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1 High-Altitude Medicine

DEFINITIONS

- High altitude: 1500 to 3500 m (4921 to 11,483 ft). This altitude is marked by decreased exercise performance and increased ventilation at rest. Altitude illness is common with rapid ascent above 2500 m (8202 ft).
- Very high altitude: 3500 to 5500 m (11,483 to 18,045 ft). Arterial partial pressure of oxygen (Pa_{O_2}) falls below 60 mm Hg and maximal arterial oxygen saturation (Sa_{O_2}) drops below 90%. Extreme hypoxia may occur during exercise or sleep and with altitude sickness. Severe high-altitude illness (e.g., high-altitude pulmonary edema [HAPE] and high-altitude cerebral edema [HACE]) occurs most commonly at very high altitude.
- Extreme altitude: above 5500 m (18,045 ft). Marked hypoxemia and hypocapnia occur, and successful acclimatization is impossible. Abrupt ascent to extreme altitude without supplemental oxygen is quite dangerous.

HIGH-ALTITUDE ILLNESS

High-Altitude Headache

Signs and Symptoms

- Often the first symptom of altitude exposure
- May be the only symptom following altitude exposure
- May or may not portend the development of acute mountain sickness (AMS; see later)

Treatment

1. Oxygen beginning at low flow rates (0.5 to 2 L/min by nasal cannula to raise arterial SaO_2 to greater than 90%) is usually very effective, if available.
2. Nonsteroidal antiinflammatory drugs (NSAIDs), such as ibuprofen 400 mg q8h, acetaminophen 500 mg q4h, or both, are generally effective for both treatment and prevention. Avoid narcotics because they may suppress ventilation and predispose to AMS. AMS treatment agents, such as acetazolamide and dexamethasone (see later), may be used to prevent or treat high-altitude headache.

Acute Mountain Sickness

AMS can be quantified by using the Lake Louise score (LLS)—see Appendix D.

Primary Signs and Symptoms

Headache, usually throbbing, bitemporal or occipital; worse at night, with Valsalva maneuver, or when stooping over; with one or more of the following:

- Anorexia
- Nausea or vomiting
- Dizziness or lightheadedness
- Fatigue, lassitude

Absence of Altitude Diuresis

There may be absence of altitude diuresis expected with normal acclimatization. During acclimatization, diuresis is expected; for example, a well-hydrated person who is acclimatizing appropriately should awaken at least once during the night to urinate. A person who does not awaken to urinate or infrequently urinates during the daytime is possibly dehydrated and also should be watched closely for signs of AMS.

Natural Course

- Natural course is highly variable.
- Symptoms may start within 2 hours after arrival at altitude.
- Symptoms rarely start after 48 hours at a given altitude.
- Most AMS resolves within 3 days.
- Some patients worsen despite remaining at a fixed altitude (e.g., nausea and headache do not resolve with rest or the symptoms worsen in intensity without progressing to HACE).

Treatment (Box 1.1)

1. Do not proceed to a higher sleeping altitude unless/until all symptoms completely resolve.
2. Monitor the patient for progression of illness (to pulmonary or cerebral edema).
3. If symptoms worsen despite an additional 24 hours of acclimatization at the same altitude, descend. Descent of 500 to 1000 m (1640 to 3281 ft) is often sufficient to achieve clinical improvement and resolution of symptoms.
4. Immediately descend if the patient suffers ataxia, altered consciousness, or pulmonary edema.
5. For mild AMS, halt the ascent and wait (12 hours to 3 days) for acclimatization to occur. Administer acetazolamide, 250 mg PO bid (pediatric dose: 2.5 mg/kg/dose bid to a maximum dose of 250 mg) for 2 days while at altitude or until symptoms have diminished.
6. Oxygen beginning at low flow rates (0.5 to 2 L/min by nasal cannula to raise arterial Sa_{O_2} to greater than 90%) is usually very effective, if available.
7. *Ginkgo biloba* 100 mg PO bid started 5 days before ascent has been shown in some studies to prevent and reduce symptoms

BOX 1.1 Field Treatment of High-Altitude Illness

High-Altitude Headache and Mild Acute Mountain Sickness
Stop ascent, rest, and acclimatize at same altitude
Acetazolamide, 125 to 250 mg bid, to speed acclimatization
Symptomatic treatment as needed with non-narcotic analgesics and antiemetics
OR descend 500 m (1640 ft) or more

Moderate to Severe Acute Mountain Sickness
Low-flow oxygen (0.5 to 2 L/min by nasal cannula to raise arterial SaO_2 to greater than 90%)
Acetazolamide, 250 mg bid (pediatric dose: 2.5 mg/kg/dose bid to a maximum dose of 250 mg)
Hyperbaric therapy
OR immediate descent of at least 1000 m (3281 ft) (or more if feasible)

High-Altitude Cerebral Edema
Immediate descent or evacuation
Oxygen by nasal cannula to raise arterial SaO_2 to greater than 90%
Dexamethasone, 8 mg PO, IM, or IV, then 4 mg q6h (pediatric dose 0.15 mg/kg/dose q6h to a maximum dose of 4 mg)
Hyperbaric therapy

High-Altitude Pulmonary Edema
Minimize exertion and keep warm
Oxygen (by nasal cannula or mask) to achieve SaO_2 greater than 90%
If oxygen is not available:
Nifedipine sustained release, 20 mg PO q8h or 30 mg PO q12h
Consider sildenafil, 50 mg PO q8h or tadalafil, 10 mg PO q12h
Hyperbaric therapy
OR immediate descent

Periodic Breathing
Acetazolamide, 62.5 to 125 mg PO in the evening

of AMS, but most reports indicate that gingko is a less reliable prophylactic drug than acetazolamide.

