Travelling to new heights: practical high altitude medicine

Over 40 million people travel to high altitude for both work and pleasure each year, and all of them are at risk of the acute effects of hypoxia. This article reviews the prevention, diagnostic features and treatments of these illnesses.

Acute mountain sickness is a common condition occurring at altitude, which it is important to be familiar with before travelling to high altitude (>2500 m). The key symptoms of acute mountain sickness are frontal headache, anorexia, sleep disturbance and vomiting. An individual often notices the symptoms of acute mountain sickness during the evening of travel to high altitude. If this individual then remains at the same altitude, acute mountain sickness symptoms will peak on day two or three and those with benign acute mountain sickness will improve by day five. However, persistence of symptoms, particularly after simple analgesia, is sinister and should alert travelling companions to the possible development of severe acute mountain sickness (*Table 1*).

The two potentially lethal conditions closely related to acute mountain sickness are high altitude pulmonary oedema and high altitude cerebral oedema. These normally follow the milder symptoms of early acute mountain sickness, although this is not always the case and both conditions may occur de novo and simultaneously. It is important while at altitude to remain vigilant for their symptoms at all times, as discussed later in this article.

Table 1. High altitude travel checklist: before travelling

Check your medical insurance cover: Ensure that your medical insurance policy covers you to the altitude you will reach and for all of the activities you may engage in, such as trekking, skiing and climbing. If it does not, purchase supplementary insurance. Check that the policy includes cover for any emergency expenses such as medical evacuation. If you plan to travel to very remote areas you need to request that your policy will also cover the high costs of a specialist evacuation
Check you have called your medical insurance agency: It is prudent to contact your medical insurance agency and advise them of your role, such as bystander or expedition medic
Check the local medical infrastructure: If you are trekking without a company, or simply working abroad at altitude, familiarize yourself with the available local hospitals and health clinics
Check your first aid kit: You may find yourself in remote regions without adequate medical supplies so a comprehensive first aid kit is essential (Table 8 gives suggestions)
Check that your recommended vaccinations for the region are up to date

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Lake Louise consensus scoring system

The diagnostic indicators of acute mountain sickness are the presenting symptoms. The Lake Louise consensus scoring system is a simple, internationally agreed diagnostic tool. The scoring system evaluates the severity of the presenting symptoms (*Table 2*). Neither clinical examination nor pulse oximetry can be used to diagnose acute mountain sickness, and this quantitative scoring system is a reliable diagnostic tool (O'Connor et al, 2004). It is important to interpret the score carefully as other illness, such as gastrointestinal infections, may cause symptoms similar to acute mountain sickness and result in an erroneously elevated score. One should assume all high scor-

Table 2. Lake Louise consensus scoring system (self-reported questionnaire)

Headache	0 None
	1 Mild
	2 Moderate
	3 Severe, incapacitating
Gastrointestinal symptoms	0 None
	1 Poor appetite or nausea
	2 Moderate nausea or vomiting
	3 Severe nausea and vomiting
Fatigue or weakness	0 None
	1 Mild fatigue or weakness
	2 Moderate fatigue or weakness
	3 Severe fatigue or weakness
Dizziness or lightheadedness	0 None
	1 Mild dizziness or lightheadedness
	2 Moderate fatigue or weakness
	3 Dizziness, incapacitating
Difficulty sleeping	0 Slept as well as usual
	1 Did not sleep as well as usual
	2 Woke up many nights, poor nights
	3 Could not sleep at all

Acute mountain sickness = altitude gain + headache + at least one other symptom + a total score of 3 or more

ers have acute mountain sickness but the possibility of a confounding factor must be considered. Other illness may lower the threshold for development of acute mountain sickness, so the existence and treatment of a co-existing pathology should also be addressed.

While acute mountain sickness is often benign and self-limiting, the underlying pathophysiological mechanisms may progress and become potentially lethal. Chronic pre-existing medical conditions do not predispose individuals to acute mountain sickness – 'fit' people attempting more ambitious ascent profiles are most likely to suffer from acute mountain sickness (Schneider et al, 2002). Sea-level fitness and exercise ability do not protect against acute mountain sickness. However, acute conditions such as viral or bacterial infections often reduce the threshold for development of acute mountain sickness.

