momentum of the vehicle by changing their center of gravity (i.e., they are unable to "actively" ride the ATV).[98] Many stakeholders (e.g., GAO, CPSC, public health officials, and industry representatives) agree that children should never ride adult ATVs.[48,61,152] The CPSC estimates that the risk of injury to young riders could be cut in half if they rode models designed specifically for young people.[152] Although manufacturers and distributors have agreed to prevent dealers from selling adult-sized ATVs to children, undercover checks by the GAO revealed that 70% of dealers were willing to make such a transaction.[61]

A child's risk of injury and death persists even when riding an age-appropriate ATV. Youth-sized vehicles are quite heavy and are still prone to rollover, even at low speeds. In the event of a rollover, children may not be able to extricate themselves from beneath a heavy vehicle. Children have less impulse control and are prone to taking more dangerous risks.[61] Children are likely to disregard basic ATV safety principles while riding. In a review of pediatric trauma center admissions over a 5-year period, Mazotas found that 70% of patients were not wearing a helmet, 56% had no adult supervision, 50% were double riding (i.e., carrying a passenger), 23% were riding on paved roads, and 16% were riding at night.[108]

ALCOHOL AND ATVS

Alcohol intoxication plays a central role in ATV-related injuries and deaths. Alcohol contributes to up to 50% of ATV crashes.[52,72,107,163,167] Alcohol was present in 50% of riders killed in West Virginia between 2004 and 2006, and in 88% the blood alcohol concentration was greater than 0.08%. Marijuana was detected in 11% of the victims, and opioids (7%), benzodiazepines (6%), cocaine (2%), and methamphetamine (1%) were also found.[72] A survey of Canadian youths found that 10% reported operating a vehicle after consuming alcohol or other illicit substances.[132] Respondents were more likely to engage in such behaviors if they were male, from rural communities, or from lower socioeconomic strata. A review of the Alberta Trauma Registry found alcohol to an independent predictor of mortality in ATV crashes (relative risk [RR] 2.33; interquartile range [IQR] 1.52 to 3.56).[93] The American College of Emergency Physicians has a policy statement supporting adoption and enforcement of legislation prohibiting use of alcohol or drugs while operating motorized off-road vehicles.[11] Such action is sound and should be vigorously pursued.

TYPES OF ATV INJURIES

ATV crashes lead to multisystem trauma. Soft tissue injuries and fractures are the most commonly reported injuries. Of ATV patients treated in U.S. emergency departments, 27% sustained contusions and abrasions, 23% sustained fractures, 17% had sprains and strains, and 11% had lacerations.[48] These injuries were in an upper extremity (29%), head or neck (28%), torso (22%), and leg (20%). Other reports indicate similar findings.[152,174] Fractures are present in up to 50% of ATV patients.[55,167] Sport-specific constellations of injuries have not been reported.

Head injuries are common following ATV accidents. Injury and death rates are compounded by lack of helmet use. Blunt head trauma with loss of consciousness is common.[170] Skull fractures (e.g., temporal bone, skull base, and face) are also frequently seen.[16,107] Intracranial injury (e.g., epidural hematoma,

subdural hematoma, subarachnoid hemorrhage, and intraparenchymal hemorrhage) should be ruled out.[61,107] As mentioned previously, riders are at risk for ocular injury. Primary ocular trauma (e.g., subconjunctival hemorrhage, open-globe injury, or retinal detachment) has been reported.[107]

Of ATV crash patients, 5% to 20% suffer blunt abdominal injuries and 13% to 22% suffer thoracic injuries.[48,108,174] Blunt renal injuries are described.[71] Specific ATV-related thoracoabdominal injury patterns have not been well described.

Intracranial trauma and other head injuries are the leading causes of death from ATV accidents. Exsanguination (e.g., from great vessel injury or internal organ injury) also contribute substantially to death rates.[46,98,101,112] Traumatic asphyxiation (as might occur in a rollover accident when the victim is unable to self-extricate) was reported as the cause of death in 15% of Australian victims.[46]

SAFETY AND RISK REDUCTION

Risk factors for ATV-related injuries include:

- Male gender
- Age younger than 16 years
- Youth riders operating an adult-sized ATV
- Failure to wear a helmet
- Carrying a passenger
- Alcohol use or intoxication
- Driving at excessive speed
- Driving on paved roads
- Lack of training and experience[52,61,98]

ATV safety stakeholders have advocated for proper ATV training and routine use of proper safety equipment (e.g., helmets). This training is especially important because ATV operation appears deceptively easy. In communities where ATVs are widely used, local populations should be educated about a helmet's ability to decrease the risk of TBI.[29,61]

The CPSC filed a lawsuit against the five main ATV manufacturers in 1988 to encourage safety standards.[61] The resulting settlement mandated that manufacturers must:

- Stop selling three-wheeled vehicles.
- Promote and sell four-wheeled vehicles with an engine size of more than 90 cc only to riders age 16 years and older.
- Promote youth-sized models with engine sizes of 70 to 90 cc for children.
- Provide free training to all purchasers and their family members.
- Conduct nationwide safety public awareness campaigns.
- Adhere to advertising guidelines.
- Affix warning labels to vehicles.
- Develop voluntary ATV industry safety standards.

The CPSC-mandated dealer training programs must include content on safe riding practices, how to operate an ATV on hills, how to use proper protective gear, how to avoid hazards of improper operation, and other topics.[61] Although such programs are sound, real-world application may fall short. As few as 10% of purchasers may actually participate in free training.[98] ATVs are often bought second-hand or through nonauthorized dealers, so purchasers do not receive training. Even dealer compliance with the CPSC's recommendations falls short. A telephone survey of ATV dealers in Illinois found that only 75% recommended child-sized ATVs for youth participants, and only 50% offered safety training.[70] To provide further outreach to consumers, the CPSC has developed a website, ATVsafety.org, which hosts safety guidelines, injury statistics, and other useful information. The CPSC also produces television and radio public service announcements.[48]

Regional safety regulations vary greatly between jurisdictions. Thirty-two states have minimum operating ages, 28 have helmet and eye protection rules, 21 require a safety certificate, and 12 require a motor vehicle license.[61] Most states prohibit use of ATVs on roadways; others allow on-road passage but require riders to wear helmets when riding on roads.[172] The efficacy of safety legislation is uncertain. Data from the Centers for Disease Control and Prevention WONDER database show that states with no helmet requirements had 23% more ATV-related deaths than did states with such requirements.[73] However, studies from Quebec and North Carolina found rates of helmet usage and numbers and types of injuries were unchanged after the enactment of helmet laws.[20,109] Safety programs have been implemented in populations of interest (e.g., hunters taking safety classes and high school students). Participants' awareness of safety issues appears to be heightened (as evidenced by preintervention and postintervention tests), but the impact of such programs has yet to be demonstrated.[81,124,171]

Professional medical societies (e.g., American Academy of Orthopedic Surgeons, American Pediatric Surgical Association, and Canadian Paediatric Society) have recognized the need for improved safety measures regarding ATV use.[33,98,175] A summary of their position statements is presented in Box 99-5.

BOX 99-5 Summary of Position Statements From Medical Societies Regarding ATV Safety

Children under the age of 16 years* should not operate ATVs, regardless of the size of the vehicle.
Use of helmets, eye protection, and protective clothing and footwear is mandatory.
Passengers should never be allowed on an ATV.
Alcohol or other intoxicants should never be consumed prior to riding an ATV.
All operators should complete a training course, including both classroom and practical sessions.
ATVs should never be ridden on paved roadways.
Riders should avoid excessive speeds, jumps and stunts, and riding after dark.

*The American Academy of Orthopedic Surgeons recommends that no one under the age of 18 years should operate an ATV.
Data from Larson A, McIntosh A: The epidemiology of injury in ATV and motocross sports, *Med Sport Sci* 58:158-172, 2012; Burd R: American Pediatric Surgical Association Trauma Committee position statement on the use of all-terrain vehicles by children and youth, *J Pediatr Surg* 44(8):1638-1639, 2009; Yanchar N: Preventing injuries from all-terrain vehicles, *Paediatr Child Health* 17(9):513, 2012.

FIGURE 99-21 Crush guard. This safety device is designed to prevent the driver from being crushed by the heavy vehicle in the event of a rollover accident. Its use is not widespread, and its efficacy has yet to be determined. *(Courtesy Quadbar Safety:* quadbarsafety.com.*)*

Improved ATV design and engineering are other possible avenues for risk reduction. Some have advocated for redesign of seats on adult ATVs, moving them far enough from the handlebars that children cannot reach them. The backs of seats could be shortened to stop at the rear axle to decrease the possibility of carrying passengers.[80] A "safety star" system for ATVs could help guide consumers to a proper vehicle.[68] Aftermarket safety products, such as crush guards, are available (see atvlifeguards.com/ and quadbarsafety.com/); these may prevent crush injuries by allowing riders to climb out from underneath a vehicle that has rolled over[103] (Figure 99-21). The efficacy of these devices is uncertain.

REFERENCES

Complete references used in this text are available online at expertconsult.inkling.com.

CHAPTER 100

Medical Liability and Wilderness Emergencies

CAROLYN S. LANGER AND BRIAN S.S. AUERBACH

This chapter presents a review of the legal issues that arise in the context of wilderness emergencies, with particular attention to those related to medical liability. With support from case studies, federal and state statutes, and various secondary sources, the chapter introduces basic legal concepts, including negligence, waiver of liability, and Good Samaritan laws. It also covers legal doctrines that are of critical importance to trip operators and wilderness medicine physicians alike, including the duty to warn, medical screening of trip participants, duty to rescue, standing orders, and medical record keeping.

Christopher Mance was a senior at Ohio University when he enrolled in a wilderness course as part of his outdoor studies. In fulfillment of a class requirement, Mance embarked on an overnight solo camping excursion in a secluded area. During this wilderness trip, he suffered an epileptic seizure and fell face first into a campfire. Mance sustained severe burns to his face, arms, and hands, which rendered him extensively disfigured. Ohio University knew that Christopher Mance had a history of seizure disorder, but Mance had signed a waiver of liability before the trip. He maintained that his seizure disorder was well controlled on a regimen of divalproex (Depakote), a medication he had been taking for years.[31]

What was Ohio University's obligation to warn Mance of wilderness hazards, such as a change in sleep patterns that can lower the seizure threshold? Did the waiver that Mance signed effectively release Ohio University from liability? Did a physician clear Mance to embark on this solo camping excursion? What are the legal guidelines for prohibiting participation in such a trip? If a physician had screened Mance's medical records and concluded that he could not participate, to what Americans with Disabilities Act (ADA) laws would that physician have been subjected? Should Mance or Ohio University bear the economic costs of his injuries?

In recent years, personal wealth, general interest, increased leisure time, globalization of the economy, and sophisticated marketing have led to expanded participation by the general public (with an aging population) in expeditions and cruises to remote environments, including wilderness areas. Such travel poses a higher risk for injury and illness than does travel in urban areas and often involves exposure to extreme weather conditions, limited access to medical personnel and supplies, and extended patient management because of limited medical evacuation capabilities. What are the medicolegal ramifications for tour operators and trip physicians? Historically, the probability of a lawsuit was low because participants were younger, more physically fit, and more experienced adventurers who tended to be greater risk takers with awareness of and willingness to assume these risks. However, increased involvement of a less prepared and marginally aware general population in wilderness pursuits has undoubtedly generated a concomitant increase in exposure to liability. To minimize liability, tour operators and trip physicians must implement sound risk management strategies for medical clearance, education, and provision of medical services to trip participants.

The issues described earlier highlight some of the common medicolegal concerns that arise when people are injured in the wilderness. This chapter addresses these and other legal issues that may be encountered by physicians and trip operators.

TORT LAW AND THE DOCTRINE OF NEGLIGENCE

CASE STUDY: SNAKEBITE AND MEDICAL MALPRACTICE

On August 11, a victim sustained a rattlesnake bite to the index and middle fingers of his left hand. Suction cups and a tourniquet were immediately applied, and the victim was transported to the hospital within 15 minutes. Another 15 minutes passed before Dr. A arrived. Dr. A proceeded to treat the patient by injecting antivenom into the base of the fingers bitten by the snake and into the left deltoid, despite an instruction sheet accompanying the antivenom that cautioned, "Do not inject serum into a finger or toe." Dr. A packed the patient's hand in ice and admitted him to the hospital. Two days later, the patient was sent home with instructions to keep ice on the hand.

Eight days later the victim's two fingers, hand, and arm were edematous, discolored, and odorous from gangrene. Dr. B assumed care of the patient. He applied a heating pad and injected antibiotics. On September 9, the two fingers required amputation. Is Dr. A liable for medical malpractice?

In tort law, members of society owe a duty to others to act reasonably and in a way that will not hurt another person or his or her property. In the context of wilderness medicine, redress for a private civil wrong is typically sought under a medical

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negligence doctrine. To bring a cause of action under a negligence theory, the plaintiff (the party filing the claim) must establish the following four elements:

1. *Duty:* The defendant has a duty by virtue of the physician-patient relationship to use due care as would a reasonably prudent physician under similar circumstances. For example, a plaintiff could argue that a trip physician owes the participants a duty to "possess and bring to bear on the patient's behalf that degree of knowledge, skill, and care that would be exercised by a reasonable and prudent physician under similar circumstances" given the prevailing state of medical knowledge and available resources.[46] To meet this duty, physicians must typically adhere to the standard of care established by the medical profession.
2. *Breach of duty:* Defendants breach their duty when they fail to conform to the duty of care or to act in accordance with norms or standards of practice. This breach may occur either through commission or omission of certain acts. For example, a physician may breach the duty of care by failing to diagnose or treat a condition (omission) or by improperly treating a patient (commission).
3. *Causation:* The plaintiff must further prove that the defendant's conduct was the direct, foreseeable, and proximate cause of the resulting injury. In other words, absent the defendant's conduct, the harm would not have occurred. Establishing causation is often the most problematic step for plaintiffs. For example, an injured traveler might allege that a trip leader or medical practitioner breached the duty of care by delaying medical evacuation, but the defendant could argue that the injury had already occurred and that any delay in evacuation neither caused nor aggravated the injury.
4. *Damages:* Finally, the plaintiff must demonstrate damages, that is, harm to the individual's person, property, or interests, for which the redress is customarily a monetary award. Awards may encompass special damages (e.g., out-of-pocket losses, medical expenses, lost earnings), general damages (pain and suffering, mental anguish, and other emotional injury), and punitive damages. Punitive damages are rare in the medical context because the plaintiff must prove that the defendant's conduct exceeded simple negligence and was intentional, grossly negligent, reckless, malicious, or fraudulent. Nonetheless, physicians should be aware that their insurance policies generally do not provide malpractice coverage for punitive damages.