8. Administer aspirin, 650 mg; acetaminophen, 650 mg; or ibuprofen, 400 to 600 mg PO for headache.
9. Administer an antiemetic (e.g., ondansetron, prochlorperazine, promethazine, metoclopramide) for nausea and vomiting.
10. Avoid sedative-hypnotic drugs and alcohol.
11. Minimize exertion.
12. Consider promptly descending 500 to 1000 m (1640 to 3281 ft) if medications are ineffective or unavailable or if illness is severe.
13. If readily available and in unlimited supply, consider administering oxygen 0.5 to 1.5 L/min by nasal cannula or simple (open

type) face mask during sleep. This is particularly effective for headache.

14. Consider administering dexamethasone 8 mg PO/IM/IV, then 4 mg q6h (pediatric dose: 0.15 mg/kg/dose q6h to a maximum dose of 4 mg) *in conjunction with descent*, for progressive neurologic symptoms or ataxia, or if the patient cannot tolerate acetazolamide. Even if symptoms resolve with use of dexamethasone, it is unwise to remain at high altitude or to ascend while taking dexamethasone, because signs of progression to HACE could be masked.
15. Consider undertaking a 2- to 6-hour treatment in a portable hyperbaric bag (e.g., Gamow bag) inflated to 2 psi. Maintaining 2 psi inside the bag is equivalent to a descent of 1000 to 3000 m (3281 to 9843 ft), depending on the starting altitude. The hyperbaric bag can be used with or without supplemental oxygen. Most portable bags require constant pumping, so recruit additional persons for assistance (see Box 1.1).

High-Altitude Cerebral Edema

Signs and Symptoms

- Ataxic gait is the hallmark of diagnosis. Ataxia in the face of recent ascent to high altitude is HACE until proven otherwise.
- Altered consciousness (confusion, drowsiness, stupor, coma)
- Severe lassitude
- Headache
- Nausea and vomiting
- Hallucinations (rare)
- Hypoxemia associated with concomitant pulmonary edema
- Seizures (rare)

Focal neurologic deficits are only rarely found in HACE and in the setting of normal consciousness suggest an alternate diagnosis.

Treatment

1. Immediately descend at least 500 to 1000 m (1640 to 3281 ft) or more. There is no upper limit to descent rate or distance. For example, if a person is able to descend rapidly to sea level, this is preferred.
2. Administer dexamethasone 8 mg IV, IM, or PO, followed by 4 mg q6h (pediatric dose: 0.15 mg/kg/dose q6h to a maximum dose of 4 mg).
3. Administer oxygen 2 to 4 L/min by nasal cannula or simple (open type) face mask, to maintain Sa_{O_2} greater than 90%. Higher O_2 concentrations and a nonrebreather mask may be required.
4. If the patient is comatose, manage the airway and drain the bladder.
5. Only after descent or if descent is not feasible, consider undertaking a 2- to 6-hour treatment in a portable hyperbaric bag (e.g., Gamow bag) inflated to 2 psi. Maintaining 2 psi inside the bag is equivalent to a descent of 1000 to 3000 m (3281 to 9843 ft),

depending on the starting altitude. The hyperbaric bag can be used with or without supplemental oxygen. Most portable bags require constant pumping, so recruit additional persons for assistance (see Box 1.1).

6. If neurologic symptoms persist despite treatment with oxygen, steroids, and descent, a cerebrovascular accident may be present. Evacuate for definitive evaluation and care.

High-Altitude Pulmonary Edema

Signs and Symptoms

- Decreased exercise performance and increased recovery time
- Dyspnea on exertion that progresses to dyspnea at rest
- Cough (mild and dry initially, becoming productive late in the disease)
- Tachycardia and tachypnea at rest
- Fatigue, weakness, and lassitude
- Low-grade fever
- Symptoms of AMS occur in approximately 50% of cases
- Cyanotic nail beds and lips
- Audible chest rales, classically beginning in the right middle lobe (auscultate right lateral chest between fourth and sixth intercostal spaces) and becoming bilateral and diffuse
- Pink or blood-tinged sputum (late finding)
- Mental status changes, ataxia, decreased level of consciousness, and coma may signify extreme hypoxemia or signal coexisting HACE
- Hypoxemia determined by pulse oximetry. It is difficult to precisely define a "normal" pulse oximetry reading at high altitude. Because variables are constant for traveling companions on the same itinerary, one strategy is to average the readings among well companions and consider substantially lower readings (10% or more) in persons who are unwell as tantamount to hypoxemia.

Treatment

1. Immediately descend at least 500 to 1000 m (1640 to 3281 ft). Because of augmented pulmonary hypertension and greater hypoxemia with exercise, exertion must be minimized.
2. Administer oxygen 2 to 4 L/min by nasal cannula or simple (open type) face mask to maintain Sa_{O_2} greater than or equal to 90%. Higher O_2 concentrations and a nonrebreather mask may be required.
3. If supplemental oxygen is not available, consider giving nifedipine 20 mg sustained-release capsule q8h or 30-mg sustained-release capsule q12h to reduce pulmonary arterial pressure.
4. Keep the patient warm because cold stress elevates pulmonary arterial pressure.
5. Consider using pursed-lip breathing or continuous positive airway pressure (CPAP) delivered by face mask.
6. Consider undertaking a 2- to 6-hour treatment in a portable hyperbaric bag (e.g., Gamow bag) inflated to 2 psi. Maintaining