# Altitude illness

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Mountains cover one fifth of the earth's surface and are popular destinations for recreation, such as trekking, mountaineering, skiing, deployment of armies and pilgrimages. More than one hundred million people live permanently at altitudes higher than 2500m[1]. With increased numbers of visitors to high altitudes, the prevention and management of altitude-induced illness has become of increased importance to expedition doctors, general practitioners and travel medicine specialists. It has become a public health concern. In this brief review, we will define high altitude illness, it's associated terms, and highlight key scientific principles related to acute mountain sickness (AMS),

**The pilgrims seeking health care** in the health camp organized by Mountain Medicine Society of Nepal (MMSN) and Himalayan Rescue Association Nepal (HRAN) at sacred Lake Goshain Kund at 4380m in Nepal Himalayas during the festival.




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The mountains of Nepal Himalaya. **Matiram Pun** (centre) with friend and Buddhist Monk.

high altitude cerebral edema (HACE), and high altitude pulmonary edema (HAPE). Finally we will provide practical recommendations to those ascending to altitude.

Altitude illness is anticipated in those travelling to higher than 2500m though most forms are mild. However a few might encounter life threatening conditions and even death if they are not treated on time. High altitude illness is a collective term for AMS, HACE and HAPE. It is used to describe the cerebral and the pulmonary syndrome that develops in unacclimatised people after ascent to high altitude.

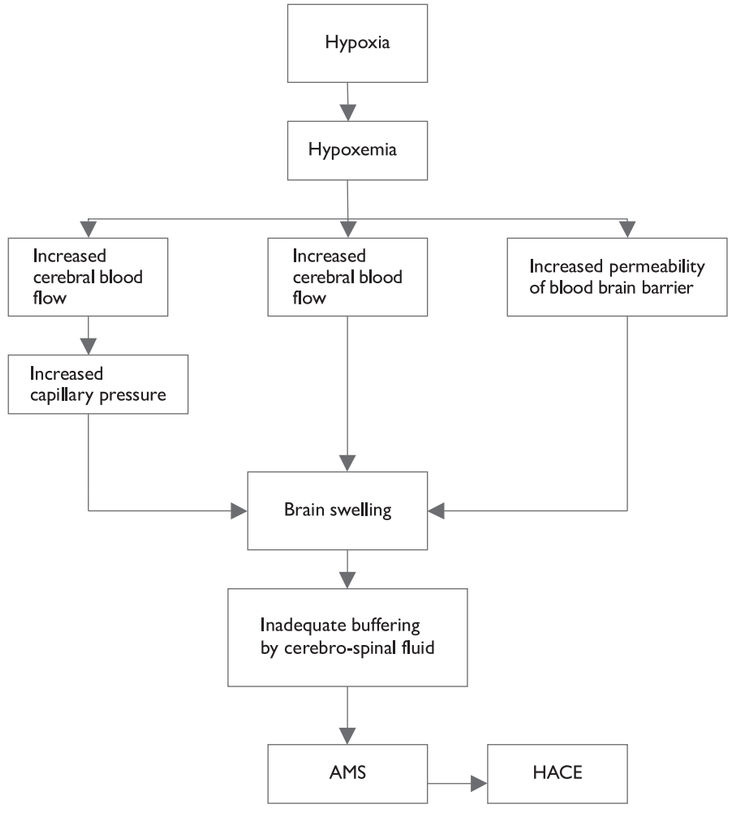


**Figure1: pathophysiology of acute mountain sickness and high altitude cerebral edema**[1]
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The most important risk factors for the development of high altitude illness are the rate of ascent, altitude reached (especially the sleeping altitude), and individual susceptibility. There is no associated susceptibility to age and sex. Physical fitness is not a protective factor against high altitude illness. Vascular endothelial growth factor (VEGF) production in hypoxia has supported the hypothesis that angiogenesis may be involved in HACE,[2] and the sustained plasma VEGF at high altitude is a feature of subjects more prone to AMS[3].

