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

Wilderness EMT Lesson Plan

Part 10: Altitude Illness

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The ASRC-CEM Wilderness Emergency Medical Services Institute

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

The WEMSI Wilderness EMT Curriculum

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

With its prerequisites, this Curriculum complies with the Wilderness Prehospital Emergency Care curriculum established by the Wilderness Medical Society. We assume that students have the knowledge and skills of an EMT-Basic or EMT-Paramedic. (The curriculum can accommodate both EMTs and paramedics in the same class.) The other prerequisite is certification to the Virginia Ground Search and Rescue Field Team Member standards or equivalent. EMT standards are available from state EMS offices or the U.S. Department of Transportation. The Virginia GSAR standards are available from the Virginia Department of Emergency Services, 310 Turner Road, Richmond, VA 23225-6491. The curriculum is competency-based rather than hours-based, but can be competed in roughly five intensive days. The curriculum also provides a checklist of recommended clinical training.

WEMT Lesson Plan Development

An outline for each of the twenty sections of the WEMT curriculum was created by a Task Group of five to twenty selected members, but draws on many published sources and consultants. A Task Group Leader guides the Task Group in reviewing and revising the section, and the Project Coordinator actively supervises all aspects of curriculum development. Each Task Group provides references to support its statements and for further reading, and a glossary.

They also have been refined through seven pilot classes, several which have been held under the auspices of the Virginia Department of Emergency Services and Division of Emergency Medical Services. These agencies played a major part in development of the curriculum.

When the outline satisfies the Task Group, it goes to our **Editorial Board**. This Board includes officers of the ASRC and Center for Emergency Medicine, experts in emergency medicine, search and rescue, and education, and a State EMS director. Once it is acceptable to the Board, we release the Lesson Plan to the public.

Because we expect many good suggestions from the public, we are publishing these Lesson Plans, in a sense, as "drafts." We will distribute these individual Lesson Plans as widely as possible. After all Lesson Plans have had a year of public review, we will review and revise as appropriate, then issue a single comprehensive curriculum. We will continue to review and revise the curriculum regularly.

We actively solicit suggestions from anyone reading this. Please send your comments to the Task Group Leader as listed on the title page.

We are writing a textbook based on the material in the lesson plans. The Project Coordinator is the Editor-in-Chief, and works closely with Task Groups to consolidate and revise the material into a comprehensive textbook. All who have contributed to the curriculum will be acknowledged as contributors. The textbook will be submitted for publication in 1997.

Notes: *Altitude Illness*

The immediate management of altitude illness is taught in EMT and EMT-P classes. However, the coverage is scanty, and the information is often out-of-date in this rapidly-changing field. We do not want to go into details of the pathophysiology of altitude illness, which is still somewhat murky. However, certain principles are now well established, in addition to the well known imperative of descent. Wilderness EMTs must know about the roles of acetazolamide, nifedipine, and steroids for altitude illness.

X. Altitude Illness

A. Educational Objectives

1. List common medical problems that may be exacerbated by altitude exposure.
2. List the symptoms of acute mountain sickness.
3. Describe major predisposing factors for altitude illness, and describe the effect, if any, of aerobic condition on the likelihood of acute mountain sickness.
4. List three measures to prevent altitude illness.
5. Describe the signs, symptoms, and natural history of:
   a. mild and severe acute mountain sickness;
   b. high altitude cerebral edema (HACE);
   c. high altitude pulmonary edema (HAPE);
   d. peripheral edema from altitude; and
   e. high altitude retinal hemorrhage (HARH).
6. Outline the recommended treatment for mild acute mountain sickness, for mild and severe HACE, and for mild and severe HAPE.

B. General

1. altitude illness
   a. acute mountain sickness (AMS)
   b. chronic mountain sickness
   c. high altitude pulmonary edema (HAPE)
   d. high altitude cerebral edema (HACE)
   e. high altitude retinal hemorrhage (HARH)[*1]
2. AMS very common, HAPE less common, HACE even less common
3. direct effects of altitude and hypoxia **not** mountain sickness:
   a. decreased mental function due to hypoxia
   b. shortness of breath due to hypoxia
   c. periodic (Cheyne-Stokes) breathing, especially at night
   d. (effects of altitude discussed more in *The Wilderness Environment*)
4. altitude illness

