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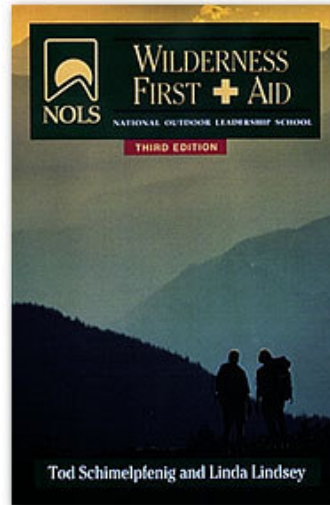
PUBLICATIONS

Altitude Illness

An excerpt from NOLS Wilderness First Aid

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Introduction

Each year approximately 6,000 people climb Mount Rainier- elevation 14,408 feet. Another 6,000 trek to the base of Mount Everest, reaching altitudes of 18,000 feet, and 800 people attempt to climb Denali-elevation 20,320 feet. Skiers in the Rocky Mountains often ski at altitudes of 11,000 to 12,000 feet; many arrive at altitude and ski within 24 hours of leaving low elevations. Thousands of people trek in Nepal, South America and Africa every year at altitudes of over 13,000 feet.

All of these people are at risk for altitude illness. Recent studies show that 66 percent of the climbers on Rainier, 47 percent of the Everest trekkers, and 30 percent of the Denali climbers develop symptoms of altitude illness.

NOLS expeditions have managed life-threatening cerebral edema at 21,000 feet on Cerro Aconcagua in Argentina and pulmonary edema at 9,000 feet in Wyoming's Wind River Range. Prevention through acclimatization provides some protection from altitude illness, but there is no immunity. If you travel in mountains you need to know how to prevent, recognize and treat altitude illness.

Altitudes are defined as:

High altitude.....8,000 - 14,000 feet
 Very high altitude.....14,000 - 18,000 feet
 Extreme altitude.....above 18,000 feet.

Lack of oxygen is the number one cause of health problems at altitude. Normally, oxygen diffuses from the alveoli into the blood because the gas pressure is greater in the alveoli than in blood. At altitude, diminished air pressure (barometric pressure) reduces the pressure in the alveoli and decreases the amount of oxygen diffusing into the blood. For example, in a healthy person at sea level, blood is 95 percent saturated with oxygen. At 18,000 feet it is only 71 percent saturated; i.e., it is carrying 29 percent less oxygen.

As altitude increases, barometric pressure falls logarithmically. Distance from

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the equator, seasons and weather also affect barometric pressure.

The greater the distance from the equator, the lower the barometric pressure, given the same elevation. For example, if Mt. Everest were located at the same latitude as Denali, the corresponding drop in barometric pressure would make an ascent without oxygen impossible.

As for seasons and weather, air pressure is lower in winter than in summer, and a low pressure trough will reduce pressure. While temperature does not directly affect barometric pressure, the combination of cold stress and lack of oxygen increases the risk of cold injuries and altitude problems.

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Adaptation to Altitude

The body undergoes numerous changes at higher elevation in order to increase oxygen delivery to cells and improve efficiency of oxygen use. These adaptations usually begin almost immediately and continue to occur for several weeks. People vary in their ability to acclimatize. Some adjust quickly while others fail to acclimatize, even with gradual exposure over a period of weeks.

In general, the body becomes approximately 80 percent acclimatized after 10 days at altitude and approximately 95 percent acclimatized by six weeks. The respiratory rate peaks in about one week and then slowly decreases over the next few months, although it tends to remain higher than its normal rate at sea level. After 10 days, the heart rate starts to decrease.

When we descend, we begin losing our hard-won adaptations at approximately the same rate at which we gained them; 10 days after returning to sea level, we have lost 80 percent of our adaptations.

