



High Altitude Illness, Acute Mountain Sickness, AMS, Mal de Montagne, Soroche, High Altitude Pulmonary Edema, HAPE, High Altitude Cerebral Edema, HACE, mountaineering, trekking, hypoxia, hypoxic, hypoxemia, oxygen, acetazolamide, Diamox, acclimatization, High Altitude Illness, Acute Mountain Sickness, AMS, Mal de Montagne, Soroche, High Altitude Pulmonary Edema, HAPE, High Altitude Cerebral Edema, HACE, mountaineering, trekking, hypoxia, hypoxic, hypoxemia, oxygen, acetazolamide, Diamox, acclimatization

All About Altitude Illness

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This information is intended to be educational in nature and should not be construed as medical advice. You should consult your physician regarding any specific medical conditions or questions and before taking any medications.

Normal Acclimatization

What is meant by high altitude? Some "formal" medical definitions:

- High Altitude: 1500 - 3500 m (5000 - 11500 ft)
- Very High Altitude: 3500 - 5500 m (11500 - 18000 ft)
- Extreme Altitude: above 5500 m

Practically speaking, however, we generally don't worry much about elevations below about 2500 m (8000 ft) since altitude illness rarely occurs lower than this. **Acclimatization** is the process of the body adjusting to the decreasing availability of oxygen. It is a slow process, taking place over a period of days.

Certain **normal** physiologic changes occur in every person who goes to altitude:

- Hyperventilation (breathing fast)
- Shortness of breath during exertion
- Increased urination
- Changed breathing pattern at night
- Awakening frequently at night
- Weird dreams

As one ascends through the atmosphere, barometric pressure decreases (though the air still contains 21% oxygen) and every breath contains fewer and fewer molecules of oxygen. One must work harder to obtain oxygen, primarily by breathing faster. This is particularly noticeable with exertion, such as walking uphill. Being out of breath with exertion is normal, as long as the sensation of shortness of breath resolves rapidly with rest.

As the amount of oxygen in the lungs decreases, the blood becomes less and less efficient at acquiring and transporting oxygen. This means that no matter how fast one breathes, attaining normal blood levels of oxygen is not possible at high altitude.

Dramatic changes take place in the body's chemistry and fluid balance during acclimatization. The osmotic center, which detects the "concentration" of the blood, gets reset to a more concentrated level. This results in an **altitude diuresis** as the kidneys dump fluid. The reason for this reset is not

understood, though it has the effect of increasing the hematocrit (concentration of red blood cells) and perhaps improving the blood's oxygen-carrying ability somewhat. It is normal at altitude to be urinating several times per night. If you are not, you may be dehydrated, or you may not be acclimatizing well.

Persistent hyperventilation (to glean oxygen from the thin air) results in an over-reduction in the level of carbon dioxide (a normal metabolic waste product) in the blood. It turns out that the presence of carbon dioxide is the key signal to the brain that it is time to breathe (the lack of oxygen is a much weaker signal, kind of an ultimate safety valve). As long as you are awake it isn't much trouble to remember to breathe, but at night, an odd breathing pattern develops due to a prolonged argument between these two "respiratory centers" in the brain. **Periodic breathing** consists of cycles of normal breathing, breath-holding, and accelerated breathing. The breath-holding may last up to 10-15 seconds. **This is not correlated with altitude sickness.** It may improve slightly with acclimatization, but does not usually resolve until descent. Periodic breathing can cause a lot of anxiety in trekkers:

- In the trekker who wakes up during the breath-holding phase and *knows he has stopped breathing.*
- In the trekker who wakes up in the post-breath-holding hyperventilation phase and thinks he's short of breath and has HAPE.
- In the trekker who wakes up and realizes *his neighbor has stopped breathing.*

In all these cases waiting a few moments will establish a normal breathing pattern. If periodic breathing symptoms are troublesome, a medication called [acetazolamide](#) may be helpful.

