High Altitude Medicine

Fred Ziel, MD
Endocrinology
Kaiser Woodland Hills
Assoc Professor of Medicine UCLA
Learning Objectives

1) Describe physiologic acclimatization and how to achieve it for high altitude travel
2) Describe the major medical high altitude syndromes with their respective prophylactic and treatment options
3) Identify 3 high altitude travel cultural competency pearls
4) Identify different risks of altitude-related illnesses between ethnic groups
5) Have some fun
Mountaineering Medicine

- Travel Medicine
- Emergency Medicine
- Chronic Medical Conditions
- Dentistry
- Heat and Cold Injuries
- Altitude-related Syndromes
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### 8000 meter summits

<table>
<thead>
<tr>
<th>Summit</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everest** 8848</td>
<td></td>
</tr>
<tr>
<td>K2* 8611</td>
<td></td>
</tr>
<tr>
<td>Kangchenjunga 8584</td>
<td></td>
</tr>
<tr>
<td>Lhotse 8516</td>
<td></td>
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<tr>
<td>Cho Oyo* 8021</td>
<td></td>
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<tr>
<td>Makalu 8465</td>
<td></td>
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<tr>
<td>Dhaulagiri 8167</td>
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</tr>
<tr>
<td>Manaslu* 8163</td>
<td></td>
</tr>
<tr>
<td>Nanga Parbat 8125</td>
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</tr>
<tr>
<td>Annapurna 8091</td>
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</tr>
<tr>
<td>Gasherbrum I 8068</td>
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</tr>
<tr>
<td>Broad Peak* 8047</td>
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</tr>
<tr>
<td>Shishapangma* 8046</td>
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</tr>
<tr>
<td>Gasherbrum II 8035</td>
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</tbody>
</table>
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Morbidity at Altitude

• Trekking
  - 30% trauma
  - 35% altitude syndromes
  - 35% other

• Mountaineering (>7000 m)
  - 70% falls, avalanche, rockfall

- Annapurna: 130 (41%)
- Nanga Parbat: 216 (28.2%)
- K2 *: 198 (26.8%)
- Kangchenjunga: 165 (22%)
- Manaslu *: 240 (21.7%)
- Dhaulagiri: 313 (18%)
- Makalu: 206 (11%)
- Gasherbrum 1: 195 (10.8%)
- Shishapangma *: 201 (9.5%)
- Everest ***: 1,950 (9.3%)
- Broad Peak *: 255 (7%)
- Lhotse: 243 (4%)
- Gasherbrum 2: 650 (2.6%)
- Cho Oyo *: 1,400 (0.5%)
Acclimatization

Physiologic adaptation to both the lower barometric pressure and pO2 of high altitude
<table>
<thead>
<tr>
<th>Metres</th>
<th>Feet</th>
<th>Pressure (mmHg)</th>
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<tbody>
<tr>
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<td>0</td>
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<tr>
<td>1000</td>
<td>3281</td>
<td>674</td>
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<td>2000</td>
<td>6562</td>
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<td>7000</td>
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<td>8000</td>
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<td>267</td>
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<tr>
<td>8848</td>
<td>29029</td>
<td>236</td>
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</table>
Arterial oxygen saturations measured on the 1994 British Mount Everest Medical Expedition at various altitudes (sea level, n=20; 2855 m, n=41; 3460 m, n=42; 3835 m, n=40; 4270 m, n=41; 4930 m, n=42; 5118 m, n=38; 5300 m, n=20; 6400 m, n=8).
Arterial Oxygen SATURATION %

Decreasing Acidity CO₂ Temperature

Increasing Acidity CO₂ Temperature

Arterial Oxygen PRESSURE torr
O₂ Hb SATURATION - %

A - ARTERIAL
V - VENOUS
A - V = 23% SAT'N
M - MEAN CAPILLARY pO₂

SEA LEVEL

20,000 FEET

ARTERIAL pO₂ MM Hg

0 20 40 60 80 100
Major Changes in Acclimatization

- Increased breathing
- Increased cardiac output (temporary)
- Decreased cardiac output (later)
- Increased red cells
- Better exchange of air in alveoli
- More blood is moved
- Enables more oxygen to be acquired (especially during work)
- More carriers available for oxygen
Optimal Acclimatization Periods

- 300 meters per day above 3000 meters; rest day every 3 days
- 6000 meter summits; >1 week @ 4000 m
- 7000 meter summits; >2 weeks @ 5000 m
- 8000 meter summits; >3 weeks @ 6000 m
Climb High; Sleep Low