Medical malpractice is a specific form of negligence occurring during execution of a physician's professional or fiduciary duties. Medical malpractice can be defined as medical care that falls below the standard of care expected of a reasonably prudent physician under similar circumstances, resulting in foreseeable harm to the patient.[44] In all negligence suits, the plaintiff bears the burden of proof in establishing the requisite four elements under a "more probable than not" standard. In other words, the plaintiff must establish that there was a greater than 50% probability that the defendant's breach of duty caused the harm.

In the snakebite case presented earlier, the first element is clearly demonstrated. Dr. A's actions established a physician-patient relationship and acceptance of the duty to render care. Establishing the second and third elements is more problematic. The court held that Dr. A did not breach his duty. The court elaborated, "There are wide variations in accepted methods of treatment of rattlesnake bites. The method of treatment chosen and used by the defendant was an acceptable method of treatment." In other words, even though physicians must act with the level of skill and learning possessed by minimally qualified members of the profession, they are judged by reference to the beliefs of the school that they follow. That is, their practice need not be followed by a majority consensus, provided that it is supported by a recognized school of practice in the medical community.

The court further held that the plaintiff failed to establish causation. Expert testimony showed that "rattlesnake bites in extremities always present some chance of tissue destruction" and that the most probable cause of tissue death in the two distal phalanges was the rattlesnake venom. Thus Dr. A was found not liable. Whether Dr. A's intervention met the standard of care and caused the ultimate amputation are debatable. Typically, though, both parties to the litigation use expert witness testimony to establish their respective positions vis-à-vis standard of care and causation issues.

Each state has its own body of statutory, regulatory, and case law in addition to federal law. Thus, although this chapter presents general legal and risk management principles, physicians should always familiarize themselves with the laws and precedents in their own states before implementing policies and procedures related to wilderness or travel medicine. Unless the trip application has a jurisdiction clause explicitly limiting the venue for litigation (often the state in which the tour outfit has its headquarters or principal place of business), a plaintiff could theoretically bring a claim in his or her own state of residence, in the state where the physician is licensed, in any state where the tour outfit conducts business or has some nexus, or in the jurisdiction where the injury occurred.

LIABILITY CONCERNS IN WILDERNESS MEDICINE

The remainder of this chapter examines how the legal doctrines apply in the unique circumstances of wilderness medicine. Not surprisingly, increased participation of the general population in adventure travel has led to higher—and in many cases unrealistic—expectations on the part of the public. Some unseasoned travelers to remote destinations anticipate the same level of medical resources (including personnel, equipment, medications, and evacuation capabilities) as those to which they have access via large, urban tertiary-care medical centers. It is therefore vital for tour operators and trip physicians to understand the duty and standard of care to which they must adhere and to educate trip participants regarding the medical risks of travel.

DUTY TO WARN AND EDUCATE TRIP PARTICIPANTS

CASE STUDY: DUTY TO WARN

A middle-aged male traveler booked a tour to Bolivia through a travel agent. In the trip brochure, the tour operator represented itself as an experienced and reputable company and stated that it researched all locations to which it arranged tours and "would care for participants from 'portal to portal.'"[42] In addition, the travel agent asked both the tour operator and local health agencies about health requirements and necessary precautions. During the trip, the traveler developed high-altitude cerebral edema after flying from Chile (at sea level) to La Paz, Bolivia (elevation 3962 m [13,000 feet]), in less than 1 hour. He subsequently sued the travel agent and tour organizer for failure to warn him of the health risks associated with his travel.

In general, there is no duty to warn of dangers that are as obvious to the participant as to the organizer. Obvious dangers might include possible seasickness or airsickness, substandard sanitation, and poor environmental conditions. Moreover, travel agents and tour operators have no duty to investigate potential vacation sites (not even those where conditions and terrain are dangerous) or lower standards of medical care in foreign countries. However, they do have a duty to warn travelers of known unreasonable risks or dangers, such as political turmoil and criminal attacks, which are foreseeable or likely to occur. Typically, to incur this duty to warn, the travel agent or tour operator must have actual or constructive notice of the hazardous condition arising from their knowledge of special circumstances (e.g., prior occurrences). In addition, travel agents and tour operators may contractually expand their duty to warn through representations made in brochures or other advertisements. In the case mentioned earlier, for example, the court recognized

that tour organizers are not insurers of the safety of tourists with whom they contract and need not warn of obvious hazards. Nonetheless, in this case the travel organizer contractually expanded its obligation through its representations and brochures and created a reasonable expectation on the part of the tourist that it would research the risks of high-altitude travel and warn him of accompanying dangers.

Even in the absence of liability, trip organizers and medical practitioners have incentive to prevent travel-associated injury or illness, because they suffer financially and ethically when a tourist experiences physical or financial loss, fellow travelers are inconvenienced, or the reputation of the company or medical practice is potentially damaged. Sound risk management principles dictate that travel companies provide as much useful information as feasible to prevent adverse consequences. Companies lacking the wherewithal to research health hazards may benefit from the assistance of a medical adviser. Depending on the nature of the trip, some or all of the following information may be useful to participants:

- Environmental conditions (e.g., climate, altitude, terrain)
- Activity level (type, intensity, duration, and frequency of activity or exertion required)
- Specific health hazards (e.g., tropical diseases, marine envenomation, frostbite, heat injuries)
- General health information (e.g., safety of local food and water, local medical resources)
- Known risks (e.g., political unrest, high crime areas)
- Recommended immunizations

Whether an outfitter has an obligation to provide helmets and safety equipment depends on many factors, including anticipated hazards, experience of participants, industry practice, and so forth. However, even when the outfitter requires participants to furnish their own safety equipment, it is advisable for the outfitter to identify potential hazards and required gear. Perhaps a more pressing concern is the noncompliant participant who refuses to wear or use furnished safety gear or who otherwise acts in a reckless manner. In these instances, signed waivers may be of some value, but juries are not always sympathetic to waivers because the trip operator is sometimes perceived as being in a better position to ensure participant safety. The more prudent risk mitigation step might be to include a statement in the trip brochure or application indicating that the trip operator may, in its discretion, dismiss any participant at any time during the trip for cause, including failure to wear appropriate safety gear or to comply with safety rules, at no liability or cost to the trip operator.

MEDICAL CLEARANCE OF TRIP PARTICIPANTS

Tour operators have no duty to medically screen trip participants. Travelers have a responsibility to exercise due caution for their own safety. Nonetheless, do tour operators have the right or an incentive to screen participants? Medical clearance of travelers may serve several beneficial purposes. It can function to educate participants about potential health hazards, thereby reducing their risk for harm. Medical screening affords the participant's private physician the opportunity to more effectively manage the patient's care. It also may enable a tour operator to arrange accommodations in advance for participants with special needs. Moreover, medical clearance may reduce the tour operator's liability, costs, and inconvenience.

On the other hand, medical screening has certain disadvantages. Some authorities consider medical screening useless because a high-risk patient with a strong desire to go on a trip may ignore the inherent dangers and conceal a significant medical history (or shop around for a physician willing to grant the medical clearance). In addition, since enactment of the ADA in 1990, many tour operators fear discrimination lawsuits for medically screening out disabled persons. However, with a proper understanding of the legal issues underlying medical clearance and the ADA, tour operators and physicians can safeguard the interests of all parties involved.

THE AMERICANS WITH DISABILITIES ACT

Molly, who is a double amputee as a result of a car accident, applies to Whitewater Ventures to participate in a rafting trip. The outfitter rejects her application, claiming that she would not be able to meet their safety standards and swim independently. Frank is hearing impaired and requests that National Park Adventures (NPA) provide a sign language interpreter on a biking and hiking trip out west. NPA refuses, citing the unduly burdensome expense involved in hiring a signer. Tommy is a 10-year-old boy with autism who requires a behavior plan and one-to-one aide to support him in a parks and recreation program run by a major metropolitan park agency. The city indicates that it cannot accommodate this request because its staff lacks the required expertise to provide these services. Meghan uses a wheelchair for mobility, and is interested in participating in a mountain trek in Nepal. The adventure outfitter declines her request to provide bus transportation throughout the entire trek. Do all of these individuals have a legal right to access these recreational activities, and must the providers of these recreational opportunities offer an accommodation if needed?

For persons with and without disabilities alike, recreational, travel, and wilderness pursuits provide enjoyment and diversion and lead to enhanced fitness, self-esteem, leisure skills, social opportunities, mental well-being, and quality of life.[33] The ADA opened doors to leisure and recreational activities for persons with disabilities (see Chapter 94). Under Title II of the ADA, state and local governments may not refuse participation by a person with a disability in a service, program, or activity simply because that person has a disability.[9] Title III of the ADA prohibits all places of public accommodation and services operated by private entities from discriminating against the disabled.[10] These private entities include both for-profit businesses (such as adventure outfitters and tour operators) and nonprofit groups (such as community sporting leagues, YMCAs, and Boys and Girls Clubs).

Furthermore, an entity may not apply eligibility criteria that screen out an individual or any class of individuals with disabilities "unless such criteria can be shown to be necessary for the provision of the goods, services, facilities, advantages, or accommodations."[11] For example, "a cruise line could not apply eligibility criteria to potential passengers in a manner that would screen out individuals with disabilities unless the criteria are 'necessary.'"[12]

An entity is not, however, required to permit an individual to participate in services when the individual poses a direct threat to the health or safety of themselves or others. This determination that the participant poses a significant risk must be an individualized assessment using reasonable judgment based on current medical knowledge or the best available objective evidence. In addition, the "safety exception" may justify excluding individuals when they pose a threat to themselves. The safety exception holds that an entity may impose legitimate safety requirements that are necessary for safe operations. As an example, the regulations cite as a valid screening criterion the requirement for all participants in a recreational rafting expedition to meet a necessary level of swimming proficiency.

For screening criteria to be valid, they must be uniformly applied to all prospective participants, not merely to those with disabilities. Moreover, they must be based on actual risks, not on mere speculation, stereotypes, or generalizations about a person or class of persons with a particular disability. A tour organizer could not, for example, categorically exclude all persons with a history of angina from a high-altitude trip, but rather must afford individuals with documented, well-controlled angina an opportunity to establish their fitness and eligibility for the trip. In the case described earlier, Whitewater Ventures may require that Molly be able to swim independently, but the provider must apply this criterion to all applicants and must afford Molly the opportunity to demonstrate her ability to meet this eligibility criterion. Moreover, as a reasonable accommodation (see later), Molly could likely wear a personal flotation device, if needed, to demonstrate swimming proficiency.

Even when screening criteria are valid and the prospective participant cannot meet those requirements, a public accommodation must make reasonable modifications in policies and

practices or must accommodate the disabled individual unless such modifications would cause an economic or administrative burden or would fundamentally alter the nature of the goods, services, or facilities offered. For example, in the case of Tommy described earlier, if the metropolitan park agency has a budget in the millions of dollars, the cost of hiring an outside aide to provide one-to-one support for Tommy and to develop and implement a behavior plan may not be an undue burden. On the other hand, if National Park Adventures is a small entity with annual revenues of $300,000 and only two full-time staff members, a court might find a signer to be an economic burden for such a small outfit, although the court might cite other less costly accommodations that NPA could provide to Frank, such as a written tour book. These decisions must be made on a case-by-case basis depending on the facts of the case. Similarly, a court would consider the specific facts of a case in determining if an accommodation would fundamentally alter the nature of the goods, services, or facilities. A cruise line could be required (as a reasonable modification) to provide an individual who relies on a wheelchair for mobility with a stateroom on the same level as the restaurant. However, a mountain trek would not be required to transform to a bus tour to accommodate this same individual.

MEDICAL SCREENING

To minimize the potential for discrimination claims, tour operators should provide physicians granting medical clearance as much information as possible regarding the physical demands of the trip. Tour organizers must provide detailed information concerning environmental conditions, specific health hazards, health and living conditions at the destination site, and availability of local medical resources. Companies should be as specific as possible in describing environmental conditions (e.g., altitude in feet, temperature in degrees). Trip organizers also must delineate the type, intensity, duration, and frequency of activity (e.g., bus tour, mild walking [1.6 to 3.2 km or 1 to 2 miles per day], vigorous hiking [specify distance and terrain], backpacking [specify weight of gear], trekking to remote areas [e.g., 24 hours from definitive medical care], climbing, swimming, canoeing).

The health care professional in turn must tailor the medical history and examination to the physical demands of the trip. The physician should become familiar with the patient's medical history, including any medications that could interact with the environment to which the patient is traveling. If applicable, the clinician should advise the patient to bring extra medications or medical equipment (e.g., a spare pair of eyeglasses, extra hearing aid batteries, anaphylaxis kit) in case complications or exacerbations occur. The physician also should inform the patient of applicable first-aid procedures and may also need to inform the trip organizer of special needs or accommodations.

Because patients and their physicians are sometimes hesitant to disclose confidential medical information to a travel company, medical clearance forms should emphasize functional abilities and limitations rather than diagnoses. If medical clearance forms request sufficiently detailed information about the prospective participant's medical fitness to meet the physical demands of the trip, travel companies frequently do not need to know about specific medical diagnoses. Companies that request confidential medical information should disclose this information only to employees who have a need to know and should ensure that the company medical adviser or trip physician safeguards this information in a locked file, typically at the company's offices, unless arrangements have been made for the physician adviser to store medical records at his or her private office. The company also may want to encourage high-risk patients to share medical information with trip leaders or bring along key medical records. It may be desirable for the trip physician or individual trip participants to bring along key medical documents or summaries that can easily be stored in their backpacks, particularly when traveling under Spartan conditions or to remote sites. Even though a medical adviser employed by the company or a private family physician makes determinations about medical fitness and medical clearance, the travel company bears legal responsibility for excluding disabled participants or for failing to accommodate their needs.

