Chapter X:

Altitude Illness

Wilderness EMS Institute

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

Wilderness EMT Textbook

Chapter X: 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 Curriculum Development Project*, is devoted to developing curricula 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 seven 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 chapter is one part of the ASRC-CEM Wilderness Emergency Medical Technician Textbook. In concert with the WEMT Curriculum, the Textbook 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 many other sources in creating this Textbook. These include the Wilderness EMT program of 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 Textbook. The National Association of EMS Physicians has developed and has published clinical guidelines for delayed/prolonged transport; WEMSI protocols are also available as a model.

With textbooks used by its EMT and SAR prerequisites, this Textbook provides all the training material needed to complete the Wilderness Prehospital Emergency Care curriculum established by the Wilderness Medical Society. (Indeed, early drafts of this textbook were a major resource for the WMS curriculum.) 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.) We also assume that students have the knowledge and skills of the Virginia Ground Search and Rescue Field Team Member standards or better. (EMT standards are available from state EMS offices or the U.S. Department of Transportation. The Virginia GSAR standards and GSAR Manual 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 recommends clinical training, for which guidelines are available in the Curriculum.

WEMT Textbook Chapter 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 supervises all aspects of curriculum development.

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, our two sponsors. It also includes experts in emergency medicine, search and rescue, and education, and a State EMS director. Once the Lesson Plan is acceptable to the Board, it is released to the public.

Along with the Task Group Leader, the Editor-in-Chief then produces a Textbook chapter based on the Task Group's outline. Having a single editor provides a coherent, unified style. Basing each chapter on the Task Group's Lesson Plans, as approved by the Editorial Board, ensures accuracy. Each chapter provides glossary entries for any new terms. (New, that is, to a reader with basic EMT and SAR training.) In the complete textbook, these glossary entries will be merged and alphabetized. Each chapter also provides references to support its statements and for further reading. Background material that need not be presented in a class based on the Curriculum appear *in this small, italic font.*

The textbook will be commercially published when completed. All profits will be used to support curriculum development. The textbook will be submitted for publication in 1994. Until then, preliminary versions of the chapters will be printed in this format. These preliminary versions are for use **only** at classes authorized by the Executive Director.

A Course Guide, providing detailed information about Wilderness Emergency Medical Technician training and course scheduling, will also be available in mid-1994; a checklist for recommended in-hospital training is available now. For a price list of available publications, write to: Center for Emergency Medicine, 320 McKee Place, Suite 500, Pittsburgh, PA 15213-4904, or call: (412) 578-3200.

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.

General

The term altitude illness includes several syndromes, including acute mountain sickness (AMS), chronic mountain sickness, high altitude pulmonary edema (HAPE), high altitude cerebral edema (HACE), and high altitude retinal hemorrhage (HARH).*[1] AMS is very common, HAPE less common, and HACE even less common.

Certain medical consequences of altitude, due simply to direct effects of altitude and hypoxia, are not considered mountain sickness. Examples include decreased mental function due to hypoxia, shortness of breath due to hypoxia, and periodic (Cheyne-Stokes) breathing, especially at night. The effects of altitude are also discussed in the chapter on *The Wilderness Environment*.

Altitude illness is extremely unlikely below 6000 or 7000 feet (2000 meters) elevation. Likelihood of altitude illness depends on rapidity of ascent as well as altitude, but becomes a more common problem as you rapidly ascend to 10,000 feet (3000 meters). When you ascend to 14,000 feet (4300 meters) or above, even if slowly, altitude illness becomes even more likely.

Altitude exposure is known to exacerbate certain medical conditions. In particular, angina pectoris, congestive heart failure, and chronic obstructive pulmonary disease may all become significantly worse at altitude simply due to

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.

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

decreased oxygen availability. Hypertension is made worse by acute exposure to altitude.[2]

The exact cause of altitude illness is controversial, but some suggest the following. In simplified form, the root cause of acute mountain sickness is hypoxia caused by hypoventilation. This then causes headache and nausea. In high altitude cerebral edema, capillaries leak fluid, causing brain swelling. Hypoxia also leads to vasoconstriction in the lungs, resulting in increased pressure in some of the blood vessels there, and again leaking capillaries leading to pulmonary edema.[3]

Predisposing factors for altitude illness include:

* low home altitude
* low sleeping altitude;
* rapidity of ascent; and
* an individual susceptibility for altitude illness.

