Altitude-related illness and men’s health

ALASTAIR G. DICK

With adventurous travel destinations now commonplace, it is important to be aware of the dangers of extreme environments, such as high altitude, as Alastair Dick explains.

Adventure travel has expanded rapidly in the past few years – travels to extreme environments that were until recently the preserve of explorers and the military have become commonplace for adventurous individuals. Travel to high altitude has many attractions, but is not without risk. Exposure to high altitude is associated with a particular constellation of conditions ranging from mild self-limiting problems to acutely life-threatening illnesses. The risk to an individual of suffering these can be minimised with sensible preparations and an understanding of their cause, prevention and treatment.

Patients planning to travel to altitude may request advice from their primary care physicians. A sound understanding of the effects of altitude on the body and the associated problems, as well as their prevention and treatment, will allow the physician to offer appropriate advice.

ALTITUDE AND ITS EFFECTS

The percentage of oxygen in the atmosphere is fixed at around 21 per cent, but upon ascent from sea level barometric pressure falls, and with it the partial pressure of oxygen in inspired air. As altitude increases, the amount of oxygen available to the body decreases. The partial pressure of oxygen at the summit of Kilimanjaro (5895m) is approximately half of that at sea level, and at the summit of Everest (8848m) it is only one-third. It is this hypobaric hypoxia that is responsible for altitude-related illness.

ACCLIMATISATION

Of key importance is the principle of acclimatisation. Up to a certain altitude (around 5800m) the body undergoes a number of changes to adjust to the hypoxia.

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decreased oxygen availability – it is these changes that allow activity and habitation at high altitude. The time course of these changes runs from minutes/hours (tachycardia and hyperventilation) to weeks (increase in haemoglobin concentration). Up to 3500m most individuals will undergo a significant degree of acclimatisation over two to four days. Allowing time for these changes to occur in low-level dwellers visiting altitude is the most important way to prevent altitude-related illness.

CONDITIONS ASSOCIATED WITH ALTITUDE
The conditions associated with altitude can be considered to be those involving the central nervous system and those involving the respiratory system.

The conditions affecting the central nervous system are often considered a spectrum, with the common and less severe high-altitude headache and acute mountain sickness (AMS) at one end, progressing to the rare but life-threatening high-altitude cerebral oedema (HACE). The less severe forms of altitude illness are thought to occur in over half of all travellers to altitude, but fortunately the more severe forms are rare.

High-altitude headache
This is an almost universal condition occurring on arrival at altitude above 2500m. There is usually a mild to moderate dull headache that generally improves with simple analgesia and hydration, and resolves entirely on descent. If the headache does not improve and is associated with other signs or symptoms, a diagnosis of AMS needs to be considered.

Acute mountain sickness
This is a syndrome of non-specific symptoms that can occur within hours of arrival at altitude above 2500m. The cardinal symptom is headache in combination with gastrointestinal upset, anorexia, fatigue and sleep difficulties. The diagnosis is clinical and can be aided by the application of the Lake Louise scoring system, which can stratify severity of the condition based on a simple questionnaire. The pathophysiology is not well understood; the condition may be a result of hypoxia-induced cerebral vasodilation or mild cerebral oedema.

High-altitude cerebral oedema
The development of altered mental state, ataxia or focal neurological abnormalities heralds the development of this life-threatening condition. The pathophysiology is not fully understood, but the predominant processes may include both vasogenic and cytotoxic cerebral oedema. Untreated, the condition can progress over hours to coma and death.

High-altitude pulmonary oedema
Altitude-related changes in pulmonary vascular permeability and pulmonary arterial pressures can result in non-cardiogenic pulmonary oedema. The condition can occur without preceding AMS, and can take slightly longer (two to four days) to develop.

The initial symptoms are usually a dry cough and decreased exercise tolerance. Sufferers may become tachycardic, tachypnoeic and have signs of right heart failure on examination. Later in the course, a classic bubbly productive cough that can be blood-stained may develop. Untreated, the condition may progress rapidly, resulting in marked hypoxaemia and death, and is the most important cause of altitude-related mortality.

PREVENTION OF ALTITUDE-RELATED ILLNESS
The key to prevention of all altitude-related illness is sensible preparation to allow time for a slow ascent, adequate acclimatisation and rapid descent if necessary. The ‘climb-high, sleep-low’ approach is often adopted,
with the Wilderness Medical Society advising that above 3000m individuals should sleep no more than 500m higher each day, and include a rest day for every 1000m ascended.6

Pharmacological prophylaxis
In individuals with no prior history of altitude-related illness following a slow ascent pattern, prophylactic medication should not be required. Some common treks, notably the one-week treks up Mount Kilimanjaro in Tanzania (Figure 1), often significantly exceed the suggested daily ascent rates. Those taking part in these treks, in addition to those with previous altitude-related illness, may benefit from prophylactic medications. The Wilderness Medical Society risk categories for AMS are shown in Box 1. Pharmacological prophylaxis should be considered for those situations in the moderate-risk category and is recommended for those in the high-risk category.

