HIGH ALTITUDE ILLNESS

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The term "high-altitude illness" is used to describe the brain and lung problems that can develop in unacclimatized persons shortly after ascent to high altitude.
Because millions of visitors travel to high-altitude locations each year, AMS is a public health problem and has economic consequences, esp. for the ski industry. High-altitude pulmonary edema and cerebral edema, though uncommon, are potentially fatal. High-altitude illness also provides a useful model for studying the pathophysiological process of low oxygen in an otherwise healthy population.

Definitions:

High altitude: 1500 to 3500 m (4950 to 11,500 feet). Onset of illness is marked by decreased exercise performance and increased ventilation at rest.
Very high altitude: 3500 to 5500 m (11,500 to 18,050 feet). The pressure of oxygen in the arteries (PaO2) falls below 60 mmHg, and the saturation of oxygen (SaO2) falls below 90%.
Extreme altitude: Beyond 5500 m. Marked decrease in oxygen (hypoxemia) and decrease in carbon dioxide (hypocapnia) occur, and acclimatization is impossible.

Sleep Disturbances: Common at high altitude and are believed to result from lack of oxygen to the brain (cerebral hypoxia).

Signs and symptoms:

a. Increased wakefulness
b. Periodic breathing
c. Frequent arousal
d. Decreased rapid eye movement (REM) sleep

Periodic Breathing: Night deep breathing (hyperpnea) followed by no breathing (apnea).

Treatment for Sleep Disturbances and Periodic Breathing:

a. Give acetazolamide (Diamox) 125 mg PO at bedtime.
b. Use sleeping pills (hypnotics) cautiously because of the potential for respiratory depression.
c. If the disturbed sleep is thought to be unrelated to altitude and a sleep agent is elected, use triazolam .0125 to .025 mg or temazepam 15 mg.

High-Altitude Deterioration: Acclimation impossible, with victim's condition deteriorating, marked by weight loss, lethargy, weakness, headache, and poor-quality sleep. More common in persons with chronic diseases, particularly those associated with low oxygen (hypoxemia).

The only definitive treatment is descent to a lower altitude.

Acute Mountain Sickness (AMS)

A. General
   1. Incidence of 15 - 40% of Colorado resort skiers (depending on altitude of resort), 40% Rainier climbers, 70 - 100% if flown to 14,000 ft.
   2. Incidence is higher in children under one year old, thus don't bring young children to altitude.
   3. Related to **RATE OF ASCENT**, altitude reached, **SLEEPING ALTITUDE**, and physiological factors. 9,000 ft. is a threshold for most people. No relationship to physical fitness or gender. Younger adult may be more susceptible. Children probably same incidence as adults, although recently it has been found that children under one year have a higher incidence of AMS and should not be taken to altitude.

4. **Individual susceptibility** and reproducibility. Low lung capacity, low hypoxic ventilatory response (HVR), exaggerated pulmonary hypertension in response to hypoxia (low oxygen) all contribute to illness. It has been noticed that Sherpas have greater lung capacity, high HVR, and less pulmonary artery constriction. Cerebral circulatory responses and individuals' brain anatomy play important role, but can't be tested at sea-level. Past history a risk factor and **best predictor.**

B. Diagnosis—**THINK AMS!**
   1. **Setting:** rapid ascent to a higher altitude in unacclimatized persons.
   2. **Symptoms:** headache, dizziness, loss of appetite, nausea, insomnia, lassitude, dyspnea (shortness of breath). Note: mostly neurologic symptoms. Periodic breathing common, not a sign of AMS. Early AMS **exactly like a hangover.**
   3. In early stages, **a lack of physical findings.** Advanced: findings of pulmonary and cerebral edema. **Ataxia,** change in mental status and cyanosis most useful indicators of serious illness.
   4. **Differential diagnosis:** dehydration, exhaustion, CO (carbon monoxide) poisoning, infections of lung or brain, migraine events, TIA's, hypothermia, drugs, psychiatric problems.