PROFESSIONAL LIABILITY, MEDICAL MALPRACTICE, AND GOOD SAMARITAN LAWS

In addition to complaints arising from lack of proper health warnings, injured trip participants commonly base claims on the company's failure to provide adequate medical services and facilities and negligent delivery of medical care. Historically, tour operators and cruise ships have had no obligation to ensure the health or safety of participants or to provide health care, particularly physicians' services, on trips. Trip organizers should nonetheless ascertain the appropriate standard of care for their particular circumstances by determining medical resources that other companies have provided on similar expeditions to similar destinations. Companies generally have the duty to staff trips to remote locations with personnel who have "significant training to provide adequate first aid and medical care until evacuation can be arranged."[25] Typically these staff members are emergency medical technicians (EMTs) or laypersons with basic first-aid training. Organizers of trips to locales with readily available medical care may have a lesser obligation to furnish staff trained in first aid. In the event of an adverse medical outcome, travel company employees are judged by a "reasonably prudent person" standard; that is, they have the duty to use reasonable care to furnish such aid and assistance as an ordinarily prudent person or trip leader would under similar circumstances.

Several professional medical organizations, such as the American College of Emergency Physicians and the Wilderness Medical Society, have sought to define and establish standards of care for the provision of medical services on cruise ships and expeditions. Many companies voluntarily staff physicians on their trips (and publicize that they have done so) for the comfort and convenience of the participants or to provide a competitive marketing advantage. Travel companies that advertise the presence of trip physicians and medical facilities in brochures, contracts, and other correspondence to participants or prospective participants contractually expand their obligation by creating an implied or express contract for the availability of certain medical services. At a minimum, it is expected that trip physicians will have the resources and capability to evaluate and manage emergencies and, when necessary, will arrange for more definitive care for the types of injuries and illnesses that might be reasonably anticipated on these types of trips.[6]

Who, if anyone, is liable when the physician commits medical malpractice? Is the physician protected by Good Samaritan laws? A nurse was accompanying an elementary school group on a trip to a farm in order to provide first aid and administer medication if needed. A boy who did not attend that school, but happened to be on the premises at the same time, poked himself in the eye with a wire. The nurse volunteered to look at the eye, administered ice, and reportedly instructed the boy's father to seek medical care if any problems developed. Two days later the eye was found to be infected, and after several surgeries, the boy eventually lost the eye. The boy's family sued the nurse for gross negligence. Under the Good Samaritan statute in that jurisdiction, a nurse is liable only for acts or omissions constituting gross negligence when the nurse "voluntarily and without the expectation of monetary compensation renders first aid or emergency treatment at the scene of an accident or other emergency, outside a hospital, doctor's office or any other place having proper and necessary medical equipment, to a person who is unconscious, ill or injured."[32] The court found in favor of the nurse, ruling that she was under no duty to render assistance to the child. She was on the premises to provide nursing services exclusively to the elementary school students on the class trip, which did not include the injured boy. She volunteered to help him and had no expectation of monetary compensation for such assistance.

Although Good Samaritan laws vary from state to state, most of these laws generally hold physicians and other personnel free

from liability when assisting in an emergency, provided their conduct was not grossly negligent (a higher threshold than simple negligence), wanton, or willful. Other provisions common to many Good Samaritan laws include requirements to render care in an emergency or at the scene of an emergency, to act in good faith, to provide services gratuitously, and to have no pre-existing duty to the victim to respond or provide aid. For example, if a physician happens upon a stranger in need of emergent care while hiking up a mountain and provides medical care, his or her services would most likely fall within the purview of Good Samaritan laws.

On the other hand, does the physician acting as the "trip physician" lose his or her Good Samaritan protection? A typical custom in the adventure travel industry is to offer physicians generous discounts on trips in exchange for the provision of medical support for fellow participants. Many of these physicians are under the mistaken impression that they are covered by Good Samaritan laws in the event of a malpractice claim. The discounted fee, however, is the equivalent of compensation, and these physicians, along with those on straight salaries, would in all likelihood be considered independent contractors with a pre-existing duty to render medical care to fellow participants.

This potential exposure to malpractice claims has two important risk management implications for expedition physicians. First, physicians must familiarize themselves with the medical issues that they are likely to encounter on their trips and must possess the knowledge and skills to diagnose and treat relevant medical disorders. There is currently no prescriptive training, certification, or specialty requisite to serving as a trip physician. However, in determining the standard of care, a jury would expect the physician to anticipate foreseeable medical problems, assess the patient, and administer first-aid measures as would a reasonably prudent physician under similar circumstances, taking into account the remote location, extremes of environment, and limited capability to transport medical equipment on the trip. A physician employed on a cruise to known endemic areas must be familiar with diagnosis and treatment of tropical diseases. A physician with a mountain trekking group should be able to recognize signs and symptoms of high-altitude sickness and be proficient in management of this condition.

The trip physician's specialty is generally not a shield from liability. For example, a psychiatrist who holds himself or herself out as a trek physician would not be exculpated in a malpractice claim merely because he or she lacked training and experience in infectious diseases, primary care, emergency medicine, and other relevant areas. Therefore, physicians who lack the necessary skills to diagnose, treat, or stabilize basic first-aid, primary care, or emergency conditions may want to consider declining participation as a compensated trip physician because they would likely be held to the same standard of care as, for example, a primary care or emergency physician. On the other hand, specialty alone does not disqualify a physician from participating as a trip physician if he or she has acquired appropriate skills through prior participation in similar activities, conferences, previous duty in the public health service or military, and so forth. The determinative issue is how the "reasonably prudent physician" would have prepared for the trip and diagnosed and treated the patient under similar circumstances. Certifications, such as Advanced Cardiac Life Support, Advanced Trauma Life Support, and various wilderness medicine programs, are useful in demonstrating that the trip physician had training and acquired a certain level of proficiency in understanding and applying the standard of care. However, these certifications will not, in and of themselves, absolve the physician of liability, because the physician must still demonstrate that he or she adhered to the appropriate standard of care in any particular malpractice claim.

Physicians should not assume that their medical malpractice insurance policies cover claims arising out of medical services rendered on trips. Many insurance policies carry limitations on coverage for care delivered outside the scope of a physician's normal practice or beyond a certain geographic area. In these cases, trip physicians should seek extended coverage through their own insurance policies or through the tour organizer.

Both the plaintiff and defendant typically rely on expert witness testimony to identify the standard of care and offer an opinion regarding the defendant physician's adherence to that standard of care. Various state licensing boards are beginning to grapple with what their roles should be, if any, in sanctioning expert witnesses who give false or misleading testimony or who otherwise carry out their functions in a negligent manner. State licensing board policies on disciplining expert witnesses are not uniform across the country, but the American Medical Association (AMA) and many component state medical societies are advocating greater state government oversight of expert witness conduct and formal sanctioning when indicated, including possible loss of licensure. Regardless, any physicians wishing to serve as expert witnesses should closely scrutinize their qualifications and suitability to testify about wilderness medicine issues. The AMA House of Delegates has proposed the following minimum requirements for qualification as an expert witness (Policy H-265.994[3a]):

> The AMA believes that the minimum statutory requirements for qualification as an expert witness in medical liability issues should reflect the following: (i) that the witness be required to have comparable education, training, and occupational experience in the same field as the defendant or specialty expertise in the disease process or procedure performed in the case; (ii) that the occupational experience include active medical practice or teaching experience in the same field as the defendant; (iii) that the active medical practice or teaching experience must have been within five years of the date of the occurrence giving rise to the claim; and (iv) that the witness be certified by a board recognized by the American Board of Medical Specialties or the American Osteopathic Association or by a board with equivalent standards.[21]

The negligence of a physician generally will not be imputed under a theory of respondeat superior (master-servant relationship) to the tour organizer or carrier. Many courts have noted that the relationship between a trip member and physician is not a traditional activity over which a cruise ship or tour organizer has control. Moreover, a shipping or travel company is not in the business of providing medical services to participants and does not possess the requisite expertise to supervise a physician brought along for the convenience of the participants. Nonetheless, once the carrier or tour organizer undertakes to hire a physician, it owes a duty to participants to exercise reasonable care in the selection of a competent and qualified physician. To the extent that the company fails to discharge this duty, it may be subject to a cause of action for the negligent hiring of an incompetent physician. Therefore, cruise lines and tour operators should ensure that trip physicians are proficient in general medical care, emergency treatment, and medical management of diseases endemic to the destination site.

Furthermore, travel companies and cruise ships should brief trip physicians on available resources, host country medical facilities, and evacuation procedures. Finally, companies should conduct formal credentialing of prospective trip physicians by verifying medical school graduation, board certification, and state licensure, and researching any history of disciplinary actions.

WAIVER OF LIABILITY

Under certain circumstances, a defendant in a lawsuit may avoid liability *even though* the plaintiff proves every element of the cause of action alleged. Such circumstances are known as "affirmative defenses," and they play a critical role in all manner of disputes; for example, well-known defenses in a criminal context include *duress, insanity,* and *self-defense.*

When negligence is alleged against an operator, physician, or other party in a wilderness setting, the defendant frequently raises the defense of *waiver of liability.* Waiver is typically achieved with a contractual release from liability, which is a signed agreement on the part of the injured party that the defendant will not be liable for injuries caused by the defendant's negligence. The naive wilderness operator might attempt to protect itself and its staff, medical and other, from liability by simply requiring its participants to sign such a contract. It turns out, however, that contractual release is not simple. Even though the legal system

generally allows two willing parties to bind themselves by contract to any terms they agree on, there are many cases in which courts refuse to enforce waiver provisions.

NO WAIVER FOR GROSS NEGLIGENCE

Gross negligence is a form of negligence in which the party's failure to exercise reasonable care constitutes an *extreme* departure from the ordinary standard of conduct. It is, in some sense, a "worst" case of negligence, although still unintentional. Many jurisdictions that would allow a party to contractually release another party for ordinary negligence refuse to enforce releases for gross negligence, on the basis that such releases run contrary to public policy.

In its 2007 holding in the case of *Santa Barbara v Janeway,* the Supreme Court of California handed down a ruling that brought California law in line with the majority of states, where an agreement in the context of sports or recreational programs to release liability for gross negligence is unenforceable as a matter of policy.[8] In *Janeway,* the parents of a 14-year-old developmentally disabled child sued the City of Santa Barbara for the wrongful death of their child, Katie Janeway. Katie, who suffered from cerebral palsy, epilepsy, and other developmental disabilities, participated in a summer camp conducted by the City in 1999, 2000, 2001, and 2002. She had a history of seizures brought on by exposure to water, of which the camp administrators were aware.

On the second day of the 2002 camp, Katie suffered a seizure waiting to enter the locker room of the camp's pool. A camp counselor who had been assigned to monitor Katie while she was at the pool observed the seizure, but Katie appeared to recover quickly and was subsequently allowed to swim. The same counselor, who was supposed to be watching Katie, turned her back for a very short time and lost track of the child. The counselor had the lifeguards clear the pool, and Katie was found drowned at the bottom of the pool, approximately 5 minutes from when she had last been seen.

In the litigation that followed, the camp raised the defense of contractual waiver, based on a form signed by Katie's mother that released the camp and its employees for liability arising out of "any negligent act." The issue of whether that waiver was effective as to gross negligence came before the California Supreme Court, which found that although the wording "any negligent act" certainly included gross negligence, "an agreement purporting to release liability for future gross negligence … violates public policy and is unenforceable." In so holding, California came into line with the majority of states where the law is the same: it would go against public policy to enforce waivers for gross negligence.

OTHER BARS TO WAIVER

In addition to the common bar against waivers for gross negligence, many states prohibit releases for *ordinary* negligence under all manner of circumstances. For example, the *Janeway* court noted vast variation in the laws of different states. A majority of states bar a parent from releasing a minor's claims for negligence.[24] Vermont has voided releases for ordinary negligence in the context of recreational skiing on the basis that the ski resort is able to prevent dangerous conditions over which the skier has no control.[50] Connecticut has similarly invalidated waivers for activities that include snow tubing and horseback riding.[43] Washington State has voided agreements releasing public school districts from liability from future ordinary negligence related to interscholastic athletics.[54] New York has voided waivers in the context of auto racing, resort skiing, horseback riding, parachuting, tennis, and other recreational activities.[40] Virginia has voided *all* preinjury releases for liability.[26] Many states also bar enforcement of waivers for future negligence when such waivers are against the public interest. For example, in California, as in most states, a hospital cannot obtain releases for ordinary negligence.[53]

The above enumeration of bars to waiver is by no means exhaustive. It does give some indication, however, as to how difficult it can be to state any general rule as to what circumstances are sufficient to guarantee enforceability of a waiver. Instead, the ability of a party to obtain an effective release depends greatly on the type of activity and the state whose law is applied.

EFFECTIVE WAIVER

In light of the subtleties of waiver law, an operator cannot guarantee enforcement of its waiver; there are many steps necessary for an effective waiver that can increase likelihood of enforcement. Most important is to obtain advice of competent legal counsel regarding the following key issues:

- *Jurisdiction:* Enforceability of a waiver depends heavily on the state whose law is enforced and the activity to be covered. This is not a simple question. Consider a tour operator, such as Overland Inc. of Williamstown, Massachusetts, which operates hiking trips throughout states such as California and Vermont for high school students from all 50 states and internationally. In such complicated circumstances, only competent legal counsel can draft a waiver that is most likely to be enforced.
- *Assumption of risk:* Waivers are more likely to be enforced when they are accompanied by an acknowledgment and assumption of risk. This makes sense; whereas it may be fair to allow a party to give up claims when that party understands the risks inherent to the activity, courts are much more reluctant to enforce releases where the injured party did not acknowledge such danger.
- *Consideration:* Contracts that are not supported by a legal construct known as "consideration" are not enforceable. Consideration is best understood as meaning "value in return." For example, a woman rents skis from a shop, pays for them, leaves the building, and begins to drive away. An employee runs out and has the woman sign a release form in the parking lot. This release is likely unenforceable for lack of consideration: the woman already had gotten everything she wanted out of the deal—skis. With no value in return, the waiver is likely unenforceable. A short difference in timing would make all the difference; if the ski shop refused to hand over skis until its renters signed releases (which is standard practice in the industry), it would at least ensure that the waiver is supported by consideration.