How common is acute mountain sickness?

The incidence of acute mountain sickness directly correlates with the degree and speed of ascent. People arriving on a skiing holiday at resorts situated higher than 2000 m have a moderate risk of acute mountain sickness and 25% of people report some symptoms (Montgomery et al, 1989). When lowlanders fly directly to La Paz in Bolivia (3700 m) one in four develops acute mountain sickness shortly after arrival and a small proportion of these individuals will be extremely unwell (Carlsten et al, 2004). If an individual remains at altitude for 6–12 hours or longer the risk of experiencing symptoms is greater. However, spending a few days at a particular height may reduce symptoms and allow acclimatization.

Treatment of acute mountain sickness

Acute mountain sickness is unpleasant and the discomfort of headaches should be relieved with mild analgesia such as paracetamol (*Table 3*). This is unlikely to mask progression to high altitude cerebral oedema or high altitude pulmonary oedema.

Acetazolamide is widely used at altitude and is reported to reduce the incidence and severity of acute mountain sickness. For those travelling above 2500 m, acetazolamide 125 mg twice daily has been found to be as effective as higher doses but with reduced likelihood and severity of side effects (Basnyat et al, 2006). It may also improve general performance through aiding a restful night's sleep. Acetazolamide seems to be an effective respiratory stimulant and increases the partial pressure of oxygen in arterial blood, thus reducing the desaturation associated with periodic breathing which disrupts sleep (Leaf and Goldfarb, 2006). Taking acetazolamide will not mask the symptoms of acute mountain sickness. If the drug is discontinued acclimatization may slow but there will be no rebound effect. It is important to remember that acetazolamide is not a substitute for proper acclimatization. A good knowledge of acute mountain sickness and following a sensible ascent profile (*Table 4*) is effective in preventing acute mountain sickness (Vardy et al, 2005). When taking acetazolamide many experience paraesthesiae of the periorbital region, hands and feet alongside a notable diuresis. These common side effects often decline with continuation of the drug. Also, acetazolamide notoriously makes fizzy drinks taste flat.

The phosphodiesterase-5 inhibitor sildenafil will, in some individuals, cause vasodilation of the pulmonary vasculature and there is some evidence that this may improve exercise capacity in a hypoxic environment. However, at present there is no conclusive evidence of any benefit from taking sildenafil. Sildenafil has been shown to exacerbate headache, which may imply that it has the potential to worsen acute mountain sickness symptoms and cerebral oedema (Ghofrani et al, 2004). At altitude it will still have its renowned effect upon sexual function.

There is no evidence supporting the use of a wide variety of herbal remedies in the prevention of acute mountain sickness, examples include *Ginkgo biloba* or coca extraction from the coca leaf which are commonly used in South America.

What are the clinical features of high altitude pulmonary oedema?

A state of excessive breathlessness may herald the development of high altitude pulmonary oedema. This is con-

Table 3. Treatment of acute mountain sickness

Gold standard – do not ascend, rest for at least 24 hours or descend until symptoms cease
If symptoms increase in severity descend as soon as possible
Paracetamol and/or ibuprofen to relieve headache
Acetazolamide 125 mg twice daily
Monitor individual using Lake Louise scoring system regularly (daily assessment is appropriate when ascending)

From Auerbach et al (2003)

Table 4. High altitude travel checklist – while travelling

Basic hygiene: Most high altitude mountain ranges are in developing countries where sanitation is inadequate. It is therefore important to take simple precautions to prevent gastrointestinal illness. Drink bottled water and avoid foods washed in untreated water. Wash your hands using antibacterial soap or use alcohol gel. Do not use your own cutlery to serve food from communal dishes
Follow a sensible ascent profile: A good ascent profile is the only effective way to prevent acute mountain sickness. As a rule, above 3000 m, ascent gain should be no greater than 300 m per day and should be punctuated by rest days. At heights greater than 4000 m the length and frequency of rest periods should increase. It is also beneficial to return to a lower altitude to sleep – 'climb high and sleep low'
Understand and recognize the symptoms of acute mountain sickness
Do not ascend if symptoms of acute mountain sickness start and descend if symptoms increase. Some individuals may still develop acute mountain sickness at high altitudes despite acclimatization lower down
Consider a rest day if unwell – if any illness is not responsive to simple treatments (such as paracetamol given for a headache) it is sensible to stop ascent, or even descend. At the very least, rest for a day while monitoring symptoms