Adaptation to Altitude

- Early Changes
 - Increased respiratory rate
 - Increased heart rate
 - Fluid shifts

- Later Changes
 - Increased red blood cell production
 - Increased 2, 3 DPG production
 - Increased number of capillaries

Increased Respiratory Rate

During the first week of adaptation, a variety of changes take place. Respiratory rate and depth increase in response to lower concentrations of oxygen in the blood, causing more carbon dioxide to be lost and more oxygen to be delivered to the alveoli. The increased respiratory rate begins within the first few hours of arriving at altitudes as low as 5,000 feet. The lost carbon dioxide causes the body to become more alkaline.

To compensate for the body's increasing alkalinity, the kidneys excrete bicarbonate--an alkaline substance--in the urine. This adaptation occurs within 24 to 48 hours after hyperventilation starts.

Increased Heart Rate

Cells require a constant supply of oxygen so the heart beats more quickly to meet the demand. Except at extreme altitudes, heart rate returns to near normal after acclimatization.

Fluid Shifts

Blood flow to the brain increases to provide the brain with its required volume of oxygen (equivalent to that available at sea level).

In the lungs, the pulmonary capillaries constrict, increasing resistance to flow through the lungs and raising pulmonary blood pressure. Dangerously high blood pressure in the pulmonary artery may cause fluid to escape from the capillaries and leak into the lungs (pulmonary edema).

Increased Red Blood Cell Production

As acclimatization continues, the bone marrow contributes by increasing red blood cell production. New red blood cells become available in the blood within four to five days, increasing the blood's oxygen-carrying capacity. An acclimatized person may have 30 to 50 percent more red blood cells than his counterpart at sea level.

Increased 2, 3 DPG Production

Within the blood cells 2, 3 Diphosphoglycerate (DPG) increases. This is an organic phosphate that helps oxygen to combine with red blood cells. Production of myoglobin, the intramuscular oxygen-carrying protein in red blood cells, also increases.

Increased Number of Capillaries

The body develops more capillaries in response to altitude. This improves the diffusion of oxygen by shortening the distance between the cell and capillary.

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Altitude Illness

High altitude illness results from a lack of oxygen in the body. Anyone who ascends to altitude will become hypoxic (the condition of having insufficient oxygen in the blood). Why some people become ill and others don't is not known. It is known, however, that most people who become ill do so within the first few days of ascending to altitude. The only sure treatment is to descend.

Six Factors That Affect The Incidence and Severity of Altitude Illness

1. Rate of ascent--the faster you climb the greater your risk.
2. Altitude attained (especially sleeping altitude)--the higher you sleep the greater the risk.
3. Length of exposure--the longer you stay high the greater the risk.
4. Level of exertion--hard exertion, without rest or hydration, increases the risk.
5. Hydration and diet--high fat and high protein diets, and dehydration, increases the risk.
6. Inherent physiological susceptibility--some people are more likely to become ill and we don't know why.

The three common types of altitude illness are acute mountain sickness (AMS), high altitude pulmonary edema (HAPE) and high altitude cerebral edema (HACE). AMS is the most common. It is not life threatening but if not treated, it can progress into HAPE or HACE. HAPE is less common but more serious. HACE is rare but can be sudden and severe.

Acute Mountain Sickness

Acute mountain sickness is a term applied to a group of symptoms. It is more apt to occur in unacclimatized people who make rapid ascents to above 8,000 feet. It also occurs in people who partially acclimatize then make an abrupt

ascent to a higher altitude.

Signs and Symptoms

Signs and symptoms tend to start six to 72 hours after arrival at high altitude. They usually disappear in two to six days. Symptoms are worse in the mornings, probably due to normal decrease in rate and depth of breathing during sleep, which lowers blood oxygen saturation. Symptoms include the following.

Signs and Symptoms of Acute Mountain Sickness

- Headache
- Malaise
- Loss of appetite
- Nausea, vomiting
- Peripheral edema
- Disturbed sleep
- Cyanosis

Headache

Increased cerebral blood flow helps the brain maintain its oxygen supply, but the expanded volume causes pain as the system adapts.