Only legal counsel can provide proper advice on effective waiver. Depending on the nature and scope of the activity, and location of the operation, waiver may simply be impossible. In such cases, the operator may seek protection of indemnity or may take further measures to ensure that their operation and employees undertake reasonable care of the well-being of their participants. In theory, after all, waiver only comes into play when the defendant has actually been negligent.

DUTY TO RESCUE AND ABANDONMENT DOCTRINE

A physician who is on an expedition to Alaska and approaching the summit of Denali happens upon a trekker with multiple fractures and hypothermia. Does the physician have an obligation to treat the victim or attempt a rescue?

To answer that question, consider the example of David Sharp, a climber who died of severe altitude sickness and hypothermia while on Mt Everest in May 2006. Sharp lay by the side of the trail exhausted, his situation worsening, as numerous climbers trekked past him and made their summit attempts. Although a few climbers provided Sharp with supplemental oxygen, essentially he was left to die, and he perished on the mountain. David Sharp's plight and death generated international outrage over the procession of climbers who passed him by, apparently ignoring his dire condition.[34] Although moral debate ensued from this tragic story, from a legal standpoint, the climbers who walked past Sharp without offering assistance were completely within their legal rights. Sharp's case illustrates

the general rule that some special relationship must exist to create a duty; conversely, without any special relationship, no duty exists.

In particular, it is well-settled law in the United States that there is no duty of a physician (or any other individual) to rescue an individual merely happened upon in need of medical care or assistance, except in certain exceptional circumstances.[57] Most notably, when an individual has created a hazardous situation that directly causes another individual harm, there *does* exist a duty for the perpetrator to rescue the victim.[47] In the case of a biking accident on a remote trail, the individual who caused the accident, through negligence or purely bad luck, has a duty to assist the injured. Louisiana has a law on the books requiring a hunter who accidentally shoots another hunter to aid in the injured party's rescue. This duty is most simply fulfilled by alerting authorities or the emergency medical system. Duty to rescue also exists with certain relationships beyond physician and patient, such as parent and minor child or in *loco parentis* babysitters or schoolteachers.[36]

Internationally, however, there are numerous countries that *do* obligate a duty to rescue. Generally, countries whose legal system is rooted in civil law (such as those of continental Europe, Asia, and South America) have a duty to rescue, whereas common law countries (such as the United States and other former British colonies) do not recognize a general legal duty to rescue.

HARM TO THE RESCUER

In cases where the circumstances of the rescue are caused by a party, through negligence or otherwise, the party who caused the original harm also bears legal liability for harm caused to the rescuer during the rescue. In the landmark case *Wagner v International Railway* of 1926, Justice Cardozo states that "danger invites peril … The wrongdoer may not have foreseen the coming of a deliverer. He is accountable as if he had." Consequently, an injured rescuer may recover damages for harm sustained during a rescue attempt from the party who caused the original harm.[55]

In a wilderness context, a physician has a duty to the patients he or she agrees to treat or treats, but not necessarily to everyone he or she happens upon in his or her travels. As in an ordinary medical malpractice case, only when the physician-patient relationship is established can a plaintiff prevail in proving medical malpractice in a wilderness setting.

ABANDONMENT DOCTRINE

Once established, a physician-patient relationship is subject to abandonment principles should the relationship end. Abandonment is the unilateral termination of the physician-patient relationship by the physician without adequate notice to the patient, despite the need for ongoing medical care. In general, a physician has no legal duty to provide care for or to rescue endangered strangers. "The law imposes no liability upon those who stand idly by and fail to rescue a stranger who is in danger."[35] Moreover, abandonment occurs only in the presence of an established physician-patient relationship. Thus, the physician who refuses to enter into a physician-patient relationship and initiate treatment will not be held liable for abandonment.

Traditionally, once an individual initiated a rescue attempt, he or she could abandon rescue efforts at any time. "[The] motives in discontinuing the services are immaterial… [The rescuer] may without liability discontinue the services through mere caprice or because of personal dislike or enmity toward the [victim]."[32] However, if by giving aid the rescuer has put the victim in a worse position than before the attempt to aid, the rescuer may be liable. For example, the victim may have relied on the rescuer's efforts to his or her detriment, foregoing other opportunities to obtain assistance during the rescuer's intervention.

The best risk management tool is to assume that physicians who either implicitly or explicitly agree to treat patients create a duty to provide continuity of care. Given these circumstances, physicians can generally avoid liability for abandonment under the following conditions:

- The physician and patient mutually consent to terminate the relationship.
- The patient dismisses the physician.
- The victim no longer requires care, recovers, or dies.
- The physician dies or is disabled.
- Further rescue efforts would place the rescuer's life in danger.
- The physician gives the patient reasonable notice of his or her intent to withdraw from the care of the patient and, particularly in an emergency, continues to treat the patient until another qualified health care provider takes over the case.

Improper termination of the physician-patient relationship may lead to a cause of action for breach of contract or professional negligence, as well as for abandonment.

STANDING ORDERS AND MEDICAL KITS

There is tremendous variability in the medical expertise of trip leaders and participants and in the resources, including medical equipment and supplies, that accompany treks and trips into the wilderness. Delivery of medical care by nonphysicians represents one of the most problematic and controversial issues for trip organizers. Absent any representations to the contrary in travel brochures or other documents sent to participants, there is no implied or express contract to provide medical care to trip participants. Nonetheless, because of the nature of the business proprietor-customer relationship, trip leaders have some preexisting duties, namely, to exercise due care in the performance of their duties and in facilitating evacuations, when feasible, as would be considered reasonable under the circumstances. In other words, if they have made no claims to the contrary, trip leaders and staff have no duty to render care beyond basic first-aid services that an ordinary layperson could provide.

May a nonmedical trip leader or an EMT, paramedic, or other allied health care provider render medical services beyond the scope of his or her training or certification? One state board of registration in medicine defines the practice of medicine as:

> Conduct, the purpose or reasonably foreseeable effect of which is to encourage the reliance of another person upon an individual's knowledge or skill in the maintenance of human health by the prevention, alleviation, or cure of disease and involving or reasonably thought to involve an assumption of responsibility for the other person's physical or mental well-being: diagnosis, treatment, use of instruments or other devices, or the prescription or administration of drugs for the relief of diseases or adverse physical or mental conditions. A person who holds himself out to the public as a physician or surgeon, or with the initials M.D. or D.O. in connection with his name, and who also assumes responsibility for another person's physical or mental well-being, is engaged in the practice of medicine. The practice of medicine does not mean conduct … engaged in by persons licensed by other boards of registration with authority to regulate such conduct; nor does it mean assistance rendered in emergency situations by persons other than licensees.[13]

Consider the hypothetical example of a trekker who suffers a painful shoulder dislocation with diminished distal pulses. A nonphysician attempts a joint reduction. Successful reduction allows for a safe evacuation in the following 12 to 24 hours by hiking out with the comfort of a sling. Without reduction, a painful shoulder dislocation, especially in the setting of neurovascular compromise, would have necessitated a more urgent rescue, possibly including helicopter transport, and much higher risk to the injured person and rescuers. Such practice of medicine in the wilderness context is routinely implemented by outdoor programs without issue. Legally, most states require that an EMT or paramedic act under the supervision of a physician. Supervision usually entails direct observation, radio or telephone communication, or written guidelines, protocols, or standing orders (usually with reasonable access to a physician who can respond to questions and provide requested guidance). These statutes were enacted under the assumption that physician consultation

would be fairly accessible. Even with the advent of cellular telephones and telemedicine, many trekkers and travelers to remote regions cannot easily obtain physician consultation. In general, trip leaders and staff who practice beyond the scope of their education, training, and certification could be engaging in the unlawful practice of medicine.

Even in an emergency situation, it is unclear whether Good Samaritan statutes protect trip leaders and staff. As previously discussed, travel companies and their trip leaders are to a certain extent compensated for safeguarding the safety and welfare of participants. Therefore it seems most likely that courts would use a reasonable care standard in determining the negligence of trip leaders. In other words, the court would determine how a reasonable trip leader with similar education, training, and certification would respond in similar circumstances, taking into account the emergent nature of the victim's illness or injury, remoteness of location, scarcity of medical equipment, limited means of evacuation, and inaccessibility of definitive medical care.

Many wilderness expeditions carry medical kits stocked with prescription drugs, including controlled substances. Epinephrine is one such medication, particularly germane to wilderness medicine, that has legislation supporting its use by nonmedical persons. Activist groups have worked with state legislators and EMS agencies to promote legal use of the EpiPen by trained EMTs. Although some states still lack coverage, most support EpiPen use by EMTs. In 2009, the New York State Assembly passed a bill that requires all ambulances in the state to carry EpiPens.[38] More recently, this trend has extended to public workers. For example, Arkansas passed legislation in 2009 that authorizes public sector employees, including tour operators, forest rangers, and teachers, to use EpiPens.[3] The New York Assembly took a stronger stance, enacting legislation in February of 2010 that requires these devices at all children's overnight, summer day and traveling camps.[39] Other states have followed suit. Internationally, Ottawa enacted "Sabrina's law," named after a young girl who died of anaphylactic shock at a school where the nursing office was not equipped with this lifesaving medication.[45] Generally, this legislation has been widely supported and is likely to expand further to states and countries that have not already enacted it.

Despite progressive legislation liberalizing the use of EpiPens, other medications frequently contained in wilderness medical kits do not have such coverage. Outdoor outfitters routinely carry prescription pain medications and antibiotics into the backcountry. This practice is high risk from a medicolegal perspective and generally not supported legally or covered by standard malpractice coverage. Failure of nonmedical trip leaders to provide these medications would not be considered negligence because doing so is in violation of the law, particularly when the trip organizer did not create the peril and provided adequate advance warnings to trip participants. If a nonphysician dispenses drugs, it could very likely constitute the unlawful practice of medicine. Moreover, physicians who do not accompany the travelers but who nonetheless write the initial prescriptions to stock the medical kits expose themselves to lawsuits arising out of any malpractice on the part of the trip leader with regard to use of those medications. For example, a nonmedical trip leader might improperly diagnose and dispense medications or might overlook certain drug interactions. In addition, physicians who write prescriptions to stock medical kits face the risk of being disciplined by their respective state boards of medicine for inappropriate prescribing practices, particularly if medications are dispensed to an unintended recipient or if there is an adverse event.

This legal dogma is of little comfort to trip leaders who find themselves in emergency situations. In some instances, trip leaders on overseas travel have been known to purchase or to recommend that participants purchase medications abroad that would require prescriptions in the United States. These drugs are sometimes available over the counter in foreign countries. Although the purchase and use of these medications are legal on foreign soil, travelers should be cautioned about the potential lack of guarantees regarding safety, quality, and efficacy of locally procured drugs. If the nonphysician trip leader chooses to dispense medications, whether originally stocked in the medical kit before departure from the United States or obtained abroad, a court would in all likelihood judge any adverse consequences in accordance with a "due care" standard. That is, a trip leader who dispensed medications with resultant harm to the patient would be expected to demonstrate the due care of a reasonably prudent person under similar circumstances, taking into account the emergent nature of the medical condition, remoteness of the trip, availability of definitive medical care, and so forth. To avoid potential liability, trip organizers should adhere to the following basic risk management principles:

- Do not advertise medical capabilities and resources beyond the scope of expertise of trip staff members or resources readily accessible in the country.
- Emphasize the need for trip participants to bring along an adequate supply of their own prescription drugs, and even verify that they have done so.
- Caution trip participants about the lack of safeguards concerning the safety, quality, and efficacy of medications obtained overseas.

If trip organizers choose to equip staff members with medical kits, one expert in wilderness medicine recommends that the contents of the kit be based on the following factors[19]:

- Environmental extremes encountered during the trip
- Endemic diseases
- Medical expertise of the medical officer
- Medical expertise of the expedition members
- Number of people on the trip
- Responsibility for local health care
- Length of the trip
- Distance from definitive medical care
- Availability of rescue (i.e., helicopter)

MEDICAL RECORD KEEPING IN WILDERNESS MEDICINE

Good record keeping is of paramount importance in the practice of wilderness medicine. The medical record is both a health care document and a legal document. Although storage space and the portability of written or electronic medical records on trips to remote locations are often limited, trip physicians should nonetheless strive to be as thorough as possible in documenting medical care. The medical record functions as a complete, written, and chronologic record of a patient's medical history, condition, and treatment. In medical malpractice claims, which are frequently litigated years after the alleged occurrence, these records may be the only written source from which the sequence of events and subsequent treatment can be reconstructed. Moreover, memories fade and witnesses become less available over time. Therefore courts tend to give tremendous weight to the written record and will often assume that documented events occurred and undocumented events did not occur, particularly when the oral testimonies of the litigants conflict.

Although the length and content of entries vary with the specific circumstances, notes should at a minimum include the patient's chief complaint, the results of the physical examination (including normal findings), an assessment, and treatment plan. The key point to remember in creation of medical records is that they may be used to prove or disprove that the medical practitioner adhered to the appropriate standard of care. Therefore physicians should record sufficient details to reflect their thought processes and to justify care provided under the circumstances. Moreover, physicians should document events chronologically and as soon as feasible after delivery of medical care. Once notes have been entered into the written or electronic medical record, the medical practitioner should never alter (or write or type over) the original notes. Entries should not be removed or inserted. If corrections are necessary, for written records, the physician may place a single line through the error, enter the correction, and initial and date the correction. For written or electronic medical records, the clinician may draft an addendum. Addenda should be placed after the last entry in the chart. Of course, notes should always be legible, signed, and dated by the health care provider making the entry. Upon completion of the trip, the company

should treat these medical records as confidential information and place them in locked medical files, granting access to designated personnel (company medical advisers or others with a need to know) only. Some states have explicit laws or regulations that dictate the minimum period for retention of medical records. In the absence of such laws, travel companies and cruise lines should store medical records for the period of time corresponding to the statute of limitations for tort claims in their states, which, although varying from state to state, is typically about 2 to 3 years.