Those who have developed altitude illness once are likely to develop it again. Of interest, males are many times more likely to develop HAPE than females,* but being female is no protection against AMS.[4,5,6,7]

Physical fitness and experience in high altitude climbing confer no immunity to altitude illness. Indeed, some studies show a slight increase in altitude illness among those who are in very good aerobic condition,[8] though evidence is accumulating that this is not true.[4,9] One study showed that a combination of poor aerobic condition and a low-carbohydrate diet resulted in severe AMS.[10] Some suggest that obesity is a risk factor for altitude illness.[2,11]

Dehydration does not, as once thought, predispose to altitude illness. However, dehydration does markedly decrease performance at altitude. Those at altitude should also stay well-hydrated, because a decreased urine output despite good hydration may be a sign of altitude illness.

Severe AMS/HACE and HAPE may cause confusion or a decreased level of consciousness. However, if you see a patient at altitude with a focal neurological deficit, you cannot ascribe this to altitude. You should evacuate the patient immediately for evaluation for a possible stroke or TIA (transient ischemic attack), both of which are more common at altitude than at sea level.

Prevention of Altitude Illness

Staged Ascent

Altitude illness is clearly related to the rate at which you ascend. Slower ascents, or ascents with planned rest stops, markedly decrease the incidence of altitude illness. Sometimes, high altitude climbers can descend each night, because sleeping altitude is so important in the development of altitude illness.[12]

Drugs

Acetazolamide (e.g., Diamox®): Acetazolamide is effective both in preventing[13,12,14] and

* Those who develop altitude illness tend to have lower oxygen saturation and have increased levels of many hormones, including renin, angiotensin, aldosterone, norepinephrine, epinephrine, ACTH, and cortisol. Data from the high-altitude medical research center at the "Campanna Regina Marghereta" Alpine Hut, presented at the 1991 World Congress on Wilderness Medicine, by Oswald Oelz, M.D., showed a HAPE male:female ratio of 49:1, though the ratio of male:female climbers was only 2:1. The data also shows an 81% incidence of HAPE in those who have had it before, compared with 10% in control subjects.

in treating altitude illness.[15] Use the same dosage for either. The usual adult dose is 250 mg twice a day,* either PO or IV. Some have suggested doses of just 125 mg twice or even once a day. Some have recommended giving the dose three times a day, but Dr. Hackett recommends using the same twice a day dose for both prevention and for treatment. To be most effective, start acetazolamide at least twenty-four hours before ascent. Acetazolamide is a sulfa drug, and those with a sulfa allergy must not take it. For such people, dexamethasone is a reasonable alternative for prevention. Acetazolamide works by increasing ventilation and increasing oxygenation, not just by masking symptoms.

Dexamethasone (e.g., Decadron®): Dexamethasone works well for treating acute mountain sickness and HACE, but not HAPE.[16,17] Symptoms may return if the drug is withdrawn, so it is important to continue therapy if unable to descend. Some have recommended that it be used to help prevent AMS,[18] and one study showed it worked better than acetazolamide.[19] Another study, however, showed that lower than recommended doses may be ineffective for prevention.[16] As with any potent steroid, dexamethasone may have significant side effects. At present, we recommend that you use 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]**

Nifedipine (e.g., Procardia®, Adalat®) will help prevent high altitude pulmonary edema in those who have had it before. However, nifedipine may have side effects including orthostatic hypotension (lightheadedness from low blood pressure on standing up). Therefore it is not suitable for routine prevention, except possibly for those with a prior history of high altitude pulmonary edema.[22]

High-Carbohydrate Diet

There is good evidence that high-carbohydrate meals improves exercise performance at altitude, and decreases the symptoms of AMS.[10,23] A diet high in carbohydrates was shown in one study to reduce the incidence of altitude illness by 30%.[24,25] Since most people develop anorexia (decreased appetite) at altitude, sweet drinks make an ideal form of carbohydrate supplement.[26]

Appropriate Exercise Levels

Some climbers report that heavy exercise makes one more likely to develop altitude illness, though no controlled studies are available.