C. Pathophysiology—AMS is related to brain swelling.
   1. Factors contributing to brain swelling:
      a. The degree and rate of onset of hypoxemia (low blood oxygen). Atmospheric hypoxia (low oxygen) leads to alveolar (lung) hypoxia and arterial (artery) hypoxemia, which initiates the pathophysiologic changes. New evidence suggests that most persons at high altitude will have some degree of brain swelling, but the greater the hypoxemia, the more deranged the physiology. *Rapid onset of hypoxemia overwhelms the body's adaptive responses, while gradual onset permits improvement in oxygenation, displacement of cerebrospinal fluid (normal liquid in the brain: CSF) to accommodate swelling, and changes in CSF production and absorption.*

      b. Hypoventilation
      Inadequate ventilation can be due to low HVR, respiratory depressant drugs, or ascent too rapid for adequate acclimatization. This causes greater hypoxemia and therefore greater hypoxic stimulus. Coupled with the relatively higher CO2, cerebral blood flow is augmented, favoring brain edema.

      c. Impaired gas exchange
      The pressure of oxygen in the arteries is determined by alveolar (lung) oxygen pressure and the difference between the arteries and lungs (A-a). Edema (fluid) in the lungs is common in those with AMS, causing increased lung-artery oxygen difference and therefore greater hypoxemia.

      d. Fluid retention
      Those acclimatizing well have a diuresis (increased urine output) secondary to re-set of osmolarity (controlling electrolytes and fluid) center in the brain, with suppression of ADH and aldosterone (two chemicals that help us retain fluid and electrolytes), while those with AMS have an antidiureses (less urine) with elevated ADH and aldosterone.

      e. Individual anatomy
      The first compensation for brain swelling is displacement of CSF (normal brain fluid) into the spinal canal. These values are highly variable and may help explain the essentially random nature of AMS. They are also relatively constant in an individual, which may help explain individual reproducibility.

2. Mechanisms of brain swelling
    a. Cytotoxic (damage to cells) edema—shift of fluid into cells: the classic explanation, now doubted. May play a role in severe end-stage illness.

    b. Vasogenic (blood vessel) edema---**Leaky capillaries**. Exact method of leak not known. There are many theories.
3. Intracranial dynamics
    a. As brain volume increases, ICP (intracranial pressure) rises.
    b. Cerebral vasodilation (dilated blood vessels) causes increased cerebral blood flown (CBF) and increased cerebral blood volume, engorging the brain.
    c. The initial compensation for increased brain volume is displacement of CSF into the spinal space. This is followed by increased CSF absorption and decreased CSF formation. (Diamox decreases CSF formation).
    d. As brain edema continues, ICP rises beyond perfusion (blood flow) pressure, cerebral blood flow stops, causing death. Localized compression of brain structures or ischemia (decreased blood flow) may produce focal (local) neurologic findings, but usual picture is diffuse depression of ability to function.

D. Treatment is directed toward reducing brain swelling
1. Reduce hypoxia (decreased oxygen)
    a. Descent—1,000 ft. may be adequate—as far as necessary for results.
    b. Oxygen if available, especially good for headaches and confusion.
    c. Hyperbaric therapy if available (portable pressure bag).
    d. Oxygen plus hyperbarics if patient in extremis.

2. Speed the process of acclimatization
    a. Diamox, 125-250 mg every 12 hours. 5 mg/kg/day in 2 divided doses for children. Promotes diuresis (urination), stimulates ventilation, decreases CSF formation.
    b. Acclimatization at same altitude okay for minor self-limited illness, but **sick person never left behind alone.**

3. Treat symptoms
    a. Analgesics—Tylenol, aspirin, codeine, or extra strength excedrin.
    Anti-vomiting medicines—Compazine 10mg IM, PO (also increases HVR). May need Benadryl for side effect of Compazine.

4. Reduce brain capillary leak
    a. Decadron 4mg PO, IM, IV every 6 hours. May need to continue until patient evacuated to lower altitude, since rebound may occur with cessation, and drug does not improve acclimatization.

5. Reduce brain edema
    a. Diamox, Lasix (may make or worsen dehydration, therefore it is best not to use).
    b. Hyperventilation: voluntary HV helps while awake.