MEDICAL LIABILITY IN FOREIGN COUNTRIES

International travel continues to be popular. In addition to leisure travel, many medical professionals have the opportunity to provide on-call medical services for a variety of foreign excursions, including cruises, treks, and climbing expeditions. Although many of the theories of liability discussed in this chapter around the world are similar to those in the United States, there may be notable differences from domestic law.

This section should be read as a primer for any medical professional contemplating foreign travel, but is no replacement for finding a foreign attorney should the need arise. In addition to a basic overview of foreign medical liability, a physician traveling abroad should also know the basic steps for retaining a foreign attorney.

GOOD SAMARITAN LAWS ABROAD

Just as Good Samaritan laws vary from state to state, so too do they vary from country to country. Any medical professional contemplating foreign travel, whether as a physician or as a layperson, should become familiar with the laws of their destination regarding the liability assumed by coming to the aid of a person in need. Below is a short list of commonly visited countries and their respective Good Samaritan laws:

- Europe[52]
  - Great Britain: No duty to act unless there is a preexisting relationship that gives rise to the duty, but can be held liable if negligent rescue causes harm.
  - France: No duty to act, but liability can arise from any harm suffered during a rescue, unless that harm was necessary for the rescue.
  - Germany: Duty to act, but no liability for harm that occurred during the rescue.
  - Belgium: Duty to act unless there is serious danger to rescuer.
  - Finland: Duty to act, liability for harm suffered during negligent rescue.
  - Portugal: Duty to act unless serious danger to rescuer.
  - Spain: Duty to act for medical professionals; liability for harm suffered during negligent rescue.
  - Italy: Duty to act, but no liability for harm that occurred during rescue, unless due to negligence.
- Asia
  - China[29]: No duty to act, but liability can arise from harm suffered during a rescue. Good Samaritan laws are beginning to be enacted in certain provinces.[49]
  - Singapore[7]: No duty to act, but no official Good Samaritan law.
  - India[23]: No official Good Samaritan law.
  - Korea[30]: No duty to act; no liability for harm during rescue unless negligent.
  - Russia[51] Duty to act.
- Africa
  - Uganda[16]: No official Good Samaritan law.
- Australia[4]: Most territories limit liability to harm that occurs during a negligent rescue.

This nonexclusive list demonstrates the wide range of duties each country expects its citizens and visitors to uphold while within its boundaries. Countries that may share borders do not necessary share laws or legal systems; therefore, consulting a legal expert before extended travel is recommended for any medical professional.

TRANSPORTING MEDICAL SUPPLIES OVERSEAS

Many physicians, whether traveling for leisure or through contract, wish to carry their own medical supplies when traveling overseas. In general, transport of most supplies is not problematic. However, when transporting medications, in particular pain medications, care should be taken to determine the laws concerning narcotics in a particular country. Penalties for carrying restricted medications can be severe, potentially resulting in extended jail sentences or corporal or capital punishments.[28] The International Narcotics Control Board has issued several whitepapers concerning transport and regulation of narcotic medications abroad, including Model Guidelines for the International Provision of Controlled Medicines for Emergency Medical Care.[18,56]

RETAINING A FOREIGN ATTORNEY

Unless a U.S. attorney is also licensed in a particular foreign jurisdiction, the attorney cannot represent any party outside of the United States; a medical professional in need of foreign legal services must search for local counsel. Finding foreign counsel can be a daunting task, especially after a medical emergency has occurred. The U.S. Department of State[17] lists several points of consideration that should be undertaken in the search for a foreign attorney:

- Understand your attorney: Know the basic facts of your situation, but do not expect the attorney to be able to provide quick answers to a complicated question.
- Fees: Know the local currency and a general operating rate for your attorney. Many lawyers may expect payment in advance, while others may be willing to work for deferred fees. If you are planning to leave the country imminently, ensure that your attorney knows you will be leaving the country before any retainer agreement is signed.
- Method of payment: Ensure that your prospective lawyer can accept a form of payment that you can provide, whether it is the local currency, travelers' check, check, or credit card. Be aware that many banks and credit companies charge additional fees for foreign transactions.
- Progress reports: Foreign court activities and proceedings can be faster or slower than those of courts in the United States. Ensure that your lawyer will periodically update you on the progress of your case, and, if you have left the country, inform you if you need to return to the jurisdiction.
- Language: Is the foreign attorney fluent in English or your native language? Many court systems will allow for translation services, but beware of the "telephone" effect if too many parties are involved.
- Time: Find out from your prospective attorney how much time is estimated for the case to resolve.
- Travel restrictions: If you were planning to be in the foreign country for only a short period of time, ensure that the attorney explains your obligation about whether or not you must remain in the country for the duration of the case.

The Department of State cannot directly recommend a particular attorney,[18] so a physician in need of an attorney should find the nearest embassy, which should have a list of possible foreign counsel. In addition to the Department of State, both the American Bar Association (ABA)[1] and the American Society of International Law (ASIL)[2] maintain databases of information about foreign counsel that a physician can use in finding legal aid abroad.

MEDICAL CARE PROVIDED IN-FLIGHT

Not all injuries occur on the ground; a recent study estimated that a medical emergency will occur in the air once every 604 flights.[41] U.S. air carriers are obligated under federal law to

provide medical kits and automatic external defibrillators on all aircraft and train crew members in their use,[5,14] but medical situations can often arise in-flight that require immediate intervention by trained medical personnel. However, positioning of the aircraft, which might be located outside the borders of the contiguous United States, can lead to legal complications not present in traditional ground location settings.

In the case of in-flight medical care rendered onboard a flight operated by a U.S. air carrier traveling over U.S. territory, responding medical professionals are granted liability protections against a potential lawsuit by the Aviation Medical Assistance Act of 1998 (AMAA), which states:

> An individual shall not be liable for damages in any action brought in a Federal or State court arising out of the acts or omissions of the individual in providing or attempting to provide assistance in the case of an in-flight medical emergency unless the individual, while rendering such assistance, is guilty of gross negligence or willful misconduct.[5]

While the language of the Act does not clearly define gross negligence, flagrant disregard for a patient's health and safety is the generally accepted standard, as when an intoxicated physician treats a patient.[37] Consistent with the other U.S. medical liability principles discussed above, there is no legal duty for a physician to respond to a medical emergency that occurs during a domestic flight.

The AMAA additionally applies to international flights operated by domestic air carriers. However, the legal calculus becomes less clear on flights traveling internationally operated by international carriers. At least one U.S. court has held that the AMAA does not apply to foreign air carriers.[27] Although air carrier liability on international flights is standardized internationally by the Montreal Convention,[15,20] no such standardization exists concerning liability for the medical professional who responds to an in-flight emergency that occurs during an international flight. Generally, the country of aircraft registration determines the liability law to be applied, but the citizenship of physician or patient, along with the actual location of the aircraft at the time of the emergency, can also potentially dictate the choice of law,[22] In contrast to the United States and the United Kingdom,[48] many countries, as discussed above, impose a legal obligation for a medical professional to assist during an emergency.

Although a responding medical professional may be asked to advise the flight crew as to the status of the patient and severity of the emergency, the final decision on whether the flight should be diverted is made by the pilot commanding the aircraft. Responding professionals should always take advantage of all available ground-based medical support. Ultimately, whether legally obligated to assist or not, a medical professional providing assistance to a person in need during a flight should practice with the same level of ethics and attention to care as they would on the ground.

CONCLUSION

The services of medical professionals on cruises and expeditions can be invaluable to the safety and welfare of participants. Expanded participation of higher-risk individuals on trips to more remote regions of the world increases the liability exposure of health care providers. Legal issues, particularly causation, become more complex when medicine is practiced in these unconventional settings. By following the risk management principles outlined in this chapter, physicians can continue to provide effective care while minimizing their liability.

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Complete references used in this text are available online at expertconsult.inkling.com.

CHAPTER 101

Ethics of Wilderness Medicine

KENNETH V. ISERSON AND CARLTON E. HEINE

Ethics is the application of moral values and principles to guide human action. Providing care for others often involves intense human interactions. Thus, health care providers must frequently examine ethical issues in their work. Although the moral issues in wilderness medicine are an extension of traditional medical ethics, they are not directly comparable with the moral issues that arise either in medicine delivered in health care facilities or care delivered by urban emergency medical services. Wilderness medicine is unique, and its special attributes create unique ethical problems (Table 101-1). The working environment, concepts that involve standards of care, safety of rescuers and patients, and even the relationship between the provider and patient are different in a remote environment than in a traditional medical setting. For example, a hospital's working environment is rarely a factor considered by the hospital-based practitioner in the determination of what medical care to deliver, but the working environment is of major concern in the wilderness. Similarly, whereas patients usually have a clear legal relationship with the hospital practitioner and arrive at a hospital requesting care, neither condition is necessarily true in the wilderness setting. Even more striking are the differences between the hospital and the wilderness settings with regard to equipment availability, personnel training, need for evacuation or rescue, and provision for the safety of those involved. All of these differences can lead to unique ethical dilemmas in wilderness medicine.

This chapter provides an overview of ethical values as they apply to wilderness medicine. It describes a model for bioethical decision making in wilderness medicine, and provides examples of unique dilemmas that may be encountered in wilderness settings.

APPLICATION OF VALUES AND PRINCIPLES TO GUIDE HUMAN ACTIVITIES

Moral values are acquired throughout life from many sources, and develop into ethical action guides. In everyday situations, individuals may be unaware that these values are guiding their actions. However, when faced with situations that are rarely encountered, people may question how they should apply their

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TABLE 101-1 Differences Between Hospital Practice, Emergency Medical Services, and Wilderness Medicine

Aspect of Medicine	Hospital Practice	Emergency Medical Services	Wilderness Medicine*
Environment	Controlled, known, static	Partly controlled, partly known, changeable	Uncontrolled, partly known, changeable
Patient	Known, requests care	Unknown, sometimes requests care	Unknown, sometimes requests care
Equipment	Sophisticated	Adequate	Rudimentary
Security	Safe	Usually safe	Questionable
Personnel	Highly educated, definitive care	Highly educated, basic care	Variable education, basic care
Evacuation	Rare	Built into system	Major concern
Rescue	No	Rare	Common

*Includes search and rescue.

values to solve practical problems. Such situations develop in wilderness medicine because the settings can challenge practitioners to demonstrate expertise outside the usual scope of their medical specialties.

Both patients' and clinicians' values control patient-clinician encounters. When patients express their values, clinicians can get an impression of patients' views about the necessary treatment, desired quality of life, and other complex attitudes that control willingness to seek and accept medical care. The clinician's values, both personal and professional, are also part of the relationship and sometimes conflict with the patient's values.

Ethical discussions often revolve around applying ethical principles in a consistent manner or in a way that could be applied by all practitioners in the same situation. Ethical principles or rules should be applied consistently across all scenarios. If an accepted principle is that a patient with decision-making capacity may make his or her own decisions about health care, then this principle should be applied to all situations, not just when it is convenient for the health care provider. Likewise, if the principle is universal to medical practice, then all health care providers (not just a privileged or unique group) should be able to apply it to their practices.

SOURCES OF VALUES

Moral values are the guideposts used to structure an individual's actions in life. They signify a person's duties and responsibilities, what is important to them, and how they interact with others. Thomas Aquinas said that there are three vital things for each person: "to know what he ought to believe; to know what he ought to desire; and to know what he ought to do."[1]

Moral values derive from many sources: family, society, school, religion, professional training, and related interactions. Family and religion generally guide development of values during the formative years. For nearly all people, these values form the bedrock upon which their lives are structured. Additional significant influences are the media, schooling, and society. Education broadens a child's experiences and values beyond the home. Finally, societal pressures continue to influence most individuals' value systems throughout life. Taken as a whole, different individuals' values derived from these multiple sources may conflict, leading to disagreements when ethical dilemmas arise over which action to take.

Professional schooling and interactions further refine how a person's values are applied. For example, one reason that medical students take anatomy courses is to destroy an ingrained cultural value against mutilating the dead. This allows them to accept and acquire the values of beneficial mutilation (i.e., surgery), handling the dead (e.g., resuscitation, pathology, transplantation), and invading another's body (i.e., invasive medical procedures).[9] In addition, when exposed to clinical practice, medical students, nurses, medics, and other health care providers learn to adopt the values of their preceptors. In any residency program, trainees learn intrinsic professional values, and the majority of trainees behave remarkably like the faculty.

VALUES IN MODERN BIOMEDICAL ETHICS

Another category of professional values, which is sometimes referred to as the *Georgetown bioethics catechism,* has emerged as an ideal for modern medicine, especially in the United States. These values include autonomy, beneficence, nonmaleficence, and distributive justice.

For the past four decades in the United States, the overriding professional and societal bioethical value has been a patient's autonomy. *Autonomy* recognizes an adult's right to accept or reject recommendations for his or her personal medical care (even to the extent of refusing all care) in the presence of appropriate decision-making capacity. Current bioethical opinion demands that clinicians respect patient autonomy. This is the counterweight to the long-practiced paternalism of the medical profession, wherein the physician alone determined what was good for the patient. Coupled with paternalism is coercion, which is the threat or use of violence to influence behavior or choice. The august figure in white (or in a medic's or search-and-rescue team's uniform) who implies that there will be dire consequences if medical recommendations are not followed remains a potent challenge to patient autonomy.

At the patient's bedside, *beneficence,* which is the act of doing good, and confidentiality, which is the nondisclosure of personal health information (and which was not part of the original Georgetown list), have been long-held and nearly universal tenets of the medical profession. Likewise, personal integrity—adherence to one's own moral and professional standards—is basic to ethical thought and action. One basic tenet taught to all medical students is *nonmaleficence:* "First, do no harm." This credo, often stated in its Latin form as *Primum non nocere,* derives from the historic knowledge that patients' encounters with physicians can be harmful as well as helpful. It recognizes every physician's fallibility.