Although there is no hard and fast rule to define different levels of altitude, generally the altitude from 1500-2500m is called intermediate altitude; 2500-3500m as high altitude; 3500-5800m as very high altitude and the height above 5800m is known as extreme altitude.[4]

As one goes higher up a mountain the partial pressure of oxygen is decreased so the body must adjust to having less oxygen. A number of physiological changes that occur to enable the body to function optimally in the low oxygen environment is known as acclimatisation, lack of which is the cornerstone to altitude illness and it can be achieved only through slow ascent.

## ACUTE MOUNTAIN SICKNESS (AMS)

Acute mountain sickness consists of a constellation of non-specific symptoms. Specific symptoms include anorexia, nausea, vomiting, insomnia, dizziness, lassitude or fatigue and light-headedness. Headache is the cardinal symptom. Presence of headache in an otherwise healthy individual at more than 2500m altitude is thought to be AMS. These symptoms appear 6-12 hours after the arrival to a new altitude and resolve after 1-3 days in the same altitude. The diagnostic physical signs are lacking so there is a need to differentiate mountain sickness from conditions like exhaustion, dehydration, hypothermia, alcohol hangover and migraine.

Although the exact pathophysiological process of AMS is unclear, symptoms are thought to be due to cerebral swelling either from vasodilation induced by hypoxia or through cerebral edema.

The main principle of the treatment of AMS is to prevent further ascent until the symptoms resolve. Rest at the same altitude usually resolves the symptoms; the patient should improve without treatment within 24-48 hours. If the symptoms deteriorate one should descend as soon as possible. Descent of only 500-1000m leads to the resolution of symptoms of acute mountain sickness.

Medical therapy plays an important role when descent is not possible or supplemental oxygen is unavailable. Acetazolamide, a carbonic anhydrase inhibitor, works by increasing the bicarbonate excretion in the urine, making the blood more acidic, which consequently drives ventilation, which is the mainstay of acclimatisation. Doses of 250mg eight hourly have been used widely and found to be effective to reduce the AMS symptoms. Dexamethasone (8mg initially and then 4mg every six hours) have also been effective in relieving AMS symptoms. Simple analgesics and antiemetics would reduce headache and nausea in early forms of AMS.

Allowing time for acclimatisation through gradual ascent is the best strategy. Once above 2500m sleeping altitude should not be increased by more than 300-600m in 24 hours and an extra day should be added for acclimatisation for every increase of 1000-1200m. 'Climb high, sleep low' should be the guiding principle. Although rate of acclimatisation for individuals vary, a large part of acclimatisation occurs over the first one to three days. Acetazolamide 250 mg twice daily taken one day before ascent has been effective to prevent the symptoms of AMS[5] although, 125 mg twice daily has recently been found effective[7].

## HIGH ALTITUDE CEREBRAL EDEMA (HACE)

High altitude cerebral edema has been widely viewed as the end stage of AMS and is generally preceded by the symptoms of AMS. It is a clinical diagnosis, defined as the onset of ataxia, altered consciousness in someone with AMS. Other symptoms are weakness, disorientation, loss of memory, hallucination and psychotic behaviour. It might progress to coma and death due to brain herniation. HACE is commonly associated with retinal haemorrhage, palliloedema and cranial nerve palsy and occasionally focal neurological deficit. In persons with HAPE, severe hypoxemia may lead rapidly from AMS to HACE.

In both brain and lung, at high altitude, hypoxia elicits neurohumoral and haemodynamic responses that result in overperfusion of microvascular beds, elevated hydrostatic capillary pressure, capillary leakage and consequent edema[5]. Fluid accumulation in the brain is thought to be caused by cytotoxic edema, vasogenic edema or both.

HACE is considered to be the end stage of AMS. Anyone with symptoms of AMS should follow three principles: stop further ascent until symptoms have resolved, descend if there is no response to medical treatment, and quickly descend at the very first sign of HACE. Otherwise it might prove fatal.

Dexamethasone (8mg initially then 4mg six-hourly orally) [5] will relieve some symptoms that would make evacuation easy. Oxygen, if available, should be used to aid evacuation. Hyperbaric chambers improve oxygenation and relieve symptoms thus simulating descent to a lower altitude.

