Advice for high altitude expeditions

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Introduction:
Increasing numbers of people are now travelling to areas of high altitude, frequently in the pursuit of ever more popular leisure activities such as skiing, trekking and mountaineering. Estimates in the region of 40 million people per year venturing to heights of over 2500m have been quoted. It is generally accepted that ‘high’ altitude refers to a height of 1500-3500m; ‘very high’ altitude to 3500-5500m; and ‘extreme’ altitude to over 5500m above sea level. Journeying to these places of high altitude carries significant risk of illness and death. Amongst trekkers in the Nepal region of the Himalayas a figure of 15 deaths per 100,000 was seen from 1984-1987 of which 13% (3 out of 23) were due to altitude related illness.

With increasing altitude the air pressure falls but the proportion of air that is oxygen remains the same. This means that the oxygen level falls with increasing altitude. This lack of oxygen at high altitude causes hypoxaemia (a lack of oxygen in the blood stream) which leads to the illnesses associated with high altitude environments. Hypoxaemia is, however, only one of the problems encountered at high altitude; other problems frequently encountered are:

- Decreasing temperature
- Decreasing humidity (the amount of water vapour in the air)
- Increasing penetration of UV light
- Increased exposure to ionising radiation
- The inherent remoteness of most high altitude environments
- Risks of trauma from falling or being fallen upon (rocks and snow) associated with some mountaineering activities.

The body responds to the low blood oxygen levels with a number of physiological changes that we describe as acclimatisation. If the body fails to acclimatise effectively the symptoms of Acute Mountain Sickness (AMS) develop.
**Acclimatisation:**
The most obvious body changes seen during acclimatisation are an increase in breathing depth and rate and increase in heart rate. After a few days at high altitude these symptoms seem to subside, after which one is said to be acclimatised. However the increased breathing is sustained during residence at high altitude and is one of the ways the body keeps the oxygen levels in the blood as close to normal as possible. After a few days the body also makes more red blood cells in order to try and increase the amount of oxygen that is carried in the blood. There is a great deal of individual variation in acclimatising. The main factors determining whether or not acclimatisation will be effective is the speed of ascent and the overall height gained. The slower one ascends the greater likelihood of more effective acclimatisation.

**Graded Ascent**
The safest way to avoid the symptoms of AMS is by graded ascent. Guidelines vary, as there is no method of ascending which completely removes the risk of developing AMS. A generally accepted rule-of-thumb to ascend safely is as follows:

- Avoid rapid ascent from sea level to a height over 3000m
- Spend two to three nights at 2,500m to 3,000m before going any higher
- Once above 3000m, each night should be spent no more than 300m higher than the last
- A rest day should be taken every two to three days (i.e. two nights spent at the same altitude)

Ascending faster than this increases the likelihood of high altitude illness but there is wide variation between individuals.

Other sensible measures that should be taken when trekking at high altitude include:
- Avoid alcohol and sedative drugs
- Eat a high carbohydrate diet
- Avoid excessive overexertion. Mild exercise may aid acclimatisation, e.g. short day walks during rest days, but heavy exercise should be avoided.

**Acute Mountain Sickness (AMS):**
Most individuals will begin to feel unwell if they ascend rapidly to a height over 3000-3500m. The incidence of AMS depends primarily on rate of ascent and final altitude reached, but also on the person’s individual susceptibility. Overall the incidence of AMS in adults ascending from sea level to 2,000m is about 25%. People with AMS most commonly complain of:

- Headache
- Breathlessness
- Sensation of forceful heartbeat
- Fatigue
- Loss of appetite
- Nausea and vomiting
- Difficulty sleeping and irregular breathing at night
- Dizziness

These are the classic symptoms of acute mountain sickness and tend to occur within a few hours of arrival at a high altitude destination. The symptoms tend to be self-limiting, usually subsiding spontaneously after 3 to 5 days, but may well return if further ascent is undertaken.