Acetazolamide
This carbonic anhydrase inhibitor acts to stimulate ventilation by induction of a mild metabolic acidosis by increasing renal bicarbonate losses. It is the preferred agent for prevention of AMS. Meta-analysis has provided evidence of the efficacy of acetazolamide in reducing the symptoms of AMS.7 There is conflicting evidence in the literature for an appropriate dose – many experts advise either 125mg or 250mg twice daily to be taken from one day prior to reaching 2500m until the commencement of descent. The drug is generally well tolerated with common dose-related side-effects of paraesthesia in the hands and feet, a metallic taste in the mouth and polyuria. It is prudent for those planning on taking acetazolamide at altitude to trial the drug prior to departure to ascertain if it is tolerable.

Dexamethasone
There may be a role for dexamethasone as a prophylactic agent for AMS in those intolerant of acetazolamide.8 The recommended dose is 4mg every 12 hours.8

It must be remembered that the proposed mechanism of action of dexamethasone is not to facilitate acclimatisation; therefore discontinuing the drug while at altitude before acclimatisation could cause rebound AMS. The drug should not be used for longer than ten days to prevent suppression of endogenous glucocorticoid production.

TREATMENT
The key to management of all altitude-related illness is a high index of suspicion and preparation to descend to lower altitude as soon as possible.

Acute mountain sickness
Initial management includes stopping further ascent, rest, simple analgesics and rehydration. Other diagnoses need to be excluded such as hypothermia, hypoglycaemia or alcoholic hangover/ intoxication. If symptoms fail to improve, medical management can be trialled while considering the need for descent. If not used for prophylaxis, acetazolamide 250mg twice daily and dexamethasone 4mg six hourly are recommended.6

If there is no improvement with medical management, accompanied descent (by 300–1000m) should be initiated. If descent is not feasible, supplemental oxygen (enough to maintain arterial oxygen saturations above 90 per cent) and usage of a portable hyperbaric chamber should be considered. These foot-pump-operated pressure chambers are often carried on treks to high altitude, and allow an individual to be placed inside and the effective altitude decreased by 1000–2000m (Figure 2).

BOX 1. Risk categories for acute mountain sickness.6 Refers to unacclimatised individuals starting ascent below 1200m

<table>
<thead>
<tr>
<th>LOW RISK</th>
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<tbody>
<tr>
<td>• Individuals with no prior history of altitude illness and ascending to less than 2800m</td>
</tr>
<tr>
<td>• Individuals taking more than two days to arrive at 2500–3000m, with subsequent increases in sleeping elevation less than 500m per day, and an extra day for acclimatisation every 1000m</td>
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<tr>
<th>MODERATE RISK</th>
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<tr>
<td>• Individuals with prior history of acute mountain sickness and ascending to 2500–2800m in one day</td>
</tr>
<tr>
<td>• Individuals with no history of acute mountain sickness and ascending to more than 2800m in one day</td>
</tr>
<tr>
<td>• All individuals ascending more than 500m per day (increase in sleeping elevation) at altitudes above 3000m, but with an extra day for acclimatisation every 1000m</td>
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<table>
<thead>
<tr>
<th>HIGH RISK</th>
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<tbody>
<tr>
<td>• Individuals with prior history of acute mountain sickness and ascending to more than 2800m in one day</td>
</tr>
<tr>
<td>• All people with a prior history of high-altitude pulmonary oedema or high-altitude cerebral oedema</td>
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<tr>
<td>• All people ascending to more than 3500m in one day</td>
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<tr>
<td>• All people ascending more than 500m per day (increase in sleeping elevation) above 3000m, without extra days for acclimatisation</td>
</tr>
<tr>
<td>• Very rapid ascents (such as less than seven-day ascents of Mount Kilimanjaro)</td>
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</table>
High-altitude cerebral oedema
Any suspicion of HACE should be treated by immediate accompanied descent, dexamethasone (8mg followed by 4mg six hourly), acetazolamide (250mg twice daily) and supplemental oxygen. A portable hyperbaric chamber and supplemental oxygen can be used temporarily if immediate descent is not feasible.

High-altitude pulmonary oedema
As with HACE, immediate accompanied descent is the mainstay of treatment. Ideally, the patient is carried down to minimise exertion, and kept warm and upright. Supplemental oxygen and a portable hyperbaric chamber can be used if immediate descent is not feasible. Nifedipine can be used as an adjunct at a dose of 30mg sustained release every 12 hours.

CONCLUSION
Slow ascent and careful consideration of pharmacological prophylaxis should minimise the risks of developing altitude-related illness. Early recognition of these potential serious conditions, and treatment, most importantly by descent, should reduce the risk of serious harm occurring at altitude.

Declarations of interests: none declared.

REFERENCES

Figure 2. Portable altitude chamber bag in use in Everest region, Nepal (photograph courtesy of Dr Jim Duff)

KEY POINTS
- Acute mountain sickness is common above 2500m, especially with a rapid ascent, and usually responds to stopping ascent, rest and rehydration
- Prophylactic acetazolamide has a role where rapid ascent is unpreventable and in previous sufferers of altitude-related illness
- Headache with drowsiness, altered mental state or ataxia at altitude should be considered high-altitude cerebral oedema until proved otherwise and treated with immediate descent
- Reduced exercise tolerance together with persistent dry cough at altitude should be considered early signs of high-altitude pulmonary oedema and treated with immediate descent