High Altitude Illness: Prevention & Treatment

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A High Altitude Scenario

- You have agreed to serve as medical support for a trek to summit Mount Kilimanjaro.
- Mount Kilimanjaro is located in Tanzania
- The Summit is 5895 m
- The group you are traveling with plans to take the Marangu route
- How will you prepare and what supplies will you take?
The Seven Summits

Tanzania
High Altitude
- High Altitude: 1500-3500 m
- Very High Altitude: 3500-5500 m
- Extreme Altitude: > 5500 m

High Altitude Illness
- Acute Mountain Sickness
- High Altitude Pulmonary Edema
- High Altitude Cerebral Edema
- Acclimatization
History
- Mild forms of the illness are common
- Severe forms are rare
- Most people experience some symptoms over 10,000 feet

Risk Factors/Categories

Genetic factors
- Youth
- Seizures
- Pulmonary Hypertension
- Sickle cell trait
- Sleep apnea
- COPD
- CHF
- CAD

Previous HAS
Rapid Assent
Poor conditioning
Dehydration
Use of drugs/ETOH
### Risk Categories for High Altitude Illness

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Description</th>
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</table>
| **Low**       | - No history & ascending to < 2800 m  
                - Taking > 2 days to arrive at 2500 m with subsequent increase of sleeping elevation of < 500 m/d |
| **Moderate**  | - Prior history of AMS and ascending to 2500 m in one day  
                - No history of AMS and ascending to > 2800 m in 1 day  
                - Ascending > 500 m/d above 3000 m |
| **High**      | - History of AMS and ascending to > 2800 m in one day  
                - Prior History of HAPE or HACE  
                - Ascending to > 3500 m in one day & ascending > 500 m/d above 3500 m  
                - Very rapid ascents |
Acclimatization

- Increased Sympathetic Activity
- Increased Cardiac Output
- Tachycardia
- Hyperventilation
- Diuresis
- Increased erythropoietin levels
- Increased 2,3 DPG production

Acclimatization: Altitude versus oxygenation

<table>
<thead>
<tr>
<th>Altitude</th>
<th>Atm Press</th>
<th>$P_aO_2$</th>
</tr>
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<tbody>
<tr>
<td>Sea Level</td>
<td>760</td>
<td>90-95</td>
</tr>
<tr>
<td>2800 m</td>
<td>543</td>
<td>60</td>
</tr>
<tr>
<td>6100 m</td>
<td>356</td>
<td>35</td>
</tr>
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</table>
Acclimatization: Oxygen Dissociation Curve

Pathophysiology

- Hypoxia
- Failure to Acclimatize
- Complex neurohumoral & hemodynamic responses
- Overperfusion of microvascular beds
- Elevated capillary pressure
- Capillary leakage
- Edema
Figure 1. Proposed Pathophysiological Process of High-Altitude Illness.

At high altitudes hypoxemia can lead to overperfusion, elevated capillary pressure, and leakage from the cerebral and pulmonary microcirculation. Increased sympathetic activity has a central role in this process, and increased permeability of capillaries as

You are on day two of your trip when a member of your party approaches you complaining of a severe, throbbing headache and nausea.
Acute Mountain Sickness

- Incidence
- Symptoms
- Signs
- Differential diagnosis
- Prevention
- Treatment

AMS: Incidence

- 1991 Study in Summit County, CO:
  - 22% at 1850-2750 m
  - 42% above 3000 m
- United States mountaineering data:
  - 50% of people ascending Mt. McKinley
  - 70% of people ascending Mt. Rainier
AMS: Signs and Symptoms

- Headache and at least one of following symptoms:
  - anorexia, nausea, vomiting
  - fatigue or weakness
  - dizziness or lightheadedness
  - difficulty sleeping

AMS: Differential Diagnosis

- Dehydration
- Carbon monoxide poisoning
- Exhaustion
- Hangover
- Diabetic ketoacidosis
- Hypoglycemia
- Hyponatremia
- Migraines
- Infection
**AMS: Prevention**

- Gradual Ascent: Always and all that is needed in low risk situations
- Acetazolamide: In moderate to high risk situations
- Dexamethasone: Can’t tolerate acetazolamide?
- ? Ibuprofen