6. Patient may re-ascend with staged acclimatization, with or without Diamox.

E. General management
1. Stop ascent
    a. Cannot determine at onset if AMS will be mild or severe.
    b. Must observe for progression.
    c. Never leave victims alone or send down alone.
    d. Consider evacuation alternatives.

e. Keep warm, avoid sleeping pills and alcohol at bedtime.
f. Usually recovers in 1-2 days and can continue.

2. If patient doesn't recover or gets worse, must descend
   a. Descent is best treatment of all altitude illness.
   b. Descend below where symptoms started or as far as necessary for resutls.
   c. Descend immediately if loss of coordination, change in mental status or high altitude pulmonary edema.

3. Oxygen
   a. Should be available if sleeping over 14,000 ft of a guided trip.
   b. Indications: Incapacitating headache, severe AMS, pulmonary or cerebral edema.
   c. Low flow to conserve supplies, 1-2 liters/minute.
   d. Various delivery systems.
   e. No harmful side-effects.

4. Hyperbaric bag (Gamow bag)
   a. Can be as effective as low flow oxygen.
   b. Uses air, not oxygen, so unlimited supply.
   c. Needs to be pumped continuously; expensive, can be rented.

F. Prevention
1. Slow ascent; climb high, sleep low. Ideal rate of ascent difficult to establish because of marked individual variation in ability to acclimatize. Reasonable recommendation is not to sleep 2000 ft higher than previous night once above 8000 ft. An extra day for acclimatization every 3-4000 ft is prudent
2. High carbohydrate diet-- >70%, inproves respiratory quotient. Reduces symptoms of AMS by 30%.
3. Avoidance of respiratory depressants (esp. sleeping pills) and use of alcohol in small amounts only.
4. Chemoprophylaxis (medical prevention)
   a. Indications are forced rapid ascent or history of recurrent illness.
   b. Diamox 125 - 250 mg twice a day, for one day prior and one day after ascent. 125 mg may be adequate. Usual sulfa drug precautions.
   c. Decadron 4 mg every 6 to 12 hours—for those intolerant of Diamox, or for insertion to extreme altitude. May have to continue for three or four days, since drug does not speed acclimatization.
   d. Use of both drugs promoted by some, Diamox to speed acclimatization and dexamethasone to prevent brain swelling. I question the wisdom of polypharmacy (use of more than one medicine).

HIGH ALTITUDE PULMONARY EDEMA (HAPE)

A. General
1. Strikes 1 - 2% above 12,000 ft. sleeping altitude, but can occur at 8,000 ft.
2. Most common on 2nd night.
3. Related to rate of ascent, exertion, use of sleeping medications, cold.
4. Many (most?) people have transient, milder forms of illness.
5. There are reported to be five cases per year less than 8000 feet in the French Alps.

B. Diagnosis
1. **Early:** dry cough, increased heart rate, decreased exercise performance, shortness of breath with exercise and increased exercise recovery time.
2. **Late:** dyspnea at rest, tachycardia, tachypnea, cyanosis, productive cough, rales.

3. **Atypical presentations:** sudden death, cerebral manifestations only (esp. ataxia), acclimatized person, mixed with respratory infection, bronchospasm (wheezing).

C. Management
   1. Rest, keep victim warm. Cold stimulus may increase pulmonary artery pressure (pressure in arteries in the lungs). Avoid exercise, have pack carried, carry victim if necessary.
   2. Oxygen. Raises SaO2 % (oxygen saturation), reduces pulmonary artery pressure, stops leak of fluids into the lungs.
   3. Descent with minimal exertion. Exercise raises pulmonary artery pressure, decreases SaO2 %.
   4. Mask to deliver higher pressure oxygen.
   5. Medications which may be helpful.
      a. Procardia 10 mg PO, 20 or 30 mg extended release two to three times a day. Drug of choice if oxygen or descent not available. Reduces pulmonary artery pressure 30 - 50 %, only slightly increases SaO2%.
      b. Diamox. Not advisable in markedly breathless patients with good respiratory drive; better for those with relative hypoventilation.
      c. Lasix. Single dose of 40 mg if not dehydrated. **Rarely used.**
      d. Morphine. Small incremental doses helps to reduce dyspnea (shortness of breath). **Rarely used.**
   6. Victim may re-ascend (at own risk) when HAPE is resolved.