The concept of comparative or *distributive justice* suggests that all individuals and groups in society should share equitably in the benefits and burdens of that society. Many society-wide decisions about the allocation of limited health care resources are based on this principle. However, it is a fallacy to extrapolate from this valid principle the idea that individual clinicians can arbitrarily limit or terminate care on a case-by-case basis simply because there exists a need to limit resource expenditures.[15]

VALUES APPLICABLE TO WILDERNESS MEDICINE

Safety or Security

Safety is wilderness medicine's primary controlling value in most circumstances. Safety begins with a measure of responsibility toward oneself, then one's companions, and finally the patient. In the unique setting of wilderness medicine, this responsibility extends to the wilderness team's safety from the environment, victims, and their own poor judgment; this is a concept more familiar to emergency medical services personnel than to health care providers in normal medical practice. However, this value is of paramount importance in wilderness medicine. Safety is the responsibility of any wilderness medical provider, even if he or she is not officially designated a provider but must take over

during a medical crisis as a result of possessing special knowledge or skills. Decisions about rescue, evacuation, terminating group travel, or even attempts to perform certain medical interventions must include safety considerations.

As noted above, concerns about safety are applied in the following order: oneself, other team members, and then the patient. Ethical theory supports this hierarchy. Beneficence by medical personnel does not imply the need to endanger oneself. Indeed, if medical skills are to be useful, medical personnel must be able to render care. In addition, inherent in any leadership position is the responsibility to protect one's team. Therefore, the team members' safety is the second responsibility. Finally, the patient's safety should be ensured, but never at the expense of the medical team's safety. This is to say that, in unknown or unknowable circumstances, the medical leader may have to weigh potential risks against benefits. All risks must be considered in these "calculations," as in the case of a badly injured trekker who might survive if evacuated by aeromedical transport. If the helicopter team is willing to attempt a pickup, then the wilderness medical care provider must determine whether local conditions are sufficiently safe to justify the request, balancing the chance of benefit to the patient with potential safety risks.

One example illustrating safety issues occurred in the Pacific Northwest near Mt Baker. A group of adults and adolescents were on a hike above some snowfields when two parents and their daughter decided to glissade down one of the fields, something they had done before. As the mother and daughter sped over a crest, they dropped into a crevasse and were injured. The father pieced together what had happened and sought help. Eventually, a group of climbers was enlisted. No one was eager to descend into the trench, but one man from the climbing group agreed to be lowered on a rope, telling the group, "Just make sure you get me out."

The ethical question here is how much risk and responsibility untrained volunteers have in this type of wilderness crisis. A second issue that has to be considered is the capability of the group to attempt a rescue without endangering themselves and possibly creating the need for a second rescue. As a member of the hiking group, the father in this situation had a responsibility to help; however, because he was technically incapable of the rescue, his only responsible avenue of action was to seek help. Alternatively, bystanders have no fundamental responsibility to help or to assume any risk beyond what they are willing to assume. The man who agreed to be lowered into the crevasse would have been acting ethically if at any point in the rescue attempt he had signaled to the group to pull him up without helping the victims or if he had walked away and not allowed himself to be lowered into the trench in the first place. Despite entreaties from others, bystanders need not justify their participation or nonparticipation to anyone but themselves.[20]

In contrast, Ernest Shackelton, the appointed leader of a 19th-century attempt to be the first to reach the South Pole, had the responsibility to do his utmost to see his men safely home. During the voyage, their ship broke up in the ice, and the men had to pull lifeboats over ice to reach open sea while struggling against all odds to reach safety. Shackelton's steady and undaunted leadership is credited with helping all of his men to reach safety.[16]

A unique ethical problem that arises in wilderness settings, and that has often led to disasters, is when the team (especially the nonmedical team leader) ignores or overrides the medical person's decision. Individual team members have been harmed and multiple team members lost because factors other than the team members' safety and well-being were given priority.[14,22] Heeding the demands of safety is especially important, because the majority of people who are in the wilderness have risk-taking personalities, leading them to downplay security in favor of adventure.

Utility

In the language of ethics, utilitarian thinking plays a dominant role in wilderness ethics. Utilitarianism is the philosophy that promotes the greatest good or happiness for the greatest number of individuals. When applied to wilderness medicine, it promotes the well-being of the many over the well-being of the individual. This can be defended by simply recognizing the unique aspects of wilderness medical practice, such as the uncontrolled environment, unfamiliarity with the patient, rudimentary equipment, and changeable situations, all of which contribute to safety concerns.

The ultimate application of utility in remote settings was described in the great survivor story of the men of the *Essex;* the doomed whaling ship that was the basis for Herman Melville's *Moby Dick.*[21] As was common after shipwrecks, the men drew lots to decide who would be sacrificed and die so that the others in the small boat could live a little longer without starvation.[24] One can argue that if all of the men consented to this process, then it was ethical, but the very nature of the situation put each man under such extreme duress that it would be questionable if any man's consent could be considered voluntary. In these types of extreme circumstances, the ethics of draconian decisions, such as survivor cannibalism, are always fraught with paradoxic ethical dilemmas.[9]

Decision-Making Capacity and Consent

Many ethical dilemmas in emergency medical care revolve around ascertaining a patient's decision-making capacity, often linked with consent to, or more often, refusal of, a medical procedure. Because a basic canon of both ethics and law, as stated by Justice Cardozo, is that "[e]very human being of adult years and sound mind has a right to determine what shall be done with his own body,"[23] these decisions about what action to take can often be made more clear by understanding what is meant by the term *decision-making capacity* and how it relates to consent. (Note that the term *competent* is often used when *capacity* is really what is meant. *Competent,* meaning "possessing the requisite natural or legal qualifications," is a legal term; competency can be determined only by the court.[19])

Capacity is always decision-specific rather than global. To have adequate decision-making capacity in any particular circumstance, a person must understand the available options and the consequences of acting on the various options, and he or she must be able to compare any chosen option against the costs and benefits related to a relatively stable framework of personal values and priorities[3,4] (Box 101-1). This last requirement is the most difficult to understand and requires a subjective interpretation. The easiest way to assess it is to ask why the individual made such a decision. Disagreement with the physician's recommendation is not in and of itself grounds for determining whether a person is incapable of making his or her own decisions. In fact, even refusal of lifesaving medical care may not prove that the person is incapable of making valid decisions if that refusal is made on the basis of firmly held religious beliefs (e.g., a Jehovah's Witness refusing a blood transfusion).

A person must be permitted to consent to or to refuse any medical intervention if he or she has decision-making capacity for that decision and if the clinician respects the patient's autonomy. Three general types of consent exist: presumed, implied, and informed. *Presumed consent,* sometimes called *emergency consent,* covers the necessary lifesaving procedures that any reasonable person would wish to have if he or she was lacking decision-making capacity; controlling hemorrhage and securing an airway in an unconscious victim of a fall are common examples. *Implied consent* is when a person with decision-making capacity cooperates with a procedure, such as holding out an arm to donate blood or to allow initiation of an intravenous line. *Informed consent* is when a person who retains decision-making

BOX 101-1 Components of Decision-Making Capacity

Knowledge of options
Awareness of the consequences of each option
Appreciation of personal costs and benefits of options in relation to relatively stable values and preferences

From Buchanan AE: The question of competence. In Iserson KV, Sanders AB, Mathieu D, editors: *Ethics in emergency medicine,* ed 2, Tucson, Arizona, 1995, Galen Press.

capacity is given all of the pertinent facts regarding the risks and benefits of a particular procedure, understands them, and voluntarily agrees to undergo the procedure.[11]

Questions applying to consent in the wilderness setting can be difficult. Does the victim have the capacity to understand the situation? Will decision-making capacity be questioned only if a person refuses "good" medical care? In addition (and this is unresolved even in standard medical practice), one must consider which procedures require informed rather than implied consent. The requirement to obtain informed consent varies in practice and the law from area to area. This variation stems from differing local practice standards and state laws, and disparities in physician training. Determining decision-making capacity and providing an opportunity for a patient to consent to a procedure when appropriate are crucial to respecting that patient's autonomy.

BIOETHICAL DECISION-MAKING PROCESS*

Both standard bioethics and wilderness medical ethics often involve difficult situations with no "correct" answer. Usually more than two possible actions exist. When faced with such a dilemma, how should the health care practitioner respond? Health care professionals often apply their values without much conscious deliberation: they act instinctively based on their prior behavior and training. Values are constantly (although not necessarily consistently) applied to everyday decisions. Of course, most decisions are not ethical decisions. Ethical dilemmas arise from a conflict between two seemingly equivalent values that are represented by different and mutually exclusive possible actions.

An example of a bioethical dilemma in wilderness medicine may help illustrate ethical decision making. For example, a distress call is received from anxious relatives or by radio from a plane flying over a wilderness area. The victim is in a hazardous area or, more commonly, caught in terrible weather. The clinician directing the search and rescue team must decide how to respond to the call in a setting that may put the team in danger. The standard bioethical value of beneficence directly competes with the bioethical value of safety in wilderness medicine. Each has a strong pull on the decision maker, with each value providing good arguments for sending or not sending the rescue team. Although the value of safety may often be considered paramount in the wilderness setting, the emotional and altruistic pulls of beneficence make this a difficult choice. Considering this case, a word should first be said about rights and duties in relation to health care. Although the word *rights* is glibly used in many situations, a personal right is present only if another person or society as a whole has an identifiable duty to the individual. One person has a right to receive a service from another person only when the second person has a duty and therefore an obligation to provide that service. Correspondingly, no health care practitioner has a duty to provide all of the health care that people desire or need. However, practitioners do have a duty to provide safety, when possible, for those whom they direct in wilderness settings.

Because an ethical dilemma arises when two or more seemingly correct actions appear to have equal benefits, the choice of actions should be examined first. How are these proposed "correct" actions determined in the first place? After that, which of these actions is the more ethically acceptable?

CHOOSING AN ACTION IN THE STANDARD SETTING

Jonsen and colleagues[12] suggested four groups of factors to consider when determining a course of action in the face of a bioethical dilemma in the standard clinical paradigm. These include medical indications for the action, the patient's preferences, consideration of the quality of life, and other contextual factors. These can be seen as an "ethical square," with the top two boxes (i.e., the first two factors) having more weight (Figure 101-1).

Medical indications are often more straightforward in the wilderness setting than they are in standard health care. In the wilderness, treatment is basic, injuries and illnesses are generally acute, and intervention is normally life preserving rather than death prolonging. The clinicians use standard clinical algorithms that are appropriate for their level of training and expertise. In

MEDICAL INDICATION

1. What is the patient's medical problem? Prognosis?
2. Is the problem acute? Chronic? Critical? Emergent? Reversible?
3. What are the goals of treatment?
4. What are the probabilities of treatment success?
5. What are the plans in case of therapeutic failure?
6. In sum, how can this patient be benefited by medical interventions, and how can harm be avoided?

PATIENT WISHES

1. What has the patient expressed about treatment preferences?
2. Has the patient been informed of benefits and risks, understood, and given consent?
3. Does the patient have decision-making capacity? What is the evidence of incapacity?
4. Has the patient expressed prior preferences, e.g., advance directives?
5. If the patient is incapacitated, who is the appropriate surrogate? Is the surrogate using appropriate standards?
6. Is the patient unwilling or unable to cooperate with medical treatment? If so, why?
7. In sum, is the patient's right to choose being respected to the best extent possible?

QUALITY OF LIFE

1. What are the prospects, with or without treatment, for a return to patient's normal life?
2. Are there biases that might prejudice the provider's evaluation of the patient's quality of life?
3. What physical, mental, or social deficit is the patient likely to experience if treatment succeeds?
4. Is the patient's present or future condition such that he or she might judge continued life undesirable?

CONTEXTUAL FEATURES

1. SAFETY ISSUES. In wilderness medicine, these are often the most important considerations.
2. Are there family issues that might influence treatment decisions?
3. Are there provider (SAR or trip member) issues that might influence treatment decisions?
4. Are there financial and economic factors (evacuation/rescue costs)?
5. Are there problems of allocations of resources?
6. What are the legal implications of treatment decisions?
7. Any provider, organization-related, or institutional conflicts of interest?

FIGURE 101-1 The ethical square. SAR, search and rescue.

remote areas, questions may arise about whether an ophthalmologist should attempt to reduce a hip dislocation or whether a nurse should attempt to establish a surgical airway. These dilemmas should, when feasible, be decided with input from the patient or a surrogate. As a matter of proper planning, behavior in critical scenarios must be decided in advance. In general, however, medical indications are clear.

Bioethicists normally feel most comfortable helping to resolve cases using only the medical indications and patients' wishes, which are all above the double line in Figure 101-1. When these factors are ambiguous, however, two other sets of factors must be considered: contextual factors and quality of life. In the wilderness setting, the primary contextual factor is safety. This may overshadow all other considerations involved in a victim's treatment. Other contextual factors include the financial implications of various treatments and the effect of various options on other trip members. In the standard medical situation, this is, admittedly, a fuzzy area. Related to these, and even more nebulous, are quality-of-life factors. These relate to the nature of a person's current and presumed future existence as viewed by others. For those who retain decision-making capacity, their autonomous decisions reflect their view of life. In the wilderness setting, time and circumstances usually do not allow clinicians to make quality-of-life judgments.

CHOOSING AN ACTION IN THE WILDERNESS

The importance of safety factors in the wilderness setting leads to the altered diagram of decision making for ethical problems in wilderness medicine (Figure 101-2). This includes three groups of factors to consider when choosing a course of action: safety, medical indications, and patient autonomy. Within this decision-making model, safety factors must be given the most weight.

Safety factors include security of the medical and rescue personnel and the victim, as well as the risks of both proposed procedures and evacuation method. As mentioned previously, medical team safety is a valid consideration because of the inherent risk-taking nature of people in the wilderness. In recent legal actions pertaining to wilderness injuries, the law has recognized a "doctrine of reasonable implied assumption of risk." This implied risk is also part of an acceptable concept of wilderness triage. Wilderness triage takes place when the same injuries or illnesses that would cause minimal morbidity in a medically sophisticated environment inevitably cause death when they occur in the wilderness. A fractured femur in the lone wilderness traveler or an abdominal gunshot wound in a remote area is often a virtual death sentence. This is a risk that wilderness adventurers take, although not always with a clear understanding of the enormity of the risk.