Acute Mountain Sickness

When acclimatization lags significantly behind ascent, various symptoms occur. Acute Mountain Sickness (AMS) represents the body's intolerance of the hypoxic (low oxygen) environment at one's current elevation.

Who can get AMS? Anyone who goes to altitude. It is primarily related to rate of ascent. No way been found to predict who is likely to get sick at altitude. Which brings us to:

GOLDEN RULE 0.
It is OK to get altitude illness. It is not OK to die from it.

Don't violate this rule! **Anybody can get AMS**, there is no prevalence based on age, gender, physical fitness, or previous altitude experience. If you know what to do you should be able to avoid the severe, life-threatening forms.

GOLDEN RULE I.
Any illness at altitude is altitude illness until proven otherwise.

RECOGNIZE AMS. In the context of a recent ascent, a **headache**, with any one or more of the following symptoms above 2500 meters (8000 feet) qualifies you for the diagnosis of AMS:

- Loss of appetite, nausea, or vomiting
- Fatigue or weakness
- Dizziness or light-headedness
- Difficulty sleeping
- Confusion
- Staggering gait

It is remarkable how many people mistakenly believe that a headache at altitude is "normal" when it is actually AMS. Be willing to admit that you have altitude illness.

How to Avoid AMS

The key to avoiding AMS is a rational ascent that gives your body time to acclimatize. People acclimatize at different rates, so no absolute statements are possible, but in general, the following recommendations will keep most people from getting AMS:

At altitudes above 3000 meters (10,000 feet), your sleeping elevation should not increase more than 300 meters (1000 feet) per night, and every 1000 meters (3000 feet) you should spend a second night at the same elevation.

What To Do If You Have AMS

I cannot emphasize this too much. 🚫 **DO NOT ASCEND ANY HIGHER.** 🚫 Violating this simple rule has resulted in death.

GOLDEN RULE II.
Never ascend with symptoms of AMS.

You will get worse, and you might die. This is extremely important - even a day hike to a higher elevation is a great risk. In every instance of the many cases of High Altitude Cerebral Edema I've treated, this rule was violated. Stay at the same altitude until your symptoms completely go away. Once your symptoms are completely gone, you have acclimatized and it is OK to continue ascending. It is always OK to descend, you will get better faster.

The Severe Forms of AMS

High Altitude Cerebral Edema (HACE)

AMS is a spectrum of illness, from mild to life-threatening. At the "severely ill" end of this spectrum is High Altitude Cerebral Edema; this is when the brain swells and ceases to function properly. Obviously, this is a Bad Thing to have happen to you.

HACE, once present, can progress rapidly, and can be fatal in a matter of a few hours. Persons with this illness are often confused, and may not recognize that they are ill.

The hallmark of HACE is a change in mentation, or the ability to think. There may be confusion, changes in behavior, or lethargy. However, it is probably easier to recognize a characteristic loss of coordination that is called **ataxia**. This is a staggering walk that is identical to the way a person walks when very intoxicated on alcohol.

To test for this abnormal walk, have the sick person do a **straight line walk** (in medical speak this is called the "tandem gait test"). Be fair: do this on level ground, take off their backpack, and don't have them try it in big heavy boots. Draw a straight line on the ground, or have them follow a crack in the teahouse floor. Have them walk along the line, placing one foot immediately in front of the other, so that the heel of the forward foot is right in front of the toes behind. Try this yourself. You should be able to do it without difficulty. If they struggle to stay on the line (the high-wire balancing act), can't stay on it, or fall down, they fail the test and **should be presumed to have HACE**.

The treatment is **immediate descent**. This is of the utmost urgency, and cannot wait until morning (unfortunately, HACE often strikes at night). **Delay may be fatal.** The moment this is recognized is the moment to start organizing flashlights, helpers, porters, whatever is necessary to get this person down. How far down? At least to the last elevation at which they woke up in the morning with no symptoms of AMS. Bearing in mind that the vast majority of cases of HACE occur in persons who ascend with symptoms of AMS, this is likely to be the elevation the person slept at two nights previous. If you are uncertain, 500-1000 meters descent is a good starting point.