The 1993 Lake Louise Consensus Committee defined AMS according to a simple self-administered questionnaire that could be used during expeditions. The questionnaire is outlined below:
To diagnose AMS, *all* of criteria 1 to 3 and *one* of symptoms a to d are required:

**Criteria (all must be present)**
1. A recent gain in altitude
2. At least several hours at the new altitude
3. The presence of headache

**Symptoms (any one must be present)**
- Gastrointestinal upset (anorexia, nausea, or vomiting)
- Fatigue or weakness
- Dizziness or light-headedness
- Difficulty sleeping

**How to avoid AMS:**
AMS can occur in previously healthy individuals. There are at present no reliable physiological parameters that can predict susceptibility to AMS. Fitness offers no protection from AMS and the incidence decreases with advancing age. The primary stimulus to the conditions is hypoxia and gradual acclimatisation by slow ascent will help reduce its incidence and improve overall performance and survival at extreme altitudes.

The best way to prevent AMS is to ascend slowly to allow time for acclimatisation. This is known as graded ascent.

There has been much research into and interest in the drug Diamox (acetazolamide, a drug used by doctors in the treatment of glaucoma) and its role in the prevention and treatment of AMS. It has been shown in a number of randomised controlled studies to be effective in preventing AMS in individuals making rapid ascents to high altitude. Although controversial, it has now been suggested that smaller doses of Diamox may be as effective as larger doses, with the advantage of fewer side effects. A common recommendation for the use of Diamox in the prevention of AMS is:

- 125 to 250mg taken twice per day starting 24 hours before ascent
- Continue for the first two days at high altitude whilst acclimatising
- Maximum of four to five days treatment

Who should take Diamox? Diamox is not recommended for routine use at high altitude. Graded ascent is the preferred way to avoid AMS. It may well be useful in individuals who have to ascend rapidly to a height above 3000m and in those individuals known to suffer AMS from previous exposure to high altitude. See below for details regarding Diamox.

**Treatment of established AMS:**
Having made the diagnosis of AMS using the Lake Louise questionnaire, a plan of action should be rapidly formulated. Remember that the cause of AMS is a lack of oxygen so the simplest method of treatment is to increase the amount of oxygen available to the individual, i.e. descend to a lower altitude.

The recommendations given below regarding treatment of AMS must be considered in the light of the individual's condition and the experience of the people designated to look after them:

- In the first instance stop and rest at the present altitude, allowing the individual to acclimatise. This may take a number of days.
- Descend immediately if symptoms worsen despite no gain in altitude. Descent should be to an altitude 500m below the altitude at which symptoms appeared.
- Treatment of symptoms:
  - *Aspirin* (300mg every 4 to 6 hours, max 900mg per day) for headache
- Paracetamol (1g four hourly, no more than 4g per day) for headache
- Ibuprofen (400mg 8 hourly) for headache
- Stemetil (20mg initially then 10mg every 8 hours, max 30mg per day) or
- Metoclopramide (10mg every 8 hours) for sickness

- Specific treatments:
  - Diamox 250mg within 24 hours of symptoms appearing then 250mg 8 hours later.
  - Dexamethasone, a steroid, can be given orally and is effective in the treatment of AMS. The dose is 4 to 8mg followed by 4mg every 6 hours. It leads to improvement of symptoms within 12 hours but should be reserved for individuals with severe progressive symptoms. Treatment with dexamethasone MUST be accompanied by decent, as symptoms are likely to re-occur when treatment ceases.

- Oxygen:
  - DESCEND descending increases the air pressure so more oxygen is available.
  - MASK OXYGEN: from a cylinder or an oxygen concentrator (special machine for producing oxygen).
  - PORTABLE INFLATABLE PRESSURE BAG: oxygen can be administered by the use of an inflatable pressure bag (e.g. Gamow bag, PAC, Certec bag). The affected individual must get inside of the impermeable bag and the pressure inside is pumped up to simulate a physiological descent. The individual remains inside the bag for approximately one hour then must be assessed and if necessary the process repeated until such time as it is safe for the individual to descend. It has been found that HAPE typically requires 2 to 4 hours of treatment whereas HACE requires 4 to 6 hours. The bags tend only to be carried by mountaineers planning to travel to extreme altitude and should not be used by inexperienced operators.