USING AN ALGORITHM AS A GUIDE FOR A DECISION

In bioethics, although disagreements may arise regarding the optimal course of action chosen using a specific set of values,

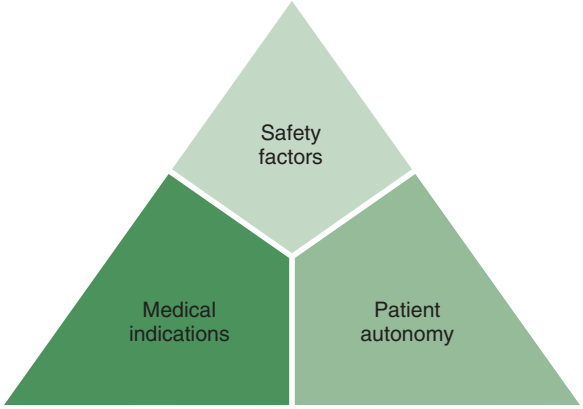

FIGURE 101-2 Wilderness medicine's ethical triangle.

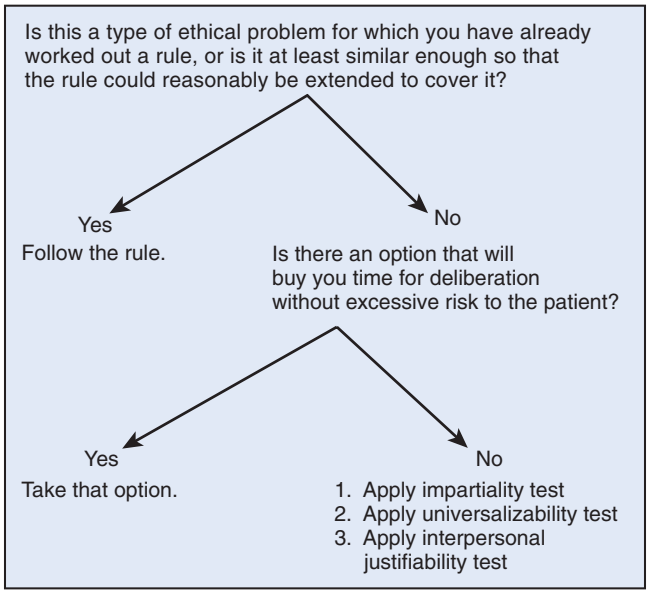

FIGURE 101-3 A rapid approach to emergency ethical problems. *(Modified from Iserson KV: An approach to ethical problems in emergency medicine. In Iserson KV, Sanders AB, Mathieu D, editors:* Ethics in emergency medicine, *ed 2, Tucson, Ariz, 1995, Galen Press.)*

general agreement often exists as to what constitutes ethically wrong actions. The method of ethical case analysis described in Figure 101-3 is designed to provide the emergency practitioner with prompt assistance for selecting an ethically correct, although not necessarily a theoretically "best," course of action.[7] This method applies equally well both in the wilderness setting and in the normal hospital setting.

The first step in using the algorithm in Figure 101-3 is to use a known precedent. This is the simplest solution to an ethical dilemma, but requires planning in advance, including reading and thinking about ethical problems. Many physicians and other health care professionals are not prepared to do this. Just as with any emergency procedure, wilderness medicine physicians and health care professionals should be prepared with a course of action for the most common ethical dilemmas likely to occur in the wilderness setting.

With no precedent, the second step is to "buy time." What action will not be harmful to the patient and will provide time for the consultation or information gathering needed to refine the action plan? In a wilderness medical setting, this might mean placing a person's arm in a sling for comfort while deciding whether an inexperienced provider should attempt to reduce a dislocation or fracture.

With no precedent on which to rely and no way to buy time, the health care professional must select a possible course of action and test it for ethical viability. The impartiality test, the universalizability test, and the interpersonal justifiability test are drawn from three different philosophical theories. First, the *impartiality test* is applied. The practitioner asks whether he or she would ask to have this action performed if he or she was in the patient's place. In essence, this is a form of the Golden Rule: "Do unto others as you would have done unto you." According to John Stuart Mill, this espouses "the complete spirit of the ethics of utility."[18] Second, the *universalizability test* asks if the health care professional would feel comfortable having all practitioners perform this action in all relevantly similar circumstances. This generalizes the action and asks whether developing a universal rule for the contemplated behavior is reasonable. This is merely a restatement of Kant's categorical imperative: "Act as if the maxim of thy act were to become by thy will a universal law of nature."[13] Finally, the *interpersonal justifiability test* asks if the practitioner can supply good reasons to others for his or her action. Will peers, superiors, or the public be satisfied with the action taken and reasons for it? This test uses David Gauthier's basic theory of consensus values as a final screen for a proposed

action.[6] If all three tests can be answered in the affirmative, the health care professional can be reasonably assured that the proposed action falls within the scope of morally acceptable actions. However, if the proposed action fails any of these tests, the algorithm must be applied to another proposed action.

ETHICAL DILEMMAS IN WILDERNESS MEDICINE

With its unique setting and mode of practice, wilderness medicine provides practitioners with situations that are rarely seen by most other providers. These dilemmas can be grouped into three categories: standards of care, priority in care, and the decision-making process (Box 101-2). As might be expected, some of the issues in each group deal with provider-patient dilemmas, whereas others have more to do with group or governmental policies. These dilemmas have few parallels in other areas of medical practice (except perhaps battlefield medical practice or medical care during major disasters), resulting in ethical decisions that differ from those in standard medical settings. Such dilemmas include providing euthanasia for potentially nonfatal medical conditions, abandoning patients, and prioritizing medical care for original patients and rescue team members. However, the ethical decision-making process used to sort through these dilemmas is similar to that used in other settings; this is a basic truism sometimes obscured by the unique setting and issues of wilderness medical care. A limited discussion of these ethical dilemmas and the values involved follows.

STANDARD-OF-CARE DILEMMAS

Limited Resources

In the wilderness setting, resources are limited. Medical equipment is usually confined to supplies that can be carried into the field on foot or, in some cases, by a pack animal or helicopter. Moreover, wilderness rescue personnel may have limited medical skills. The combination of limited skills and limited availability of supplies and equipment gives rise to ethical dilemmas. What should be included in wilderness medical kits? Their composition is resource allocation at its most basic. In addition, who makes these decisions?

Rarely do people consider pretrip decision making to be a part of medical care. However, it is very much a part of wilderness medicine. For example, decisions regarding the contents of medical kits made well in advance of, rather than during, triage will affect the patient's care. Although the individual wilderness traveler usually determines what is carried into the field, he or she generally fails to realize that this decision may set a limit on treatment. Any traveler planning a trip into a wilderness area must assume that the contents of the medical kit will be the only resources available for medical treatment. Although the group, a medical committee, or the medical director or advisor selects equipment for organized wilderness excursions or search and rescue teams, the selection still limits the medical care that can be given.

Although commercially available, standardized medical kits are usually designed on the basis of medical criteria, it is vital to recognize that some types of treatment will be implicitly unavailable because of what is excluded from these kits. No one is expected to carry a fully stocked emergency department into the field, but clearly identifying the ethical dilemmas that are entailed in compiling these kits helps team members with their decisions. For example, if a decision to not carry antiarrhythmic medications or a defibrillator is made and if a team member suffers a cardiac rhythm abnormality, then there will be little that can be done for him or her. Some people may omit medical kit items that could be useful, such as intravenous solutions. As the medical person on one doomed expedition to the Himalayan peak Nanda Devi recalled, "[My] irritation grew as [I] remembered [being] pressured into leaving intravenous fluids behind."[22] Such preexpedition resource decisions may jeopardize a team member.

Cultural Differences

Many wilderness emergencies occur in places outside of the United States or other Western countries. Are Western standards of care and attitudes appropriate when treating locals in a foreign country? Whose values control medical treatment and other actions?

Three circumstances may present ethical dilemmas in the delivery of medical care during expeditions to remote areas. The first is lack of cultural sensitivity. Aggressive offers to address disease or injury may frustrate or anger local patients or providers, whose methods of treatment fit within the region's cultural milieu and may be as good as or better than "modern" medicine. Temporarily replacing or upstaging traditional healers and their methods may degrade them in the eyes of the local population.

The second situation is when medical problems occur that are beyond the capabilities of an expedition's practitioners. After offering the care for which they are competent, practitioners may feel obligated to attempt treatments beyond their knowledge or abilities. An internist may face treating a gunshot wound to the chest, a psychiatrist may encounter a complicated obstetric emergency, or a paramedic may confront an epidemic. Often without any direction except a moral compass, these caregivers may be tempted to stretch their abilities beyond the limits of patient safety. Cultural ethical concerns should be considered when deciding which course of action to pursue.

The third situation relates to the larger question of the fairness of chance encounters: a woman's life is saved when a passing trekker is able to treat her pyelonephritis; after a surgeon relocates his hip, a man will continue to be able to provide for his family; and a paramedic happens to be on hand to intubate a child with epiglottitis. These situations by themselves rarely encompass ethical issues. The larger question, which may be more philosophical than practical, is how such interventions interfere with the balance of life in the area. Are chance encounters an aberration or simply a part of life? One of the most common situations in this category is a wilderness team from a developed country leaving medications behind with individuals who would not normally have access to them. Beyond the questions of the medications' efficacy, continued availability, and safety in inexperienced hands, there are the ethical concerns about altering the life balance of other cultures. Trekkers who traverse areas that others commonly visit do not face this dilemma, because medications are routinely distributed by a succession of groups. However, this question arises during expeditions that enter rarely visited areas, such as remote areas in Papua New Guinea or the Amazon Basin.

BOX 101-2 Ethical Dilemmas in Wilderness Care

Standard-of-Care Dilemmas
- Limited resources: The standard of care differs. What should be brought into the field? How are resources distributed?
- Cultural: Are Western standards of care and attitudes appropriate when treating locals in a foreign country?
- Untrained personnel: How much authority is delegated to untrained personnel?

Priority-in-Care Dilemmas
- Triage choices: Who should be rescued first? (Those most injured or ill? Injured or ill rescuers? Those with the best chance of survival? Women and children? Those with important information, such as scientists who have collected data? Those who do not volunteer to stay behind?)
- Issues of survival
- Issues of direct life-threatening situations for health care providers
- Motorized vehicle restrictions and environmental protection in the wilderness areas

Decision-Making Dilemmas
- Lack of availability of a surrogate decision maker or a family member
- Euthanasia
- Lack of an ethics consultation
- Advance directives
- No-rescue areas

Giving Authority to Untrained Personnel

Wilderness travelers face ethical dilemmas when they encounter medical situations for which they are not trained; this is certainly not restricted to laypersons. Medics, physician assistants, nurses, and physicians may quickly find themselves out of their depth in a wilderness setting. This occurs when they treat patients with conditions comfortably treated only in an urban environment or when an illness or injury is beyond the scope of personal experience and knowledge. When deciding whether to intervene in such a situation, the person planning to help must weigh the chance of benefiting the patient (i.e., the value of beneficence) against the chance of harming the patient (i.e., the value of nonmaleficence).

The following hypothetical case illustrates both the questions raised in this type of dilemma and application of the Rapid Approach to Emergency Ethical Problems (see Figure 101-3). A backcountry excursion sets out with a medical provider who is unprepared for orthopedic emergencies. When a group member dislocates her shoulder, the provider is unwilling to go beyond his level of training by attempting shoulder relocation, although the victim (as well as the rest of the party) encourages the attempt. Another member of the party with even less training volunteers to attempt the maneuver, so the clinician is now in a double bind, seemingly forced either to overextend his skills or to acquiesce to even less knowledgeable medical care for the victim.

How could this dilemma be resolved using the Rapid Approach to Emergency Ethical Problems? The first step would be to anticipate such a situation in advance and plan a course of action. Because orthopedic trauma is common in the wilderness, any medical provider should expect to face such a situation. Note that planning may obviate this ethical dilemma, as it does in many other situations, because the provider may then acquire the requisite orthopedic knowledge and skills in advance or may abandon plans to assume this wilderness medical role. Whether or not the skill level is unchanged, the provider may also make a decision about an ethical course of action after discussing the potential problem in advance with knowledgeable peers or after acquiring information from other sources. Perhaps the provider has previously decided to act in such situations (i.e., his or her paradigm as part of the Rapid Approach to Emergency Ethical Problems). It is reasonable to base intervention on (1) determining whether the patient has appropriate decision-making capacity; (2) informing the patient fully and honestly about the apparent situation and options; and (3) acquiescing to the patient's desires, whether attempting relocation or simply securing the arm in place. Honest acceptance of the patient's autonomy to control his or her medical care often resolves a seemingly difficult ethical dilemma.

If the provider believes that the "experienced" layman offering to help has insufficient knowledge, then the provider must decide whether the paradigm case for which he or she prepared a response is similar enough to use for the current circumstances. If it is, then the dilemma is resolved, and that rule should be followed. However, if the provider believes that the current situation differs significantly from the paradigm case or if he or she has simply failed to decide in advance about an ethical course of action, then the provider should move on to trying to buy time. In the scenario presented, buying time may consist of making the patient comfortable before contacting help or thinking through the problem. Help may be available to organized wilderness excursions through radio or mobile telephone communication. The assistance may involve experienced advice about other actions that can be taken to resolve the dilemma or orthopedic advice about ways to reduce the shoulder. Sometimes, however, no help is available or not enough time can be bought to secure help. In that case, the health care provider must make a decision to act.