Malaise

Malaise (uneasy feeling), drowsiness, lassitude occur because of decreased oxygen in the blood.

Loss of Appetite, Nausea and Vomiting

When blood is shunted to the vital organs (heart, lungs, brain), perfusion of the gastrointestinal tract decreases, compromising its function. Anorexia, nausea and vomiting are the result.

Peripheral Edema

Persons with acute mountain sickness tend to retain fluid, resulting in edema, especially of the face and hands.

Disturbed Sleep

During sleep, a person's rate and depth of respiration may gradually increase until it reaches a climax. Breathing then ceases entirely for five to 50 seconds. This phenomenon is called Cheyne-Stokes respiration. Cheyne-Stokes breathing further decreases the level of oxygen in the blood.

Cyanosis

Cyanosis (a bluish appearance) in the fingernail beds, mucous membranes and around the mouth occurs as a result of decreased oxygen saturation of the blood.

Treatment

Limit your activity during the first three days at altitudes greater than 8,000 feet; it may take three to four days to acclimatize. Drink copious amounts of fluids to help the kidneys excrete bicarbonate. Aspirin, acetaminophen or ibuprofen may ease the headache. If symptoms worsen, signs of ataxia or pulmonary edema become apparent or there is a change in the level of consciousness, descend to the altitude where symptoms began. Usually descending 2,000 to 3,000 feet is sufficient.

Treatment for Acute Mountain Sickness

- Hydrate
- Rest
- Descend if:
 -
 - Symptoms worsen
 -
 - Signs of HAPE or HACE develop

High Altitude Pulmonary Edema (HAPE)

HAPE is abnormal fluid accumulation in the lungs resulting from maladaptation to altitude. The cause is not clearly understood. HAPE rarely occurs below 8,000 feet and is more common in young males.

Assessment

The symptoms of HAPE result from the decreasing ability of the lungs to exchange oxygen and carbon dioxide. The symptoms usually begin 24 to 96 hours after ascent.

Signs and Symptoms of High Altitude Pulmonary Edema

- Signs of acute mountain sickness
- Shortness of breath on exertion, progressing to shortness of breath in general
- Fatigue
- Dry cough progressing to a wet, productive cough
- Increased heart rate and respiratory rate
- Rales, sounds of fluid in the lungs
- Ataxia

HAPE may initially appear with mild symptoms similar to AMS. The patient complains of a dry cough and shortness of breath and fatigue while climbing uphill. The heart and respiratory rate increase. Cyanosis of the fingernail beds may occur.

As HAPE worsens, the shortness of breath, weakness and fatigue occurs while walking on level ground. The patient complains of a harsh cough, headache and loss of appetite. The heart and respiratory rate remain elevated. The nail beds become cyanotic. Rales ("rattles") can be heard with a stethoscope. The patient may be ataxic. Signs and symptoms may be mistaken for the "flu," bronchitis or pneumonia.

As HAPE becomes severe, the patient complains of a productive cough, extreme weakness and shortness of breath while at rest. Heart rate is greater than 110/minute, and respiratory rate is greater than 30/minute. Facial and nail bed cyanosis may be apparent. Rales can be heard without a stethoscope. The patient coughs up frothy blood-tinged sputum. The patient becomes ataxic, lethargic or unconscious.

HAPE, like AMS, becomes worse at night due to Cheyne-Stokes respirations. HAPE is a life-threatening illness.

Treatment

Descend to a lower altitude as quickly as possible--at least 2,000 to 3,000 feet is mandatory. Give oxygen, if available. If the symptoms do not improve, descend until they do. Keep the patient warm, as cold stress can worsen the condition. The patient should avoid exercise for two to three days so the fluid in the lungs can be reabsorbed. People with mild HAPE may attempt to ascend again when the condition disappears. Watch for a relapse. A patient with moderate to severe HAPE must be evacuated from the mountain to a hospital.