The take-home message if in any doubt is… **“If in doubt descend”**

**High altitude pulmonary oedema (HAPE):**
HAPE is the most common cause of death due to the effects of high altitude. Like AMS it occurs in previously healthy individuals and its incidence is strongly associated with rate of ascent and overall altitude gained. Susceptibility to HAPE seems to be more clear-cut than susceptibility to AMS. That is to say, those individuals who have previously suffered HAPE are likely to experience the symptoms again when returning to a high altitude environment. The typical presentation is one of the onset of symptoms of AMS that do not resolve. The individual then becomes markedly short of breath, tired and may develop chest pain. The Lake Louise Consensus Committee defined the diagnosis of HAPE as – a recent gain in altitude accompanied by at least two of the following symptoms:

- Shortness of breath at rest
- Persistent cough
- Weakness or decreased exercise performance
- Chest tightness or congestion

These symptoms are the result of a build up of fluid within the lungs (pulmonary oedema), the formation of which is not a fully understood mechanism at present.

The symptoms can develop within a few hours of gaining height, but are most commonly seen on the second night at altitude. The mortality from this condition can be reduced by rapid diagnosis and treatment as appropriate treatment usually leads to complete recovery. It has been quoted in medical literature that untreated HAPE can lead to death in as many as 44% of cases.
Prevention of HAPE:
As HAPE is considered to be a continuation of the process of AMS the prevention of HAPE is the same as that described for AMS above i.e. graded ascent. Of particular importance in the prevention of HAPE seems to be the avoidance of over-exertion at high altitude, especially during the first two days. Diamox probably reduces the incidence of HAPE but studies looking into this have not been conclusive.

Treatment of HAPE:
It cannot be stressed highly enough that the definitive treatment for HAPE is rapid descent. A descent of 500-1000m usually leads to a rapid recovery and two to three days later the individual may well be able to begin ascending again at a much slower rate than previously. Of course there may be a situation in which immediate descent is impossible, especially during extreme altitude mountaineering expeditions. In this case there are various treatments that can be initiated until descent is possible:

- High flow oxygen delivered by a facemask can be life saving. This must be combined with complete bed rest for the effected individual.
- Nifedipine 10mg taken orally or under the tongue then 30mg of the slow-release capsule every 12 to 24 hours. This is a drug used by doctors for the treatment of high blood pressure. It reduces the high blood pressure of blood vessels in lungs that is seen in HAPE. Consider its use whilst awaiting descent.
- Hyperbaric oxygen (see above under Treatment of established AMS)

High altitude cerebral oedema (HACE):
This is a severe form of AMS and rarely occurs without the symptoms of HAPE being present as well. It tends to develop as a continuum from the symptoms of AMS and if left untreated HACE is highly likely to result in death of the individual.
In the same way as HAPE is due to a build up of fluid in the lungs, the symptoms of HACE are the result of fluid collecting within the tissues of the brain (cerebral oedema). The incidence of HACE is less than that for HAPE but, as mentioned, individuals usually present with a mixed picture of both disorders. Symptoms include:

- Ataxia (shaky movements and unsteadiness of walking)
- Extreme tiredness
- Altered state of consciousness such as confusion, hallucinations, impaired thinking, drowsiness and coma
- Paralysis of one or more limbs or the muscles of the face
- Seizures (like those seen in epileptic individuals)
- Blindness of one or both eyes

Of particular importance is that the individual’s confusion may lead them to think that they are not ill when they quite clearly are. Be aware of this and if you think an individual has symptoms of HACE, act quickly. HACE commonly presents one to three days following the development of AMS.

Prevention of HACE:
Once again the advice is that for the prevention of both AMS and HAPE. That is, slow graded ascent to altitude with appropriate rest days.

Treatment of HACE:
Early recognition of symptoms and rapid descent to a lower altitude is the definitive treatment for HACE. Usually a descent of approximately 500m is necessary to ensure reversal of symptoms. Whilst awaiting descent other temporary strategies can be implemented:
- High flow oxygen delivered by a facemask
- Hyperbaric oxygen (see above under Treatment of established AMS)
- Dexamethasone (4mg to 8mg intravenously, intramuscularly or orally followed by 4mg every 6 hours) It should be noted that although Dexamethasone will lead to the improvement of symptoms it does not reverse the underlying disease process and descent is still mandatory.

Recovery from HACE following descent tends not to be so obviously rapid as that from HAPE. Coma may persist for some days once descent is complete and appropriate supportive care needs to be given during this time. Individuals do, however, tend to make a complete recovery within a few weeks of the event.

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