Using step 3, the provider attempts to choose an action that is ethically acceptable (by applying the ideas found in Figure 101-2), even if it is not the optimal action that he or she might select if more time were available to consider the problem. Possible actions in this case might include attempting reduction, allowing the layperson to attempt reduction, simply immobilizing the victim's shoulder, leaving the victim and going for help, or ignoring the situation and leaving the decision to someone else. The provider must first choose a course of action (remembering that not deciding is also a course of action) and then decide whether the choice falls within the scope of ethically acceptable behavior. For example, if the proposed action is shoulder immobilization, the three tests of impartiality (i.e., the Golden Rule), universalizability (i.e., "Should every practitioner do as I plan to do?"), and interpersonal justifiability (i.e., "Would I be ashamed to have my actions publicized?") should be applied to this action. If the action passes all three tests, it is probably ethically acceptable and may be used. Remember that ethically acceptable actions may differ with the circumstances or the wilderness group involved.

Health care policy is another aspect of this type of ethical dilemma. Restricting medical practitioners from fully using their skills and knowledge may limit wilderness medical care. For example, paramedics are told that in some jurisdictions, on penalty of losing their licenses, they may not reduce fractures, perform cricothyrotomies, or, in a few locations, perform endotracheal intubations. Emergency medical technicians, first-aid providers, first responders, and the like are more severely restricted. Nurses may not know what procedures their licenses allow, and physicians are constantly concerned about liability. In general, many practitioners in wilderness settings feel that the laws and administrative policies under which they work restrict their actions. This attitude and their subsequent behavior may lead to substandard care for victims of wilderness injury or illness. The Wilderness Medical Society and other groups have begun working to overcome these limitations. Currently, however, an ethical dilemma may exist when practitioners face medical situations in the field that they know how to treat but that exceed their licenses or official certifications. A clear conflict may exist between the law and an individual's ethical responsibilities. Practitioners have to decide the best course of action, preferably in advance of the problem.

PRIORITY-IN-CARE DILEMMAS

Triage takes on new dimensions in wilderness settings. Ethical dilemmas easily arise when health care providers face not only triage among victims but also critical decisions about whether to help victims at all. These settings also produce situations in which rescuers or other members of the party may be placed in danger by helping an injured person.

Triage Choices: Whom to Rescue First and How to Distribute Resources

Medical practitioners, especially those in the fields of surgery and emergency care, are familiar with medical triage in which multiple patients need care and in which patients must be sorted by severity of injury, availability of resources, and possibility of successful treatment. These triage decisions have their own unique set of ethical dilemmas. Wilderness triage is unusual for several reasons and may present ethical dilemmas that are markedly different from those encountered in nonwilderness environments.

Three ethical dilemmas result from wilderness triage questions that are unlikely to occur elsewhere (with the exception of battlefield settings).[5] The first dilemma arises when the wilderness practitioner knows all the victims and may have personal ties to at least one. This is unlike normal triage scenarios and complicates any decision about who receives treatment, especially if resources are limited. For example, during an outbreak of giardiasis in a party of 12, the provider may have only enough metronidazole (Flagyl) to treat 5 people. Another more serious example would be a lightning strike in the midst of six people, with only one other individual capable of providing assistance. In each case, the medical practitioner applying triage criteria may be torn between medical and personal concerns.

A second ethical triage dilemma arises in what may be thought of as the "us-versus-them" situation. Members of both the wilderness party and the local population may be in the victim pool to be triaged. To whom does the provider owe

primary responsibility? Some may argue that the implicit or explicit contract between the provider and group members warrants treating group members first. However, in the battlefield setting, which may often be analogous to the wilderness setting with regard to medical ethics, the Geneva Convention specifies that patients are always to be triaged for medical care *on the basis of medical need and the ability to treat*. Whether military caregivers follow this dictum in practice is moot. The wilderness caregiver must carefully consider this issue before venturing into the field.

Finally, ethical dilemmas arise because not all team members are equal. If triage among team members is necessary, treatment on the basis of pure medical necessity is not always realistic. In the giardiasis example, will the sickest patients be treated, or will treatment be given to the less-sick guide and translator, who are needed to lead the party safely out of the wilderness? The greatest good for the greatest number, or the concept of group safety, must prevail. This may be neither a comfortable nor an intuitively obvious decision.

An ethical dilemma also arises when a rescue team member is injured while in the field. Should rescue teams treat their injured team member before, or instead of, other victims? Wilderness rescue is an inherently dangerous operation. Although the safety record of some organized and experienced rescue groups has been excellent, this is not universal, particularly with ad hoc rescue attempts.[10] Where should the team's priorities lie? Again, an analogy can be drawn with triage parameters in emergency care. The principle of triage is that, as long as resources are available, the most seriously injured are treated first. Those who cannot be saved with available resources or be evacuated in time to be saved are given only comfort measures. This situation logically and morally prevails in wilderness medical care. However, emotion rather than reason often influences actions, so the wilderness health care provider must ensure that ethical decision making prevails.

Issues of Survival

In some situations, the lives of expedition members may be put at immediate risk if an injured person receives optimal assistance. One well-known example is high-altitude climber Simon Yates, who, while trying to lower his injured climbing partner, Joe Simpson, down to base camp in the Peruvian Andes, found himself in a situation in which he had to either cut the lowering rope tethering his partner, almost assuredly killing him, or risk also dying himself.[25] (He chose to cut the rope and, amazingly, Simpson survived.)

> I couldn't help him, and it occurred to me that in all likelihood he would fall to his death. I wasn't disturbed by the thought. In a way I hoped he would fall. I knew I couldn't leave him while he was still fighting for it, but I had no idea how I might help him. I could get down. If I tried to get him down I might die with him. It didn't frighten me. It just seemed a waste. It would be pointless. … The knife! The thought came out of nowhere. Of course, the knife. Be quick, come on, get it. … I reached down again, and this time I touched the blade to the rope. It needed no pressure. The taut rope exploded at the touch of the blade, and I flew backwards into the seat as the pulling strain vanished. … I was alive, and for the moment that was all I could think about. … There was no guilt, not even sorrow. … I was actually pleased that I had been strong enough to cut the rope. There had been nothing else left to me, and so I had gone ahead with it. I had done it. … I was alive because I had held everything together right up to the last moment. It had been executed calmly. … I should feel guilty. I don't. I did right.

In another example, a diver may surface too quickly and suffer an air embolism. Reviewing the ethical considerations in wilderness medicine's ethical triangle (see Figure 101-2), both medical indications and possibly patient autonomy influence the decision to rapidly transport the victim to a recompression chamber. However, even with the medical urgency of the situation, the other divers' safety mandates that the boat remain in the area until the other divers are on board. This example demonstrates again that, in the wilderness setting, security factors are primary when making ethical decisions.

Issues of Direct Life-Threatening Situations for the Health Care Provider

Health care providers in a wilderness setting often have the opportunity to rescue others, which directly supports their underlying motivation to be of help. However, situations arise in which providing help puts the caregiver or the entire team at significant risk; this has already been discussed in Safety or Security, previously. Wilderness medical leaders commonly decline entering a dangerous situation to attempt to rescue a patient. However, a more direct and powerful ethical issue arises when the caregiver must directly and explicitly sacrifice the patient for personal or team safety; this is somewhat analogous to the difference between passive and active euthanasia. For example, this occurs when a helicopter hoisting a patient encounters difficulties that endanger the craft. Standard procedure is to cut the hoist line, sacrificing the patient. In the abstract, the safety of the helicopter crew (and possibly rescuers on the ground) outweighs that of the patient. Yet in reality, the conflict between safety and beneficence may not be intrinsically clear to the health care provider; an answer in favor of safety contradicts all professional education and experiences. This conflict must be resolved in advance or within a few seconds during the event if anyone is to survive. In the analogous scenario on the battlefield, the question is raised, "How many medics do you sacrifice to save one infantryman?" The same dilemma applies to rescuers.

DECISION-MAKING DILEMMAS

Health care decisions are generally the responsibility of the adult with decision-making capacity. If a patient lacks the ability to make these decisions, health care providers normally seek a surrogate decision maker, advance directive, or counsel of a bioethics committee or colleague. These resources are rarely available in the wilderness setting, so health care decisions can therefore become more problematic. When family or close friends are present, they may act as surrogates to make decisions for the patient, but this is much less frequent in the wilderness setting than in the urban environment. The wilderness medical provider must therefore be prepared to make difficult decisions without this guidance.

Advance Directives

To allay the problems of the absence of surrogate decision makers or knowledge about a patient's wishes, health care providers for organized expeditions, especially those in which significant risk of danger exists, may want to request that each team member complete an advance directive. The normal forms for advance directives (i.e., durable power of attorney for health care, living will) may not suffice in the wilderness setting. Rather, a more specific directive should be used. It should detail how aggressive each individual would want the team to be when trying to extract him or her from a dangerous situation if the victim (1) had a reasonable chance of survival given available resources; (2) had a reasonable chance of survival but with serious physical disability; (3) had a reasonable chance of survival but with serious brain injury; or (4) had a poor chance of surviving. It should also address what to do with the body if the individual dies. Any directive given by a team member would be tempered by the need to ensure the safety of other team members, but such a directive might give the medical provider a better idea of each team member's desires. Indeed, just discussing these scenarios with the team before the trip takes place may be beneficial for elucidating attitudes and health care desires in the wilderness.

Euthanasia

Controversy continues to rage in society and medicine over the concept of active euthanasia (i.e., mercy killing). In wilderness medicine, however, euthanasia may be less ethically problematic, although it is a very sensitive issue to discuss and devastating event for those involved. Active euthanasia may be an ethically acceptable alternative for the rare situation in which a patient will die either because he or she cannot be rescued from the wilderness environment or because survival of group members

would be jeopardized by attempting to evacuate or remain with him or her until help arrives. The seriously injured person on a high-altitude climb with inclement weather quickly approaching and the injured caver in a flooding cave are two examples. In these cases, euthanasia is based on the beneficence of relieving suffering in a doomed individual (although many in the medical profession believe that euthanasia violates professional principles), security for other members of the party (not creating more victims), and perhaps patient autonomy.[2]

Further complicating the preceding scenarios is the question of whether such patients should be simply left to die (i.e., passive euthanasia) or more humanely killed (i.e., active euthanasia). This question should be given serious consideration, because many incidents of passive euthanasia in wilderness settings occur, especially in high-risk or remote areas. For example, passive euthanasia has occurred several times on expeditions to Mt Everest when unconscious hypothermic climbers were left to die when conditions made it difficult or impossible to get them down.[22] The ethical question of what is best for the injured individual almost always comes into direct conflict with other team members' lack of confidence in their (or their medical person's) prognosis and their unwillingness to implement active euthanasia. Lack of certainty about a prognosis may sometimes be justified. For example, during a disastrous expedition to Mt Everest, a physician climber who was left for dead (active euthanasia was not discussed among team members) survived by eventually making it to camp on his own.

DILEMMAS IN WILDERNESS POLICIES

Ethical decision making plays a part in policies governing wilderness medicine. The values of beneficence and nonmaleficence make proposed and actual rules for wilderness medical practice untenable. These policies include when to stop searches, prohibition of motorized vehicles in wilderness areas, no-rescue areas, prohibition of environmental destruction, and restriction of medical providers' roles (see Giving Authority to Untrained Personnel, earlier).

When to Stop Searches

Without a body or corpse, it is difficult for managers of wilderness searches to know when to stop searching for someone who is presumed lost. Resource allocation decisions (i.e., distributive justice) create the contours of the solution to this kind of ethical dilemma. The parameters include available resources, probability of finding the lost person, danger to searchers, and likelihood of survivability under existing conditions. An example of such a dilemma occurred near Mt Rainier when a hunter briefly lost consciousness and became separated from his group. Fortunately, he was a strong, heavy man who could draw on fat stores for energy and warmth for several days. His hunting companions immediately began a search, followed by a formal search and rescue by a trained team the next morning. The dilemma was when to stop or pause the search because of bad weather, risks to the searchers, or the probability that the hunter was dead as a result of a preexisting heart condition. Severe weather caused the search to be halted after 4 days because of danger to the searchers, but it was to resume the next day after the weather had cleared. Before the search could be resumed, however, the victim found his way to a road, where he encountered a ranger. As this case illustrates, searches will often persist beyond the point at which the victim is believed to be dead in hopes of finding the victim alive or at least finding the corpse. It is the search leader's responsibility to continue the search process as long as it is reasonable to do so.[20]

Motorized Vehicle Restrictions and Environmental Protection in Wilderness Areas

A policy occasionally imposed on wilderness medical practice is that of no motorized vehicles in designated wilderness areas. This rule has logical roots but is enforced only intermittently. However, when it is used to hinder rescue efforts or delay needed medical care, it defeats a basic purpose of society: the assurance of citizens' welfare.

A related issue is the basic tenet of wilderness travel, which is that the environment should be left at least as pristine as it was found. However, situations arise when preservation of a wilderness area must be weighed against pain and suffering or life and death. Sometimes it may be necessary to chop down trees to make space for a helicopter pad or blast a new entry into a cave. Preservation of wilderness areas is an important goal, but so are preservation of human life and values, and the latter should not be overridden to reach a symbolic goal. Human life is a priority.

No-Rescue Areas

Perhaps the most pernicious concept proposed to govern wilderness medical care is that of the no-rescue area, into which adventurers would go with the foreknowledge that no rescue would be available.[17] This is akin to playing Russian roulette; people entering these wilderness areas put life and limb at risk while society condones and presumably enforces a requirement to not assist those in need. All explorers pushing the envelope of what is possible have entered these areas. The first men in space, and certainly Neil Armstrong and Buzz Aldrin, knew that rescue from the surface of the moon was not an option. The early mountaineers did not venture above 8000 m (26,247 feet) and expect a rescue if things went poorly. Today, the space shuttle has a backup plan, and climbers have been rescued from the highest altitudes. Is it reasonable to designate areas and to pursue adventures where no rescue would be attempted or even contemplated?

SUMMARY

Enjoying the wilderness and being capable and willing to provide care in remote settings fulfill many human desires. The challenges and decisions that sometimes need to be made can call an individual's values into question and haunt the individual for a long time. Preparing for these situations by thoughtfully selecting medical equipment, seeking out additional skills, and having difficult conversations with participants before a trip occurs can be as important as physical training. Sometimes, despite thorough preparation, unforeseeable events happen, and the decision tools presented in the algorithm in Figure 101-3 can be helpful to the provider and patient.

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