Avoid Alcohol

High altitude climbers report that alcohol ingestion is well-known to increase the incidence of altitude illness.

Ascent

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

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

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

Acute Mountain Sickness (AMS)

Mild AMS

Acute mountain sickness (AMS) is common after sudden ascent to altitude; many people flying to high altitude ski resorts have symptoms of at least mild acute mountain sickness. About 20% of people who ascend rapidly to about 8,000-10,000 feet (2,500-3,000 meters) will develop AMS. (However, migraine, muscle tension, and eyestrain headaches are also more common at altitude, and may simulate some symptoms of AMS.)[17,27,28]

The symptoms of acute mountain sickness, in addition to headache and nausea, include many of the symptoms of an alcohol hangover, or a migraine headache, both of which are also thought to be caused primarily by brain vasodilation:

* tiredness, malaise, and drowsiness;
* weakness and dyspnea on exertion;
* anorexia (loss of appetite); and
* difficulty sleeping, often including prominent periodic ("Cheyne-Stokes") breathing.

The normal course of mild acute mountain sickness, assuming you don't ascend any higher, is to last an average of 15 hours, then resolve completely. Sometimes the acute mountain sickness will last longer, up to 90 hours in extreme cases.

Severe AMS

Severe acute mountain sickness is recognized by increasing neurological symptoms, including confusion, ataxia (an abnormal walking gait), and grades into high altitude cerebral edema.

Chronic mountain sickness

Chronic mountain sickness is beyond the scope of Wilderness EMT training. If you are interested in it, or would like to delve into the physiological details of altitude illness, read the altitude chapter in Auerbach and Geehr's text,[29] or read Ward, Milledge, and West's compendium text on altitude medicine and physiology.[30]

High Altitude Cerebral Edema (HACE)

High altitude cerebral edema (HACE) is a severe stage of AMS, with significant cerebral edema and elevated intracranial pressure. The problem seems to be a leak of fluid from the blood into the white matter of the brain. HACE is less common than HAPE; of troops rapidly transported by air to 11,500 feet (3,500 meters), 1.25% develop HACE, while 5.7% develop HAPE; the mean altitude of occurrence for HACE is 15,500 feet (4,720 feet), slightly higher than that for HAPE.[2]

The most reliable sign of developing high altitude cerebral edema is ataxia. Ask the patient to walk a straight line, placing the heel of one foot directly in front of the toes of the other foot. At altitude, anyone who is not otherwise intoxicated, and who cannot walk the line, must descend as soon as possible.

Later stages of HACE usually show increasing somnolence and coma, followed by death.

The incidence of stroke and TIA (transient ischemic attack) is increased at altitude, and may mimic the signs and symptoms of HACE. This increased likelihood of stroke may be due to a combination of hypoxia, dehydration, and brain swelling.

High Altitude Pulmonary Edema (HAPE)

Early **high altitude pulmonary edema** (HAPE) is characterized by a dry cough, decreased exercise tolerance, and intermittent slight shortness of breath and chest tightness, usually at night. Onset is usually slower than acute mountain sickness, usually occurring from the second to the fourth day after starting the ascent, or arriving at elevation. HAPE is less common than AMS: after ascending to 12,000-14,000 feet (3,500 to 4,250 meters), only 0.5% of adults and 8% of those younger than 16 will develop HAPE.[31] As in ARDS (Adult Respiratory Distress Syndrome), protein-rich fluid leaks into the lungs. On exam, you may note an increased heart rate and increased respiratory rate even at rest, cyanosis of the lips or extremities, or râles (crackles) in the lungs. **Early diagnosis** is essential to the treatment of HAPE.

The hypoxia of HAPE may not be associated with severe symptoms, because the blunted drive to breathe is itself a factor in the development of HAPE. However, hypoxia from HAPE may cause confusion, neurological symptoms, or even coma, all without shortness of breath. Patients with more severe HAPE often develop frothy sputum. Once a patient becomes unconscious from HAPE, death usually ensues in 6-12 hours.

Peripheral Edema

Peripheral edema is common on ascent to altitude. Though at times uncomfortable, it seldom causes problems in itself, though it may be a warning of more severe altitude illness impending.