D. Prevention
   1. Same as for AMS—Diamox apparently effective, also Procardia recently shown good for prophylaxis, 20 mg slow release every 8 hours.
   2. Salmeterol, five puffs each day will prevent HAPE up to 40 %.

HIGH ALTITUDE CEREBRAL EDEMA (HACE)

A. Diagnosed by ominous progression of cerebral AMS symptoms and findings of **ataxia** and change in consciousness.
B. Therapy: descent, oxygen, dexamethasone.
C. Mechanism same as AMS- more advanced.
D. Prevention same as for AMS.

RETINAL HEMORRHAGES

A. Common, affect vision only if in macula (rare).
B. Probably an hypoxic (lack of oxygen) mechanism, leak is in capillary (small vessel) bed.
C. No treatment, no known prevention, clear spontaneously in 7-14 days.

OTHER PROBLEMS

A. Subacute mountain sickness
   1. Mild AMS symptoms continue for weeks.
   2. Diamox doesn't usually help.
   3. Descent necessary.
   4. Seen in infants born at low altitude and then taken to Lhasa, Tibet (3600 meters) and Indian soldiers spending several weeks at very high altitudes of 5800 to 6700 meters.

B. Blood clots

1. Due to dehydration, viscous (thick) blood, possible clotting problems.
2. Pulmonary embolus (clot on lungs) confused with HAPE.
3. Cerebral thrombosis (clot on brain) may mimic HACE.

C. Peripheral edema
1. Edema of the hands, face, and ankles.
2. Examine the victim for signs of AMS, HAPE, or HACE.
3. In the absence of AMS, may give a diuretic but can lead to dehydration (Lasix 10 to 20 mg PO (orally). Does resolve spontaneously upon descent.
4. Maintain adequate hydration.

D. High-altitude Flatus Expulsion (HAFE)
1. Excessive flatulence of colonic gas.
2. Give oral simethicone 80 mg PO.
3. Encourage a carbohydrate diet.

E. High-altitude pharyngitis and bronchitis ("Khumbu Cough" or "Himalayan Hack")
1. Sore throat; chronic cough, dry or productive, severe enough to cause rib fractures; dry or cracking nasal passages.
2. Force hydration, steam, hard candy, fluids.
3. Give nasal saline spray.
4. Apply topical nasal ointment: bacitracin or polysporin.
5. Use an antitussive (cough) agent.

F. Ultraviolet keratitis ("Snowblindness")
1. Eye pain, sensation of grittiness in the eyes, sensitivity to light, tearing, redness, swelling.
2. Remove contact lenses.
3. Give topical anesthetic for evaluation.
4. Give aspirin or ibuprofen.
5. Use external cold compresses.
6. Patch the affected eye(s) for 24 hours, then reexamine. Do not patch the eye if there is evidence of eye infection.
7. Encourage the victim to rest.

G. Chronic mountain sickness (CMS) or Monge's disease.
1. Not a disease of travelers
2. It affects high-altitude residents worldwide.
3. Have very high blood counts (hematocrits).
4. Headaches, insomnia, lethargy.
5. Definitive treatment is descent.
6. Oxygen.

HOW TO ACCLIMATIZE TO ALTITUDE

A. Take time to acclimatize
1. Keep sleeping altitude gain less than 2,000 ft. per night once above 8,000 ft.
2. One extra night for acclimatization every 2 - 3,000 ft. above 8,000 ft.
3. Climb high, sleep low. Make day trips to a higher altitude with a return to lower altitude for sleep.
4. Try to avoid abrupt transport to above 10,000 ft. If unavoidable, acclimatize for three nights before going any higher.

B. Help, not hinder body's natural acclimatization
1. No sleeping medications or alcohol.

2. Avoid overexertion.
3. Modest exercise on acclimatization days.
4. Avoid carbon monoxide exposure. Ventilate tents and snow shelters if cooking.
5. Encourage good hydration, high carbohydrates.

C. Recognize signs of poor acclimatization/early AMS
1. Teach clients about what to expect—normal versus abnormal.
2. Encourage clients to monitor how they feel and report to you if headaches, etc. develop.
3. Make inquires about symptoms and observe appetites, energy levels, skin color, behavior of clients.