firmed by an initial dry cough and subsequent production of an increasing quantity of frothy sputum (possibly streaked with blood) and basal crepitations. With time, increasing pyrexia will develop accompanied by a raised pulse and respiratory rate (of more than 30 breaths per minute). In high altitude pulmonary oedema, hypoxia causes patchy vasoconstriction of the lung architecture. A suggested pathological mechanism for this type of lung injury is hyperperfused areas in the lung, which result in a raised capillary pressure producing stress failure of the vessels. This allows fluid to leak rapidly into the alveoli, which are then unable to participate in gaseous exchange. The condition causes increasing respiratory distress and the sufferer literally drowns in his/her own secretions.

Further ascent or exercise may exacerbate the process, so individuals who may have high altitude pulmonary oedema should descend without delay, as this is an absolute medical emergency. If descent is impossible or delayed, any treatment should aim to relax pulmonary vasoconstriction. Administering oxygen or giving drugs such as calcium-channel blockers (e.g. nifedipine) can help achieve this (West and Mathieu-Costello, 1992).

What are the clinical features of high altitude cerebral oedema?

High altitude cerebral oedema is the development of a life-threatening rise in intracranial pressure resulting in cerebral oedema. It is characterized by increasing ataxia followed by coma. Neurological signs, such as extensor plantar responses and papilloedema, are not helpful in diagnosing high altitude cerebral oedema. Those suffering from high altitude cerebral oedema may be difficult to identify as they often withdraw from the main group; they may feel lethargic and will return to their tent or room to 'sleep it off'. Anyone who isolates themselves or seems unusually subdued should be questioned about symptoms of acute mountain sickness and high altitude cerebral oedema.

Treatment of high altitude cerebral oedema and high altitude pulmonary oedema

Typically dexamethasone and acetazolamide are used to treat high altitude cerebral oedema as they both reduce cerebral oedema (*Table 5*); however, descent remains an imperative. Nifedipine can be used in both the prevention and treatment of high altitude pulmonary oedema (*Table 6*). Mountaineering parties travelling above 4000 m are advised to carry an oxygen supply sufficient for several days.

Table 5. Treatment of high altitude cerebral oedema

Gold standard – immediate and rapid descent
Give dexamethasone 4–8 mg three times daily. If possible the initial dose should be given intravenously
Acetazolamide 125 mg twice daily

From Auerbach et al (2003)

Other medical considerations at altitude

Most high altitude mountain ranges are in developing countries making it important to differentiate acute mountain sickness from other common illnesses that often cause similar symptoms, such as traveller's diarrhoea and vomiting. Also, fatigue may be a result of the exertions of trekking and disrupted sleep.

Pregnant women should not sleep higher than 3500 m, as this may be harmful to the fetus (Entin and Coffin, 2004). Women may also want to consider different forms of contraception other than hormonal at high altitude as the risk of thrombosis is theoretically increased (Lehmann et al, 2006).

Those who suffer from migraine may experience more attacks at altitude and a good history will help to differentiate these from acute mountain sickness or, more importantly, high altitude cerebral oedema. If there is concern that the symptoms might represent high altitude cerebral oedema rather than migraine, particularly if they are not responding to simple treatment, then it is appropriate to descend and treat as high altitude cerebral oedema.

