

Medical problems of high altitude

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ABSTRACT As many high-altitude regions of the world become more popular holiday destinations, travellers need to understand how to prepare for high-altitude travel and how to deal with its potential consequences. In this article, Professor Andrew Peacock looks at the effects of high altitude on the human body and discusses how to prevent or treat diseases associated with, or made worse by, high altitude.

KEYWORDS Acute mountain sickness, altitude sickness, HACE, HAPE, hypoxia

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Increasing numbers of Westerners are travelling to the high-altitude regions of the world. As these regions have sparse medical care, it is essential for both travellers and their general practitioners to understand the possible consequences of high-altitude travel and how to prevent and treat those syndromes that are either caused or made worse by high altitude. This article describes the effects of altitude on human physiology, the process of acclimatisation to altitude, the diseases specifically associated with altitude and also those diseases that are made worse by altitude or commonly occur in high-altitude areas of the world.

It is estimated that each year approximately 30,000 Britons travel to altitudes of up to 5,500 m (18,000 ft), the height of Everest base camp. When trekking, altitude exposure is prolonged and the trekker cannot sleep low and is therefore unable to follow the old mountaineering adage 'climb high but sleep low'.

The decrease in the partial pressure of oxygen as one goes higher – a consequence of falling atmospheric pressure – is the principal reason that altitude can be harmful to health. There are two other main environmental insults associated with high altitude: low temperatures and dehydration. These are important because acute mountain sickness is more common when subjects are also cold and dehydrated. The main physiological changes associated with high altitude are shown in Table 1.

Acclimatisation to high altitude involves a complex series of physiological changes, including changes in ventilation, changes in pulmonary artery pressure, changes in cardiac output, changes in red cell number,

TABLE 1 Effects of altitude on human physiology

Lungs

- Loss of ventilatory control, especially during sleep: 'Cheyne–Stokes breathing' – cyclical hypoventilation and hyperventilation
- Airway function: irritation of airways by cold dry air
- Gas exchange: limitation of diffusion of oxygen

Cardiovascular

- Heart function is well preserved
- Hypoxia causes pulmonary vasoconstriction and pulmonary hypertension
- Systemic arterial and venous pressures largely unchanged

Central nervous system

- Hypoxia impairs or damages CNS function: this may not recover
- Stroke
- Cerebral oedema

Blood

- Increase in haematocrit/haemoglobin: hypoxia stimulates production of erythropoietin
- Increase in muscle capillaries
- Possible increased risk of thrombosis

changes in the number of capillaries in muscle and altered control of fluid balance. The rate of acclimatisation depends very much on the altitude at which travellers start and the altitude at which they plan to finish. A reasonable schedule below 4,300 m is to climb at a rate of no more than 400 m per day. Above 4,300 m this should be reduced to 150–300 m per day, with every third day a rest day. It is very important that the acclimatisation schedule is set for the weakest (i.e. slowest) member of the party and not the strongest.

DISEASES SPECIFICALLY RELATED TO ALTITUDE

A number of clinical pictures are specifically related to the effects of altitude (and over-rapid changes of altitude).

Acute mountain sickness

Acute mountain sickness is a syndrome comprising headache, dizziness, breathlessness, drowsiness, yawning, poor appetite (often associated with nausea) and poor sleep (related to Cheyne–Stokes breathing, see Table 1). On physical examination, there may be few important abnormalities, but it is important to exclude crackles in the lungs, which might suggest the onset of high-altitude pulmonary oedema, and evidence of cerebral oedema. Once the symptoms of mountain sickness develop, the subject should go no higher, but should rest at the altitude achieved for at least 24 hours. Provided that the symptoms resolve completely, the sufferer can then recommence climbing at a slow pace. If the symptoms do not remit with simple measures such as paracetamol and rest at that altitude, then the subject should descend as fast as possible and await full resolution of the symptoms.

The treatment of acute mountain sickness is supportive, but there is good evidence that prophylaxis can be achieved by giving acetazolamide 125–250 mg twice daily. This drug, a carbonic anhydrase inhibitor, probably works by making the cerebro-spinal fluid acidic, which drives respiration and, in turn, improves oxygenation.

High-altitude pulmonary oedema (HAPE)

This condition, which is often fatal, has been known about for thousands of years but was only properly described in the 1960s. The symptoms are those of acute mountain sickness, accompanied by cough, often productive of frothy, sometimes blood-stained, sputum and severe breathlessness. The physical signs are cyanosis, crackles in the lungs, high heart rate and high respiratory rate. The immediate treatment is the administration of oxygen if available, sublingual nifedipine 20 mg and then further nifedipine on a six-hourly basis. These measures are, however, only supportive and the most important action is to descend. The descent of the patient should be as fast as possible; often only 300 m will make a significant difference. If it is impossible to get the patient to a lower altitude, then a substitute is to place the patient in a Gamov bag, which can be inflated to artificially raise apparent atmospheric pressure and hence the inspired oxygen tension. The bag should, however, only be used while awaiting descent or to assist descent, not as a substitute for descent.