Diuretics such as furosemide (e.g., Lasix®) or acetazolamide are sometimes given to more rapidly remove peripheral edema, but the condition usually corrects after a few days at altitude without medication.

High Altitude Retinal Hemorrhage (HARH)

High-altitude retinal hemorrhages are common in travelers above 15,000 feet, but rarely cause symptoms, unless they involve the central parts of the retina, causing difficulty with central vision.

There is no known treatment or prevention for HARH, but descent would be wise for a person with a severe hemorrhage.

Treatment of Altitude Illness

AMS

The treatment of acute mountain sickness is mostly symptomatic.

Stop ascending or go down. Mild AMS may be a harbinger of worsening AMS to come if the rate of ascent stays the same. After the symptoms have gone, ascend at a slower rate. For more severe AMS, a descent of 500-1000 meters (1500-3000 feet) is adequate. If the patient recovers completely, he or she may safely reascend (gradually), but with the understanding that he or she is predisposed to altitude illness.

Oxygen may help, especially at night. Low flow rates are sufficient (1 liter/minute).

Aspirin or acetaminophen will help the headache.

Antiemetics (anti-nausea drugs) such as prochlorperazine (e.g., Compazine®) will help the nausea. Despite being somewhat sedating, prochlorperazine actually increases ventilation, especially when one is hypoxic.[32,33] Therefore it is ideal for the nausea of altitude illness.

Acetazolamide (e.g., Diamox®) should be started unless there is some contraindication such as a sulfa allergy. For treatment, give the standard dose (adults: 250 mg of acetazolamide every 12 hours,* PO or IV).

Give **dexamethasone** (e.g., Decadron®) 4 mg PO or IV four times a day (if prednisone is available, but not dexamethasone, a dose of 30 mg of Prednisone four times a day is roughly equivalent).

Severe AMS/HACE

For patients with altitude illness and significant neurological symptoms, the only accepted treatment is to **go back down**. If weather or terrain prevent immediate descent, you can use a backpackable fabric pressure chamber to simulate a descent.**[34,35,36,37,38] Although secondary compared with descent, other treatments may be of some benefit:***

* Low-flow oxygen.
* Give **dexamethasone** as described for mild AMS.
* Start **acetazolamide** unless allergic to it. Give the standard dose described above.
* **Furosemide** (e.g., Lasix®), in small doses (i.e., 20 mg PO or IV), will help decrease brain swelling. If you give furosemide, you must carefully monitor urine output and blood pressure.

If you have Advanced Life Support capabilities, and the patient has a markedly decreased level of consciousness:

* place a Foley urinary catheter; and
* start an IV.
* If the patient deteriorates, you may need to intubate and support ventilation.

Severe HAPE

For patients with altitude illness and severe pulmonary symptoms, as for those with severe neurological symptoms, the only accepted treatment is to **go back down.**[29,39,40,41,42,43] A portable pressure chamber may buy some time. Other secondary treatments include the following.

* If available, start high-flow oxygen.
* Keep the patient warm; cold may increase the spasm in the pulmonary blood vessels.
* If alert enough, have the patient use pursed-lip breathing, and use postural drainage (discussed further in the section on *Wilderness Medical Problems*).
* Studies show that **nifedipine** (e.g., Procardia®, Adalat®) is the treatment of choice for HAPE. The usual dose is 10 mg chew-and-swallow and a 20 mg sustained-release capsule immediately, followed by a 20 mg sustained-release capsule every 6 hours.[44,45] Nifedipine has also been used to prevent HAPE.[46]
* Start **acetazolamide** unless allergic to it. Use the standard dose described above.

Steroids such as dexamethasone are not useful in treating HAPE.

Furosemide and morphine, which are used to treat congestive heart failure pulmonary edema on the street or in the Emergency Department, are not very useful for HAPE, and are clearly secondary to nifedipine and acetazolamide.

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

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

*** These reflect the recommendations of Dr. Peter Hackett as of August 1992, and differ slightly from the recommendations of the Wilderness Medical Society Position Statements.

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.