* High Altitude Flatus Expulsion (HAFE): is butt of many jokes, but does appear in the medical literature; gases expand as ascend; gases in bowel no exception, and either escape in the form of flatus, or you explode; one case of intestinal rupture possibly due to HAFE reported; medication called simethicone, found in Mylicon® tablets and some antacids (e.g., Mylanta II®), may offer some relief; when planning ascent, common sense recommends avoiding carbonated beverages and beans; other measures often imposed by teammates, including separate tent and downwind tent site

a. depends on both altitude + rapidity of ascent
b. unlikely below 6000-7000 feet (2000 meters)
c. more common as rapidly ascend to 10,000 feet (3000 meters)
d. at 14,000 feet (4300 meters), even if slow ascent, even more likely

5. altitude exacerbates medical conditions:
   a. hypoxia makes following worse:
      (1) angina pectoris
      (2) congestive heart failure
      (3) chronic obstructive pulmonary disease
   b. hypertension worse from acute exposure to altitude[2]
6. cause of altitude illness controversial, but some suggest (simplified):
   a. root cause is hypoxia, due to hypoventilation; those with lower than normal hypoxic ventilatory drive more susceptible
   b. hypoxia and hypoventilation cause headache and nausea of AMS; in HACE, capillaries leak fluid, causing brain swelling
   c. hypoxia also leads to vasoconstriction in lungs, resulting in increased pressure in some blood vessels there, then leaking from capillaries (pulmonary edema)[3]
7. predisposing factors for altitude illness:
   a. low home altitude
   b. sleeping altitude
   c. rapidity of ascent
   d. individual susceptibility for altitude illness (those who had altitude illness likely to get again)
   e. males many times more likely to develop HAPE,* but being female no protection against AMS[4,5,6,7]
8. physical fitness
   a. physical fitness and experience in high altitude climbing: no immunity to altitude illness
   b. some studies show slight increase in altitude illness if in very good aerobic condition,[8] though evidence accumulating that this is not true[4,9]
   c. one study: poor aerobic condition and low-carbohydrate diet resulted in severe AMS[10]
   d. obesity may be risk factor for altitude illness[2,11]
9. dehydration
   a. does not, as once thought, predispose to altitude illness
   b. however, does markedly decrease performance at altitude
   c. should stay well-hydrated, because decreased urine output despite good hydration may be sign of altitude illness
10. neurological deficits:
   a. severe AMS/HACE and HAPE may cause confusion or a decreased LOC
   b. however, if patient at altitude with **focal** neurological deficit, cannot ascribe to altitude; should evacuate patient immediately for evaluation for possible stroke or TIA: both of more common at altitude than at sea level

C. Prevention of Altitude Illness

1. **staged ascent:**
   a. altitude illness related to rate of ascent
   b. slower ascents, or planned rest stops, decrease altitude illness
   c. sometimes, high altitude climbers descend each night, because sleeping altitude so important in development of altitude illness[12]
2. **drugs**
   a. **acetazolamide (e.g., Diamox®):**

(1) acetazolamide effective for preventing[12,1314] and treating altitude illness[15]

(2) same dosage for either: usual adult dose 250 mg twice a day,* either PO or IV

(3) some suggest just 125 mg twice or even once a day; some recommend three times a day, but Dr. Hackett recommends same twice a day dose for both prevention and for treatment

(4) to be most effective, start at least twenty-four hours before ascent

(5) acetazolamide is sulfa drug, and those with sulfa allergy must not take it; for such people, dexamethasone is reasonable alternative for prevention

(6) works by increasing ventilation and increasing oxygenation, not just masking symptoms

b. **dexamethasone (e.g., Decadron®):**

(1) works well for treating acute mountain sickness and HACE but not HAPE[16,17]

(2) symptoms may return if withdrawn, so important to continue if unable to descend

(3) some recommend it to prevent AMS;[18] one study showed it better than acetazolamide[19]

(4) another study, however, showed that lower than recommended doses ineffective for prevention[16]

(5) as with any potent steroid, may have significant side effects

(6) at present, we recommend dexamethasone to treat any patient with AMS, but for prevention only in those with a history of AMS, and only if allergic to sulfa (and thus allergic to acetazolamide)[20,21**]

c. **nifedipine (e.g., Procardia®, Adalat®):**

(1) will help prevent high altitude pulmonary edema in those who have had it before

(2) however, may have side effects including orthostatic hypotension (lightheadedness from low blood pressure on standing up)

(3) therefore not suitable for routine prevention, except possibly if prior history of high altitude pulmonary edema[22]

3. **high-carbohydrate diet:**

a. eating high-carbohydrate meals improves exercise performance at altitude, and decreases symptoms of AMS[10,23]

b. high-carbohydrate diet reduces altitude illness by 30%[24,25]

c. since most develop anorexia (decreased appetite) at altitude, sweet drinks ideal form of carbohydrate supplement[26]