**AMS: Treatment**

- Stop, rest, acclimatize
- Symptomatic treatment
- Acetazolamide
- Dexamethasone
- Other options
- If symptoms persist/worsen -> descent
One the third night, a frantic hiker calls you to her tent because her husband is short of breath and coughing up pink, frothy sputum.
High Altitude Pulmonary Edema

- Incidence
- Signs
- Symptoms
- Differential Diagnosis
- Prophylaxis
- Treatment

HAPE: Incidence

- 0.5-15% depending on location
- Occurs 1-3 days after ascent
- Half will previously have had AMS
- Frequently occurs at night
- Accounts for most deaths due to high altitude
HAPE: Signs and Symptoms

- Symptoms (at least two):
  - dyspnea at rest
  - cough
  - weakness/decreased exercise performance
  - chest tightness/congestion

- Signs (at least two):
  - crackles or wheezes
  - central cyanosis
  - tachypnea
  - tachycardia

HAPE: Differential Diagnosis

- Asthma
- Bronchitis
- Heart failure
- Hyperventilation syndrome
- Myocardial infarction
- Pneumonia
- Pulmonary embolus
HAPE: Prophylaxis

- Gradual Ascent
- With prior history of HAPE consider:
  - Nifedipine
  - Acetazolamide
  - Others?

HAPE: Treatment

- Descend if possible
- Oxygen
- Hyperbaric chamber
- Nifedipine
- ?? Beta agonists
- ?? Phosphodiesterase inhibitors
It is the day before your final ascent and you awake to find a member of your party wandering confused through camp in only his underwear.
High Altitude Cerebral Edema

- Incidence
- Signs
- Symptoms
- Differential Diagnosis
- Prevention
- Treatment

HACE: Incidence

- Incidence of 0.1 to 1%
- Usually progression of AMS
- Can progress rapidly to death
HACE: Signs and Symptoms

- Change in mental status
- Change in behavior
- Confusion
- Lethargy
- Seizure
- Coma
- Ataxia

HACE: Differential Diagnosis

- Psychosis
- AV malformation
- Brain tumor
- Carbon monoxide poisoning
- Hypoglycemia
- Hyponatremia
- Stroke
- TIA
- Intoxication
HACE: Prevention and Treatment

- For prevention, refer to AMS
- Immediate descent/evacuation
- Oxygen
- Hyperbaric chamber
- Dexamethasone
- Acetazolamide
Other Altitude Related Disorders

- Retinopathy
- Peripheral edema
- Venous stasis and thrombotic complications
- Pharyngitis and bronchitis
- UV keratitis
- HAFE

Prevention

- Physical fitness
- Hydration
- Adequate sleep
- Gradual ascent
- Hike high, sleep low
- Avoid ETOH and drugs
- Prophylactic treatment
# Recommended Drug Dosages

<table>
<thead>
<tr>
<th>Medication</th>
<th>Indication</th>
<th>Route</th>
<th>Dosage</th>
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<tbody>
<tr>
<td>Acetazolamide</td>
<td>AMS, HACE prevention AMS TX</td>
<td>Oral</td>
<td>125 mg BID</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>2.5 mg/kg</td>
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<td></td>
<td></td>
<td></td>
<td>250 mg BID</td>
</tr>
<tr>
<td>Dexamethasone</td>
<td>AMS, HACE prevention AMS, HACE TX</td>
<td>Oral, IM, IV</td>
<td>2 mg q 6/ 4 mg q12</td>
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<td></td>
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<td></td>
<td>4-8 mg q 6</td>
</tr>
<tr>
<td>Nifedipine</td>
<td>HAPE prevention HAPE TX</td>
<td>Oral</td>
<td>30 mg SR q 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30 mg SR q 12</td>
</tr>
<tr>
<td>B2 Agonist</td>
<td>HAPE TX/Prevention</td>
<td>Inhaled</td>
<td>2-4 puffs BID</td>
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<tr>
<td>Ibuprofen</td>
<td>AMS prevention</td>
<td>Oral</td>
<td>600 mg TID</td>
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