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

References

1. Auerbach PS, Miller EY. High altitude flatus expulsion (HAFE) [letter]. *West J Med* 1981;134:173.
2. Hultgren HN. High-altitude medical problems (CTM:IX). *Scientific American Medicine.* Ed. Rubenstein E Federman DD. 1991.
3. Schoene RB. Pulmonary edema at high altitude: Review, pathophysiology, and update. *Clinics in Chest Medicine* 1985;6(3):491-506.
4. Honigman B. Acute mountain sickness at moderate altitudes. *Syllabus: Eighth annual scientific meeting of the Wilderness Medical Society* 1992:127-40. Indianapolis, IN: Wilderness Medical Society.
5. Hackett PH, Rennie D, Levine HD. The incidence, importance, and propylaxis of acute mountain sickness. *Lancet* 1976;2(7996):1149-55.
6. Hackett PH, Rennie D. Acute mountain sickness [letter]. *Lancet* 1977;1(8009):491-2.
7. Hackett PH, Rennie D. Avoiding mountain sickness [letter]. *Lancet* 1978;2(8096):938.
8. Cymerman A, Jaeger JJ, Kobrick JL, Maher JT. Physical fitness and acute mountain sickness (AMS). *Proceedings of the First International Hypoxia Symposium* 1979. Alberta, Canada.
9. Gupta JS, Joseph NT, Malhotra MS. Physical fitness status and adaptation to high altitude. *Indian J Med Res* 1978;68:312-21.
10. Consolazio CF, Johnson HL, Krzywicki HJ. Body fluids, body composition, and metabolic aspects of high-altitude adaptation. *Physiological adaptations: Deserts and mountains.* Ed. Consolazio CF, Johnson HL, Krzywicki HJ. NY: Academic, 1972:227-41.
11. Hirata K, Masuyama S, Saito A. Obesity as risk factor for acute mountain sickness [letter]. *Lancet* 1989;2:1040-1.
12. Evans W, Robinson SM, Horstman DH, Jackson RE, Weiskopf RB. Amelioration of the symptoms of acute mountain sickness by staging and acetazolamide. *Aviat Space Environ Med* 1976;47:512-6.
13. Forwand SA, Landowne M, Follansbee JM, Hansen JE. Effect of acetazolamide on acute mountain sickness. *N Engl J Med* 1975;279:839-45.
14. Larson EB, Roach RC, Schoene RB, Hornbein TF. Acute mountain sickeness and acetazolamide: Clinical efficacy and effect on ventilation. *JAMA* 1982;248(3):328-32.
15. Grissom C, Roach R, Sarnquist F, Hackett P. Acetazolamide in the treatment of acute mountain sickness: Clinical efficacy and effect on gas exchange. *Ann Intern Med* 1992;116(6):461-5.
16. Hackett PH, Roach RC, Wood RA, et al. Dexamethasone for prevention and treatment of acute mountain sickness. *Aviat Space Environ Med* 1988;59:950-4.
17. Montgomery AB, Luce JM, Michael P, Mills J. Effects of dexamethasone on the incidence of acute mountain sickness at two intermediate altitudes. *JAMA* 1989;261(5):734-6.

18. Zell SC, Goodman PH. Acetazolamide and dexamethasone in the prevention of acute mountain sickness. *West J Med* 1988;148:541-5.

19. Ellsworth AJ, Meyer EF, Larson ER. Acetazolamide or dexamethasone use versus placebo to prevent acute mountain sickness on Mount Rainier. *West J Med* 1991;154(3):289-93.

20. Levine BD, Yoshimura K, Kobayashi T, Fukushima M, Shibamoto T, Ueda G. Dexamethasone in the treatment of acute mountain sickness. *N Eng J Med* 1989;321(25):1707-13.

21. Rabold MB. Dexamethasone for prophylaxis and treatment of acute mountain sickness. *J Wild Med* 1992;3(1):54-60.

22. Brtsch P, Maggiorini M, Ritter M, Noti C, Vock P, Oelz O. Prevention of high-altitude pulmonary edema by nifedipine. *N Engl J Med* 1991;325(18):1284-9.

23. Askew EW. Nutrition and performance under adverse environmental conditions. *Nutrition in exercise and sport.* Ed. Hickson JF Wolinsky I. Boca Raton, FL: CRC Press, Inc., 1989:367-84.

24. Consolazio CF, Matoush LO, Johnson HL, Krzywicki HJ, Daws TA, Isaac GJ. Effects of high-carbohydrate diets on performance and clinical symptomatology after rapid ascent to high altitude. *Federation Proceedings* 1969;28:937-43.