Treatment

- Descend at least 2,000-3,000 feet until symptoms abate

If you are unable to descend and have oxygen available, give the patient 100 percent oxygen at a flow rate of four to six liters per minute. If the condition does not improve increase the flow of oxygen. Descend as soon as possible.

High Altitude Cerebral Edema (HACE)

HACE is swelling of the brain thought to be caused by hypoxia-damage to brain tissue. HACE generally occurs above 12,000 feet but has been recorded at 10,000 feet in the Wind Rivers.

Signs and Symptoms

The classic signs of HACE are change in the level of consciousness, ataxia and severe lassitude. The patient may become confused, lose his memory or slip into unconsciousness. Ataxia is evident in the lower extremities first, then in the upper extremities. In severe cases the patient may be unable to hold a cup.

Other signs and symptoms may include headache, nausea, vomiting, cyanosis, seizures, hallucinations and transient blindness, partial paralysis and loss of sensation on one side of the body.

Signs and Symptoms of High Altitude Cerebral Edema

- Signs of acute mountain sickness
- Changes in level of consciousness
- Ataxia
- Severe lassitude
- Headache
- Nausea and vomiting
- Vision disturbances
- Paralysis
- Seizures
- Hallucinations
- Cyanosis

Treatment

DESCEND, DESCEND, DESCEND!! Do not hope the condition will get better if you wait. Waiting and hoping may be fatal. Descend to a lower elevation as soon as you notice any ataxia or change in the level of consciousness. Give oxygen if available.

Treatment

- DESCEND, DESCEND, DESCEND!!

Thrombophlebitis

Studies have shown that there is an increased tendency for blood to thrombose (clot) in arteries and veins at high altitudes. Dehydration, increased red blood cells, cold constrictive clothing and immobility during bad weather have been cited as possible causes.

Signs and Symptoms

Clots most commonly occur in the deep veins of the calf. The calf is swollen and painful. The lower leg may be pale or cyanotic with decreased pulses in the foot. Flexing the foot upward or walking increases calf pain. If the clot breaks loose, it can travel to the lungs and cause a pulmonary embolism.

Treatment

Loosen constrictive clothing. Give aspirin (1 or 2) every four hours for pain and to decrease the blood's ability to clot. The patient should be carried down from altitude.

Prevention

Dehydration can predispose one to blood clots. Hydration is important for prevention. Exercise feet and legs a few minutes every hour if bad weather confines the group to tents. Be careful of constrictive clothing, such as tight

gaiters.

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Final Thoughts: Acclimatization

Start out sleeping at altitudes below 10,000 feet and spend two to three nights there before going higher. For every 2,000 to 3,000 feet gained, plan to spend an extra night acclimatizing to the new altitude.

Climb high and sleep low. It is best not to increase the sleeping altitude by more than 2,000 feet at a time. Set up camp at lower elevations and take day trips to high points. Ferry loads up to a high camp and then return to the low camp to sleep as you acclimatize.

Acclimatization

- Ascend slowly
- Climb high, sleep low
- High carbohydrate diet
- Hydrate

Eat a high carbohydrate diet. Carbohydrates require less oxygen for metabolism than fats and proteins. However, a diet of exclusively carbohydrates does not meet the body's overall nutritional needs. Eat protein and fat on rest days. Avoid eating fats and protein at night. The combination of decreased respiratory rate during sleep and increased requirement for oxygen to metabolize fats and proteins increases the risk of altitude illness.

Drink copious amounts of fluid. Urine should be clear not yellow. Avoid sleeping pills, which decrease respiratory rates, aggravating the lack of oxygen.

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Summary: Altitude Illness

The risks of altitude illness can be reduced by acclimatizing to altitude. Ascend slowly, climb high, sleep low, eat a high-carbohydrate diet and stay hydrated!

The only definitive treatment for altitude illness is to

- DESCEND
 -
 - DESCEND
 -
 -
 - DESCEND!!

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