There is evidence for successful prophylaxis of HAPE with a number of agents, including calcium channel blockers and long-acting inhaled beta agonists.

High-altitude cerebral oedema

Like high-altitude pulmonary oedema, the cause of this condition remains an enigma. Even more interesting is that the two do not always go together, although hypoxia is definitely the common link. In this condition there is initial brain injury, then brain swelling, which worsens the injury. The symptoms are headache, poor cerebral function, hallucinations, psychotic symptoms and ataxia. There is obvious loss of cerebral function, inappropriate behaviour and retinal haemorrhages on fundoscopic examination. It is important to exclude hypothermia (which can cause similar symptoms); this can be excluded by simply measuring core body temperature. Immediate treatment is dexamethasone (8 mg IV, followed by 4 mg IV six-hourly). Once again, however, the most important action is descent. The patient should be got down the mountain as quickly as possible. An alternative, as above, is to place the patient in a Gamov bag, where local atmospheric pressure can be raised artificially, while awaiting descent.

Other conditions

Retinal haemorrhages

These are common at more than 4,300 m and occur in 30–100% of climbers ascending above 5,400 m. They probably represent cerebral injury but do not in themselves cause visual problems. However, they can be very alarming for the expedition doctor.

Systemic oedema

Widespread oedema is fairly common, particularly in those who are acclimatising poorly. It is not in itself an indication of the onset of cerebral or pulmonary oedema but should make the subject (or expedition doctor) watch out for other evidence of a high-altitude illness.

Clotting

On initial ascent to high altitude there is loss of plasma volume with a rise in red cell volume and hence packed cell volume (=haematocrit/haemoglobin). This has the effect of increasing the likelihood of clotting, and thrombosis may occur. Particularly worrying are pulmonary emboli and cerebrovascular stroke. Mitigation of these physiological changes is the best way of avoiding problems. It is very important to maintain adequate hydration, but in addition many doctors would give aspirin 150 mg daily to all those ascending above 4,300 m.

DISEASES COMMON IN HIGH-ALTITUDE AREAS OR MADE WORSE BY ALTITUDE

Infections

Many infections, particularly gastrointestinal infections, are common in the high-altitude areas of the world. The problem is that they usually respond very poorly to antibiotic therapy at high altitude and thus it is often necessary to take the patient down 300–600 m in order

to effectively treat infections that occur. The most common problems are acute bronchitis, skin infections and gastrointestinal infections, which are nearly always bacterial or protozoal in origin.

Lung disease

Anyone with lung disease is clearly going to suffer at high altitude; indeed they may suffer at the cabin altitude of commercial aircraft (which is equivalent to around 1,800 m). If there is any doubt at all about respiratory function of a potential high-altitude trekker, the individual should have a full respiratory assessment in a respiratory clinic before departing.

Heart disease

Heart disease (even if well controlled on medication) can cause problems in exactly the same way as lung disease, and the same degree of caution and assessment prior to travel are necessary.

CONCLUSIONS

There are specific syndromes associated with travelling to high altitude which are a consequence of the hypoxia of altitude. Since many travellers go to altitudes where significant hypoxia can be expected, it is necessary for medical staff offering advice to know what severity of hypoxia to expect at the altitude to which the traveller is going and what likely effects this might have on their cardiac, pulmonary and renal physiology. Specific syndromes associated with altitude, such as high-altitude pulmonary oedema, high-altitude cerebral oedema and acute mountain sickness can be prevented if sensible precautions are taken. Travellers should have adequate emergency therapy to treat these syndromes, while understanding that the optimal treatment is descent to a lower altitude as fast as possible.

FURTHER READING

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KEY POINTS

- Hypoxia, hypothermia, dehydration and accidents are serious risks for those planning to operate at high altitudes – careful planning and appropriate equipment are essential to deal with these risks.
- The excitement of the challenges of high altitudes must be balanced against the dangers to both participants and their potential rescuers.
- The main symptoms of acute mountain sickness (headache, dizziness and drowsiness) may not be recognised for what they are and can occur in ski resorts, high-altitude airports and even in tourist resorts.
- Advance planning should always allow time for slow ascent; there is nothing heroic about struggling on, placing both those affected and their companions in serious danger.
- If symptoms of altitude illness develop, then ascend no further until they remit. If in doubt, descend!
- Common high-altitude tourist destinations include the Himalayas in Nepal, Mount Kilimanjaro in Tanzania and the Andes in South America.
- Young children may be at particular risk of high-altitude illness and specialised advice should be sought.

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