People with HACE usually survive if they descend soon enough and far enough, and usually recover completely. The staggering gait may persist for days after descent. If recovery has been complete, and there are no symptoms, cautious reascent is acceptable.

High Altitude Pulmonary Edema (HAPE)

Another form of severe altitude illness is High Altitude Pulmonary Edema, or fluid in the lungs. Though it often occurs with AMS, it is not felt to be related and the [classic signs of AMS](#) may be absent. Signs and symptoms of HAPE include any of the following:

- Extreme fatigue
- Breathlessness at rest
- Cough, possibly productive of frothy or pink sputum
- Gurgling or rattling breaths
- Chest tightness, fullness, or congestion
- Blue or gray lips or fingernails

The treatment for HAPE is the same as for HACE: **immediate descent**. As with HACE, it is of the utmost urgency; **delay may be fatal**. The same rules apply for how far as well: to the last elevation where the victim felt well upon awakening.

Whereas HACE descent is complicated by confusion and staggering on the part of the victim, HAPE descent is complicated by extreme fatigue and possibly also due to confusion (due to inability to get enough oxygen to the brain). HAPE frequently occurs at night, and may worsen with exertion.

HAPE resolves rapidly with descent, and one or two days of rest at a lower elevation may be adequate for complete recovery. As with AMS, once the symptoms have fully resolved, cautious reascent is acceptable.

It is common for persons with severe HAPE to then also develop HACE due to the extremely low levels of oxygen in their blood (equivalent to a continued rapid ascent).

GOLDEN RULE III.

If you are getting worse, go down at once.

DO NOT WAIT UNTIL MORNING. Descend at least to the elevation where you last felt well when you woke up.

GOLDEN RULE IV.

Never leave someone with AMS alone.

People sick with AMS can get worse, and may need help descending, or may not recognize that they are getting sicker.

Things to Avoid

Respiratory depression (the slowing down of breathing) can be caused by various medications, and may be a problem at altitude. The following medications can do this, and should never be used by someone who has symptoms of altitude illness (these may be safe in non-ill persons, although this remains controversial):

- Alcohol**
- Sleeping pills** (acetazolamide is the sleeping tablet of choice at altitude)
- Narcotic pain medications** in more than modest doses

Treatment of Acute Mountain Sickness

The mainstay of treatment of AMS is rest, fluids, and mild analgesics: acetaminophen (paracetamol), aspirin, or ibuprofen. These medications will not cover up worsening symptoms. Descent is always an option, and recovery will be quite rapid.

Trekkers always wonder about how to tell if a headache is due to altitude. See [Golden Rule I](#). Altitude headaches are usually nasty, persistent, and frequently there are other symptoms of AMS; they tend to be frontal (but may be anywhere), and may worsen with bending over. However, there are other causes of headaches, and you can try a simple diagnostic/therapeutic test. Dehydration is a common cause of headache at altitude. Drink one liter of fluid, and take some acetaminophen or one of the other analgesics listed above. If the headache TOTALLY resolves (and you have no other symptoms of AMS) it is very unlikely to have been due to AMS.

Let me say a few words about **acetazolamide (Diamox®)**. This is a medication that forces the kidneys to excrete bicarbonate, the base form of carbon dioxide; this re-acidifies the blood, balancing the effects of the hyperventilation that occurs at altitude in an attempt to get oxygen. This re-acidification acts as a respiratory stimulant, particularly at night, reducing or eliminating the periodic breathing pattern common at altitude. **Its net effect is to accelerate acclimatization.** Acetazolamide isn't a magic bullet, cure of AMS is not immediate. It makes a process that would normally take about 24-48 hours speed up to about 12-24 hours.