High altitude cough

High altitude cough is a condition of unknown aetiology and can present in a similar manner to bronchitis. Both are characterized by a persistent cough, with or without sputum production and confusingly may occur together. High altitude cough will not cause persistent shortness of breath at rest, although shortness of breath will be common on arrival at high altitude. Oxygen saturations will be reduced in all individuals at high altitude but should not worsen in an individual with high altitude cough if he/she remains at the same altitude; otherwise it is likely that he/she has a respiratory infection (Mason and Barry, 2007). Respiratory infections may also reduce the threshold for the development of high altitude pulmonary oedema.

High altitude retinopathy

High altitude retinopathy is common and occurs in one third of trekkers at 5000 m (Pollard and Murdoch, 2003). High altitude retinopathy is typically asymptomatic and may only be detected by fundoscopy unless visual problems are reported. Unfortunately, no adequate treatment is available and descent is essential, as there have been reports of scotomas that have not fully resolved after exposure to high altitudes (Pollard and Murdoch, 2003).

Table 6. Treatment of high altitude pulmonary oedema

Gold standard – immediate and rapid descent, with:
Nifedipine 20 mg (slow release)
Dexamethasone 4–8 mg three times daily. If possible the initial dose should be given intravenously

From Auerbach et al (2003)

Cold injuries

Cold injuries may easily occur in the mountains, commonly during activities such as climbing and skiing. Often the individual is unaware of cold damage as it is painless. Such injuries can often be prevented by wearing the correct clothing, for example, down layers to insulate combined with wind- and waterproof garments. Local cold injury such as frostbite will affect the extremities and face so it is very important to have good socks, boots, gloves, hat and face protection.

A cold injury will initially look white and may feel firmer as ice crystals form in the tissue. Later the tissue will turn yellow-white or mottled blue-white. The area will be numb and, as the injury progresses, will become insensitive to pressure or touch. Superficial frostbite involves mainly the skin so that the tissue can still be moved over bony prominences; however, in deep frostbite the tissue is entirely hard. Frostnip is the mildest form of cold injury, while chilblains are a more severe and uncomfortable form that usually occurs in non-freezing temperatures and damp conditions. To aid evacuation an individual may be allowed to walk on cold injured limbs but, where possible, this should be avoided. When caring for a frostbite injury it is important to avoid any opportunity for infection of the damaged tissue (Long et al, 2005). *Table 7* outlines the management of cold injuries.

General hypothermia is reversible and the core should be re-warmed before the shell. Sudden movement and knocks may precipitate fatal heart rhythms during the re-warming process, and both re-warming and fatal heart rhythms are difficult to manage effectively in an exposed and remote environment (Long et al, 2005).

What should my first aid kit contain?

When travelling to altitude it is advisable to take your own supply of over-the-counter and prescription medications as medical resources may be unavailable or unreliable. In addition to the standard first aid kit, travelling doctors may be expected to carry additional medication for the treatment of acute mountain sickness (*Table 8*). It is important to have the correct amount of medical kit. You may expect to use a large amount of minor pain killers, acetalzolamide, oral rehydration sachets or solutions, and ciprofloxacin. While oral rehydration sachets are convenient, rehydration solutions can be readily made using 40 g of sugar and 3.5 g of salt dissolved in 1 litre of clean safe water.

There is no consensus about when antibiotics should be used to treat gastrointestinal infections. For the purpose of discussion, moderate infection is when the individual has four or more episodes of watery diarrhoea in 12 hours which is not improving and he/she continues to feel unwell despite adequate oral rehydration. Quinolones such as ciprofloxacin are effective in treating moderate diarrhoea (Caeiro and DuPont, 1998). A single dose of ciprofloxacin 500 mg will reduce the duration of infection to less than 24 hours in half of those treated (Sama et al, 1994). If diarrhoea persists, give ciprofloxacin 250–500 mg twice daily for 3–5 days or until symptoms improve. After this time an agent effective against anaerobic organisms, such as tinidazole, should be added to the regimen (*Table 8*) and descent or evacuation considered. Ciprofloxacin is contraindicated in those with a history of seizures and has been known to cause acute tendon rupture, particularly in those with, or prone to, tendinitis.