D. Medicines
1. Diamox 125 to 250 mg PO (mouth) twice a day starting 24 hours before ascent. An alternative dose is 500 mg sustained-release capsule every 24 hours. 125 mg may be enough.
2. Continue the drug during the ascent and until acclimatization has occurred (generally, for 48 hours at maximum altitude).
3. **Do not use in the presence of allergy to sulfa derivatives.**
4. Side effects include peripheral paresthesias, polyuria, nausea, drowsiness, impotence, and bitter taste of carbonated beverages.
5. Decadron 4 mg PO every 4 hours can be used if Diamox is contraindecated. It is best reserved for treatment, rather than prophylaxis, of AMS.

DRUG ABUSE IN HIGH ALTITUDE CLIMBING

The most common field of using drugs in the mountains concerns high altitide tourism, trekking,
and climbing. Drugs are expected to speed acclimatization, to avoid acute mountain sickness or other altitude related health disorders and to maintain the physical performance. More people want to travel "higher faster" because "acclimatization is a waste of time." One must consider the benefits as well as the risks of using drugs.

The World Health Organization (WHO) estimates 37 million travellers per year to high and extreme altitudes. Many climbers are frequently using various drugs to raise the chance of getting up to the summit whatever the price. "I feel totally diamoxolised today" is heard in many high altitude camps today.

The statistics of the Ministery of Tourism in Nepal report that altitude trekking in Nepal from 1982 to 1994 has has an increase of 330% and from 1994 to 2000 an increase of 450%. Until 2001 more than 1300 have summited Everest, many of them "adapted by numerous drugs." E. Hawley reports that in autumn of 2001, there were 36 commercial teams with about 700 climbers waiting for a chance to climb Cho Oyu. At the same time 17 teams have besieged Ama Dablam.

I will discuss some of the drugs that are used to speed acclimatization.

Amphetamines: It increases motivation, concentration and work capacity, increases ventilation, heart rate, supresses appetite and fatigue. The serious effects are immagination of "no limits" , euphoria, misjudgements, sleeplessness, giddiness, tolerance, visual and hearing halucinations, fear and panic attacks, depression of withdrawal, and death due to exhaustion. This could be the cause of death of some of the climbers who have climbed for two or three days without stopping.

Cocaine: Has a very short effective duration, increases ventilation, heart rate, and blood pressure. It leads to immagination of "no limits", euphoria and misjudgements. There is a high risk of accident.

Diamox: Is is indicated only for AMS, use in those who have had a prior history of AMS, sleep disturbance, and rapid increase to altitude. It has been used to speed acclimatization in those without the above indications and can lead to dehydration and electrolyte disturbance.

Dexamethasone: May reduce the brain blood volume and prevent leakage of blood into the brain. It causes meel changes, depression, ulcers, bleeding from the stomach, high blood sugar. It does not improve acclimatization, but minmizes symptoms of AMS and HACE. There is no study that shows using it more than four days prophylactically is of help.

Nifidipine: It treats HAPE and can be used prophylactically for HAPE. It can cause a reflex fast heart beat, headache, vomiting, and dizziness.

Aspirin: It may help in reducing brain edema, thus with headaches. The adverse effects must not be underestimated: stomach bleeding in high doses.

Ginkgo Biloba: Of the three studies performed on the drug, the consenses does not show any help in acclimatization. It is of big ecconomic benefit for the companies to promote this drug.

Other drugs that have been used and not shown to be of any benefit in acclimatization are: progesteron,
Ibuprofen, vit. E, pentoxyphylline, montelukast, iron, viagra, mate de coca, garlic. Recent studies on Viagra and Progesteron may be promissing. Viagra has recently been shown to decrease the incidence of HAPE in those predisposed to it.

Conclusion: Is there a wonder drug which can substitute acclimatization and prevent AMS? Peter Hackett feels that Ginkgo Biloba could and has minimal side effects. He also feels that Diamox "speeds the acclimatization process". It is important to remember that most drugs have side effects and can cause serious harm if used improperly. If you are prone to altitude sickness, if the type of your altitude trip is risky or if you do not want to "waste time with acclimatization", it is better to stay home or pick another activity other than the altitude treshold. **There is no better substitute than proper acclimatization.**