4. **appropriate exercise levels:** some climbers report heavy exercise makes altitude illness more likely, though no controlled studies available

5. **avoid alcohol:** high altitude climbers report drinking alcohol well-known to increase incidence of altitude illness

6. **Don't let anyone ascend with symptoms of altitude illness.**

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* susceptible people have lower oxygen saturation, increased levels of some hormones (renin, angiotensin, aldosterone, norepinephrine, epinephrine, ACTH, cortisol); in one study, HAPE male:female ratio 49:1, though ratio of male:female climbers was only 2:1; same study shows 81% incidence of HAPE in those who had it before, but only 10% in others (controls)

* 5 mg/kg/day divided into two doses (twice a day)

D. Acute Mountain Sickness (AMS)

1. **mild AMS**
   a. **acute mountain sickness** (AMS)
   (1) common after sudden ascent: many flying to high altitude ski resorts have mild AMS
   (2) 20% who ascend rapidly to about 8,000-10,000 feet (2,500-3,000 meters) will develop AMS
   (3) however, migraine, muscle tension, and eyestrain headaches also more common at altitude, and may simulate symptoms of AMS[17,27,28]
   b. symptoms of acute mountain sickness, in addition to headache and nausea, include symptoms of alcohol hangover or migraine headache, both also thought due to brain vasodilation:
   (1) tiredness, malaise, and drowsiness
   (2) weakness and dyspnea on exertion
   (3) anorexia (loss of appetite)
   (4) difficulty sleeping, often with prominent periodic ("Cheyne-Stokes") breathing
   c. normal course of mild AMS, assuming don't ascend higher, is to last 15 hours, then resolve completely; rarely may last longer, up to 90 hours
2. **severe AMS:** recognized by increasing neurological symptoms, including confusion, ataxia (abnormal walking gait); grades into HACE
3. chronic mountain sickness: beyond scope of Wilderness EMT training (if interested, or to learn more physiological details of altitude illness, read altitude chapter in Auerbach and Geehr's text,[29] or Ward, Milledge, and West's compendium on altitude medicine and physiology[30])

E. High Altitude Cerebral Edema (HACE)

1. HACE is severe stage of AMS, with significant cerebral edema and elevated intracranial pressure
2. leak of fluid from blood into white matter of the brain
3. HACE less common than HAPE; of troops rapidly transported by air to 11,500 feet (3,500 meters), 1.25% develop HACE, 5.7% develop HAPE; mean altitude for HACE is 15,500 feet (4,720 feet), slightly higher than for HAPE[2]
4. most reliable sign of developing HACE is **ataxia**: ask patient to walk straight line, placing heel of one foot directly in front of toes of other foot; at altitude, if not otherwise intoxicated and cannot walk the line, must descend ASAP
5. later stages of HACE: coma, followed by death
6. stroke and TIA (transient ischemic attack) more common at altitude, and may look like HACE; may be due to combination of hypoxia, dehydration, and brain swelling

F. High Altitude Pulmonary Edema (HAPE)

1. as in ARDS (Adult Respiratory Distress Syndrome), protein-rich fluid leaks into lungs
2. onset usually slower than AMS, usually second to the fourth day after starting ascent or arriving at elevation
3. less common than AMS: after ascending to 12,000-14,000 feet (3,500 to

** Dr. Peter Hackett is our primary source for these drug recommendations

4,250 meters), only 0.5% of adults and 8% of those younger than 16 will develop HAPE[31]

4. diagnosis:
   a. **early diagnosis** key to treatment of HAPE
   b. early HAPE characterized by
   (1) dry cough
   (2) decreased exercise tolerance
   (3) intermittent slight shortness of breath and chest tightness, usually at night
   c. may note increased heart rate and increased respiratory rate even at rest, cyanosis of the lips or extremities, or râles (crackles) in lungs
   d. hypoxia of HAPE may not be associated with severe symptoms, because blunted drive to breathe is itself factor in the development of HAPE
   e. however, hypoxia from HAPE may cause confusion, neurological symptoms, or even coma, all without shortness of breath
5. patients with more severe HAPE often develop frothy sputum; once patient becomes unconscious from HAPE, death usually in 6-12 hours

G.Peripheral Edema

1. common on ascent to altitude; though uncomfortable, seldom causes problems in itself, though may warn of more severe altitude illness to come
2. diuretics such as furosemide (e.g., Lasix®) or acetazolamide sometimes given to more rapidly remove peripheral edema, but usually corrects anyway, even without medications, after a few days at altitude