25. Krzywicki HJ, Consolazio CF, Johnson HL, Nielsen WC Jr, Barnhart RA. Water metabolism in humans during acute high-altitude exposure (4,300 m). *J Appl Physiol* 1971;30(6):806-9.

26. Askew EW, Hoyt RW, Jones TE, Baker-Fulco CJ, Edwards JSA. Carbohydrate supplementation for work at high altitude: Liquid versus solid food supplements. Abstract. *First World Congress on Wilderness Medicine, Whistler, BC, Canada.* Point Reyes Station, CA: Wilderness Medical Society, 1991.

27. Montgomery AB, Mills J, Luce JM. Incidence of acute mountain sickness at intermediate altitude. *JAMA* 1989;261(5):732-4.

28. Dean AG, Yip R, Hoffmann RE. High incidence of mild acute mountain sickness in conference attendees at 10,000 foot altitude. *J Wild Med* 1990;1(2):86-92.

29. Hackett PH, Roach RC, Sutton JR. High altitude medicine. *Management of wilderness and environmental emergencies.* Ed. Auerbach PS Geehr EC. 2nd ed. St. Louis: C.V. Mosby Co., 1989:1-34.

30. Ward MP, Milledge JS, West JB. *High altitude pulmonary edema.* Philadelphia: U of Pennsylvania P, 1989.

31. Hultgren HN, Marticorena EA. High altitude pulmonary edema: Epidemiologic observations in Peru. *Chest* 1978;74:372-6.

32. Olson LG, Hensley MJ, Saunders NA. Augmentation of ventilatory response to asphyxia by prochlorperazine in humans. *J Appl Physiol* 1982;53(3):637-43.

33. Olson LG, Hensley MJ, Saunders NA. The effects of combined morphine and prochlorperazin on ventilatory control in humans. *Am Rev Respir Dis* 1986;133(4):558-61.

34. Hackett P. A portable, fabric hyperbaric chamber for the treatment of high altitiude pulmonary edema. *Hypoxia Conference Proceedings Abstract No. 65.* 1989.

35. Gamow RJ, Geer GD, Kasic JF, Smith HM. Methods of gas-balance control to be used with a portable hyperbaric chamber in the treatment of high altitude illness. *J Wild Med* 1990;1(3):165-80.

36. Taber RL. Protocols for the use of a portable hyperbaric chamber for the treatment of high altitude disorders. *J Wild Med* 1990;1(3):181-92.

37. King SJ, Greenlee RR. Successful use of the Gamow Hyperbaric Bag in the treatment of altitude illness at Mount Everest. *J Wild Med*;1(3):193-202.

38. Robertson JA, Shlim DR. Treatment of moderate acute mountain sickness with pressurization in a portable hyperbaric (Gamow0̂) bag. *J Wild Med* 1991;2(4):268-73.

39. Gray GW, Bryan AC, Frayser R, Houston CS, Rennie IDB. Control of acute mountain sickness. *Aerospace Medicine* 1971;42:8184.

40. Larson EB. Positive airway pressure for high altitude pulmonary oedema. *Lancet* 1985;1(8425):371-3.

41. Schoene RB, Roach RC, Hackett PH, Harrison G, Mills WJJ. High altitude pulmonary edema and exercise at 4,400 meters on Mount McKinley. *Chest* 1985;87(3):330-3.

42. Hackett PH. High altitude pulmonary edema. *J Wild Med* 1990;1(1):3-26.

43. Stewart CE, ed. *Environmental emergencies.* Baltimore: Williams and Wilkins, 1990.

44. Oelz O, Maggiorini M, Ritter M, et al. Nifedipine for high altitude pulmonary edema. *Lancet* 1989;2(8674):1241-4.

45. Hackett PH, Greene ER, Roach RC, Feil P, Selland M. Nifedipine and hydralazine for treatment of high altitude pulmonary edema. Abstract. *Hypoxia-89* 1989.

46. Oelz O, Noti C, Ritter M, Jenni R, Bartsch P. Nifedipine for high altitude pulmonary oedema [letter]. *Lancet* 1991;337(8740):556.