Further information

Societies

The Wildness Medical Society (www.wms.org)
The International Society for Mountain Medicine (www.ismmed.org)

Courses

Expedition Medicine Courses provides courses in UK and overseas (www.expeditionmedicine.co.uk)
Medex and Medical Expeditions offer a diploma in mountain medicine and organize research expeditions to Nepal every 4–5 years (www.medex.org.uk)
Mountain and Marine Medicine (www.mountainandmarinemedicine.com)

Websites

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Conclusions

There are still many misconceptions surrounding acute mountain sickness and its treatment. However, the most important message is very simple; if acute mountain sickness is suspected the individual should not continue to ascend. If rest and mild analgesia do not relieve the symptoms, or if the symptoms progress, then immediate descent is the most essential aspect of treatment. Among those who go to high altitudes for recreation there is a natural reluctance to curtail holidays or change plans because of a headache. This reluctance is commonly the reason for progression of acute mountain sickness to high altitude pulmonary oedema and high altitude cerebral oedema. Both these illnesses remain poorly understood and travellers need to realize that they are life threatening. BJHM

Table 7. Treatment of frostbite

Stop – evaluate the route of evacuation: is there a possibility that the injury may re-freeze?
Do not thaw if there is a chance of re-freezing
Warm with skin-to-skin contact (hands placed in armpits)
If possible re-warm using sterile water (38–41 °C), do not allow tissue to touch container and ensure all tissue is immersed
After immersion give pain relief and elevate limb
If blisters form protect and do not allow to burst
Protect limb with a sterile dressing to avoid infection

Table 8. Recommended additions to a mountain first aid kit

	Drug	Indications	Dose
For acute management of AMS, HAPE and HACE	Acetazolomide	For AMS symptoms and HACE	250 mg – take two tablets morning and evening
	Nifedipine	For acute management of HAPE	Capsules 10 mg – take two capsules three times daily and descend
	Dexamethasone	For AMS symptoms and acute management of HACE	2 mg – take two tablets four times daily and descend
Simple analgesia	Paracetamol	For AMS headache and other mild to moderate pain	500 mg tablets – as required to a maximum dose of 4 g in 24 hours
	Ibuprofen	Mild to moderate pain and inflammation	400 mg tablets – 400 mg 3–4 times daily to a maximum dose of 2.4 g in 24 hours
	Codeine phosphate	Mild to moderate pain and diarrhoea	15 mg tablets – 30–60 mg every 4 hours as required to a maximum of 240 mg in 24 hours
Infections	Amoxicillin	Respiratory, wound, kidney and urinary tract infection	250 mg every 8 hours, double in severe infections
	Ciprofloxacin	First choice for bacterial diarrhoea (also for respiratory and urinary tract infection)	Loading dose on first day of 500 mg, 250–500 mg twice daily
	Tinidazole	Giardia	Single dose 2 g
	Metronidazole	Giardia	2 g daily in one dose for 3 days
		Amoebic dysentery	600–800 mg 8-hourly for 8 days
Gastrointestinal symptomatic relief	Prochlorperazine	To help nausea and vomiting	Onset of nausea or vomiting: 20 mg initially then 10 mg after 2 hours (orally)
			Prevention: 5–10 mg 2–3 times daily
			Severe: deep intramuscular injection of 12.5 mg
	Loperamide	Acute diarrhoea	4 mg initially followed by 2 mg after each loose stool for up to 5 days
	Oral rehydration sachets or solution	Diarrhoea	Aim to replace all fluid loss
Equipment	Dressings and tape (Micropore tape, Elastoplast tape, an excess of assorted plasters, larger dressings, crepe bandages and Melolin dressing), an excess of baby wipes, sterile wipes, alcohol gel, Savlon or Germolene, tincture of iodine, medical gloves (some sterile), thermometer (strip type), spare knee and ankle sport support		

AMS = acute mountain sickness; HACE = high altitude cerebral oedema; HAPE = high altitude pulmonary oedema. From Pollard and Murdoch (2003)

Conflict of interest: none.

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KEY POINTS

- Know the symptoms of acute mountain sickness.
- If you suspect acute mountain sickness descend without delay.
- Prepare fully for travel to high altitude and carry an adequate first aid kit.

Further reading

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