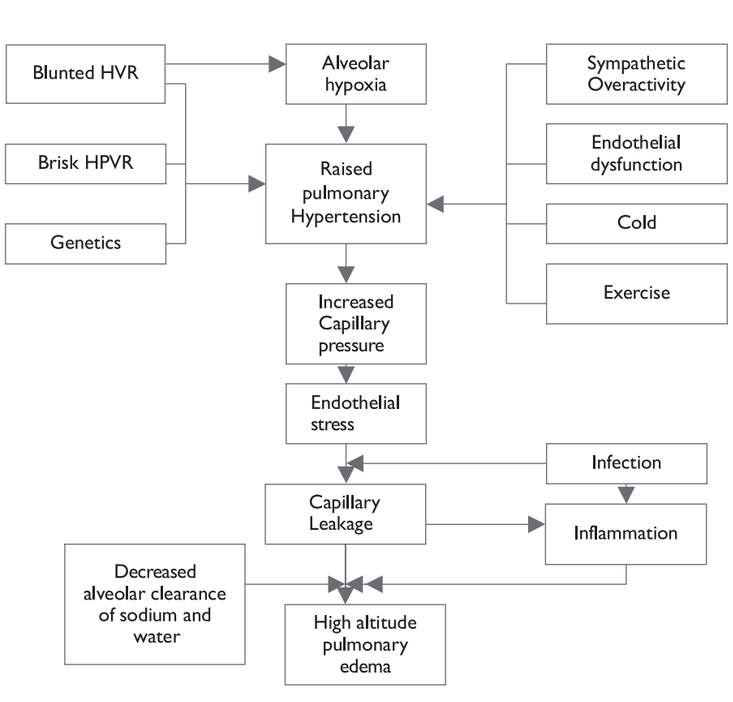


**Figure 2: Pathophysiology of high altitude pulmonary edema**[1]

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**HVR** = hypoxic ventilatory response
**HPVR** = hypoxic pulmonary vascular response

## HIGH ALTITUDE PULMONARY EDEMA (HAPE)

High altitude pulmonary edema is at the severe end of spectrum of symptoms of AMS which occurs in persons who ascend rapidly to a height of more than 2500m. It might also occur irrespective of the symptoms of AMS. Vigorous men are more susceptible to it. Other risk factors are strenuous exercise, cold weather and recent respiratory tract infection. Those who have had HAPE in the past are likely to get it again.

Early symptoms are dyspnoea on exertion and decreased exercise tolerance greater than expected for that altitude. Cough, tachypnoea, tachycardia, orthopnoea, cyanosis, rales and frothy pink sputum are the important clinical signs. Fever ($38.5^0$) is a common feature. HAPE is commonly accompanied by the signs of HACE. Symptoms occur 2-4 days after rapid ascent, and usually begin at night time rest.

HAPE is a non-cardiogenic pulmonary edema associated with pulmonary hypertension and elevated capillary pressure. Furthermore, individuals susceptible to HAPE have exaggerated rise in pulmonary artery pressure in response to hypoxia and exercise. The mechanism for this response includes sympathetic overactivity, endothelial dysfunction and greater hypoxemia resulting from poor ventilatory response to hypoxia.

Early recognition is the first key step in the treatment of HAPE, after which descent and supplementary oxygen are very effective treatments. 10mg nifedipine followed by 20mg slow release preparation every 12 hours may be useful as an adjunct to descent and oxygen[4].

Those with a previous history of HAPE should consider slower ascent to high altitude, try to recognize symptoms early and consider nifedipine prophylaxis 20mg slow release preparation every eight hours[7]. Inhaled ß-agonist has also been effective in preventing HAPE.

## CONCLUSION

People face both danger and pleasure in the high mountains. Lack of acclimatisation is the main culprit in presentations of AMS, HACE and HAPE. To become acclimatised, slow ascent should be our motto for the prevention of high altitude illnesses. The message is loud and clear: "Climb every mountain but slowly!" Over exhaustion, alcohol and dehydration inhibit acclimatisation, and must be avoided at high altitudes. If necessary, take Acetazolamide prophylactically. If you get altitude illness, firstly stop your ascent, secondly take medical treatment, and thirdly descend. Drugs are used mainly for symptomatic relief and not so much for treatment - prevention is paramount.

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