H.High Altitude Retinal Hemorrhage (HARH)

1. common above 15,000 feet, but rarely cause symptoms, unless involve center retina, causing difficulty with vision
2. no known treatment or prevention for HARH, but descent wise if severe hemorrhage

I. Treatment of Altitude Illness

1. **AMS:** treatment of AMS mostly symptomatic:
   a. **stop ascending or go down**
   (1) mild AMS may indicate worsening AMS to come if rate of ascent stays the same
   (2) after symptoms gone, ascend at a slower rate
   (3) for more severe AMS, descent of 500-1000 meters (1500-3000 feet) adequate
   (4) if recovers completely, may safely reascend (gradually), but with understanding that predisposed to altitude illness
   b. **oxygen**, especially at night (low flow rate: 1 liter/minute)
   c. **aspirin or acetaminophen** for headache
   d. **antiemetics** (anti-nausea drugs) such as prochlorperazine (e.g., Compazine®) for nausea; somewhat sedating, but increases ventilation, especially when hypoxic,[32,33] so ideal for altitude illness
   e. **acetazolamide** (e.g., Diamox®): start unless contraindication such as sulfa allergy For treatment, give the standard dose (adults: 250 mg of acetazolamide every 12 hours,* PO or IV)
   f. **dexamethasone** (e.g., Decadron®): 4 mg PO or IV four times a day (if prednisone available, but not dexamethasone, 30 mg Prednisone four times a day roughly equivalent)
2. **severe AMS/HACE:**

a. for patients with altitude illness and significant neurological symptoms, only accepted treatment is to **go back down**; if weather or terrain prevent immediate descent, can use backpackable fabric pressure chamber to simulate a descent*[34,35,36,37,38]

b. although secondary compared with descent, start other treatments:**

(1) low-flow oxygen

(2) **dexamethasone** as described above for mild AMS

(3) **acetazolamide** unless allergic to it; give standard dose described above

(4) **furosemide** (e.g., Lasix®), in small doses (i.e., 20 mg PO or IV), will help decrease brain swelling; if give furosemide, must carefully monitor urine output and blood pressure

(5) if have Advanced Life Support capabilities, and patient has markedly decreased level of consciousness:

() place Foley urinary catheter

(a) start IV

(6) if patient deteriorates, may need to intubate and support ventilation

3. **Severe HAPE:**

a. if altitude illness and severe pulmonary symptoms, as for severe neurological symptoms, only accepted treatment is to **go back down** (portable pressure chamber may buy some time);[29,39,40,41,42,43] secondary treatments:

(1) high-flow oxygen

(2) keep patient warm; cold may increase spasm in pulmonary blood vessels

(3) if alert enough, use pursed-lip breathing, and use postural drainage (discussed in *Wilderness Medical Problems*)

(4) **nifedipine** (e.g., Procardia®, Adalat®) is treatment of choice for HAPE: usual dose 10 mg chew-and-swallow and a 20 mg sustained-release capsule immediately, then 20 mg sustained-release capsule every 6 hours[44,45]; nifedipine has also been used to prevent HAPE[46]

(5) **acetazolamide** unless allergic; use standard dose (described above)

(6) steroids such as dexamethasone not useful in treating HAPE

(7) furosemide and morphine, as used to treat congestive heart failure pulmonary edema on street or in Emergency Department, not very useful for HAPE, and clearly secondary to nifedipine and acetazolamide

Glossary

AMS: Acute mountain sickness.

Anorexia: Loss of appetite.

Ataxia: An abnormal walking gait.

Cheyne-Stokes Breathing: Periodic breathing, with waxing, waning, and periods of apnea. Common in congestive heart failure, and at altitude.

Diuretics: Medications that make you excrete more urine than your might ordinarily excrete. Lasix® (furosemide) is a strong, commonly-used diuretic. Acetazolamide (Diamox®) is a mild diuretic.

HACE: High altitude cerebral edema.

HAFE: High altitude flatus expulsion.

HAPE: High altitude pulmonary edema.

HARH: High altitude retinal hemorrhage.

Hypoventilation: Inadequate rate or depth of breathing.

Hypoxia: A low level of oxygen in the blood.

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* 5 mg/kg/day divided into two doses (twice a day)

* two designs now commercially available, one in the U.S., another in France; both used in Nepal

** these recommendations from Dr. Peter Hackett as of August 1992; differ slightly from recommendations of the Wilderness Medical Society Position Statements

TIA: transient ischemic attack. An acute neurological deficit, similar to a stroke, but that completely resolves in a short time (hours).

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