- All high altitude climbs have some element of climb high / sleep low cycling
- Multiple climb high / sleep low cycles are required > 8000 meters
- Rest, hydration, and good nutrition between cycles
- Higher climbing cycles are added on top of lower climbing cycles after successful acclimatization and sleep at the elevations of the lower cycles
- It is typical to climb an 8000 meter peak several times before the summit can be safely reached
- Virtually everybody can acclimate to 6000 meters
Camps on 8000 Meter Peaks

- Base camp and 3 or 4 higher camps
- Camps are separated by distance, altitude and time
- Camps located in (relatively) protected positions
- Ideally spaced so one can travel up and down between 2 camps in single day w/o AMS or physical collapse
Syndromes of High Altitude Illness

- AMS: acute mountain syndrome
- HAPE: high altitude pulmonary edema
- HACE: high altitude cerebral edema
- HARH: high altitude retinal hemorrhage
Normal Physiology

- Hyperventilation / DOE (not @ rest)
- Polyuria
- Interrupted Sleep (Temazepam)
- Periodic Breathing / Cheyne-Stokes (Diamox)
- Facial Edema (Diamox, Lasix)
AMS Dx

- Headache plus one other symptom in the of altitude gain to over 2400 m / 8000 ft
- GI upset
- Fatigue / weakness
- Dizziness / lightheadedness
- Insomnia (more than frequent waking)
Lake Louise Score

- Total score from below (0 - 4 points)
- Headache
- GI symptoms
- Fatigue
- Dizzy/Lightheaded
- Difficulty sleeping
- Change in mental status
- Ataxia
- Peripheral edema
AMS Treatment

- Prophylaxis:
  - Diamox 125 mg bid 24 hours prior to ascent

- Treatment:
  - Diamox 250 mg bid
  - Decadron 4 mg qid for 48 hours
  - Hyperbaric Chamber
  - Rest, fluid, descent, acetaminophen, paracetamol, asa, ibuprofen
HAPE Dx

- At least 2 of the following symptoms:
  - Dyspnea @ rest
  - Cough
  - Weakness / decreased exercise performance
  - Chest tightness / congestion
- At least 2 of the following signs:
  - Cyanosis
  - Rales of wheezing
  - Tachypnea
  - Tachycardia
HAPE Rx

- Descend 610 meters / 2000 feet
- 4-6 l/min O2
- Nifedipine 10 mg x1, then 30 mg slow release bid
- Hyperbaric therapy
HACE Dx

- With AMS:
  - Altered mental status OR ataxia OR ataxia
- Without AMS:
  - Altered mental status AND ataxia OR ataxia
HACE Rx

- Descend 610 m / 2000 feet
- O2 4 l/min
- Dexamethasone 4 mg q 6 hrs
- Hyperbaric therapy
The Golden Rules

If >10,000 ft/3000 m: 1000 ft/300 m per night max., second night for every 1000 ft/300 m max.,

Golden Rule 1: If you feel ill, it is AMS till proven otherwise,

Golden Rule 2: Do not ascend with AMS,

Golden Rule 3: If it is getting worse or there is HAPE or HACE go down,

(Don’t forget your porters can get AMS too)
Gamow Bags
“English Air”

All 8000 meter peaks can be climbed without oxygen

Only on Everest does most everyone use supplemental oxygen

If oxygen is used on K2, Kangchenjunga, Lhotse, or Makalu, it is reserved for summit day
Poisk System
Summit Oxygen System
Water Purification
Travelers’ Diarrhea

- **Prophylaxis:** hygiene, bismuth subsalicylate
- **Treatment:**
  - WHO rehydration solution: 10 gm sugar, 2.5 gm salt, 2.5 gm bicarbonate / liter
  - Bacterial (E. Coli)
  - Norfloxacin 400 mg bid x 3 days
  - Ciprofloxacin 500 mg bid x 3 days
  - Ofloxacin 400 mg bid x 3 days
Travelers’ Diarrhea

- Bactrim DS bid x 3 days (cyclospora)
- Metronidazole 500 mg bid x 7 days (giardia)
- Tinidazole 2 gm hs x 2 days (giardia)
- Anti-motility drugs: Diphenoxylate, Loperamide, Codeine
Stretchers
AED
AED
Frostbite Rx: NSAID & O2