I do not recommend acetazolamide as a prophylactic medication, except under specific limited conditions outlined below. Most people who have a reasonable ascent schedule will not need it, and in addition to some common minor but unpleasant side effects it carries the risk of any of the severe side effects that may occur with sulfonamides. I feel that acetazolamide is indicated under the following conditions:

- Treatment of persons with AMS
- Treatment of persons bothered by periodic breathing at night
- Prophylactically for persons on rapid forced ascents (such as flying into Lhasa, Tibet)
- Prophylactically for those persons who have repeatedly had AMS in the past

Acetazolamide is a sulfonamide medication, and persons allergic to sulfa medicines should not take it.

Common side effects include numbness, tingling, or vibrating sensations in hands, feet, and lips. Also, taste alterations, and ringing in the ears. These go away when the medicine is stopped. Since acetazolamide works by forcing a bicarbonate diuresis, you will urinate more on this medication.

Uncommon side effects include nausea and headache. I have seen a few trekkers whose vision became very blurry after taking only one or two doses of acetazolamide; fortunately they recovered their normal vision in several days once the medicine was discontinued.

Acetazolamide Dosage:

For AMS

I recommend a dosage of 125 mg every 12 hours. This is 1/2 of a standard 250 mg tablet. This has been shown to be adequate for accelerating acclimatization and minimizes side effects. The medicine can be discontinued once symptoms resolve.

For periodic breathing

I recommend 125 mg about an hour before bedtime. The medicine should be continued until you are below the altitude where symptoms became bothersome.

Among trekkers there is a lot of mythology about acetazolamide. Let's clear the air a bit:

MYTH: acetazolamide hides symptoms

Acetazolamide accelerates acclimatization. As acclimatization occurs, symptoms resolve, directly reflecting improving health. Acetazolamide does not cover up anything - if you are still sick, you will still have symptoms. If you feel well, you are well.

MYTH: acetazolamide will prevent AMS from worsening during ascent

Acetazolamide DOES NOT PROTECT AGAINST WORSENING AMS WITH CONTINUED ASCENT. It does not change [Golden Rule II](#). I've seen plenty of people with HAPE and HACE who believed this myth.

MYTH: acetazolamide will prevent AMS during rapid ascent

This is actually not a myth, but rather a misused partial truth. Acetazolamide does lessen the risk of AMS, that's why we recommend it for people on forced ascents. This protection is not absolute, however, and it is foolish to believe that a rapid ascent on acetazolamide is without serious risk. It is still possible to ascend so rapidly that when illness strikes, it is

likely to be sudden and severe, and fatal.

MYTH: If acetazolamide is stopped, symptoms will worsen

There is no rebound effect. If acetazolamide is stopped, acclimatization slows down to your own intrinsic rate. If AMS is still present, it will take somewhat longer to resolve; if not - well, you don't need to accelerate acclimatization if you ARE acclimatized. You won't become ill simply by stopping acetazolamide.

A Review of the AMS treatment options:

Descent

Pro rapid recovery: trekkers generally improve during descent, recover totally within several hours.

Con loss of "progress" toward trek goal; descent may be difficult in bad weather or at night; personnel needed to accompany patient.

Rest at same elevation

Pro acclimatization to current altitude, no loss of upward progress.

Con it may take 24-48 hours to become symptom-free.

Rest plus acetazolamide

Pro as with rest alone, plus acclimatization is accelerated, recovery likely within 12-24 hours.

Con recovery may take 12-24 hours.

Dexamethasone

I have had very good results with the use of dexamethasone (a potent steroid medication) in treating AMS, however, there are potentially serious problems with inappropriate use of this drug (it can hide symptoms). See the [physician's section](#) for more detail.

Questioning Your Porters About AMS Symptoms

If you hire your own porters, please be aware that they are just as susceptible as you to the ravages of AMS. I feel that porters may be at increased risk of severe forms of altitude illness as they are unlikely to know anything about AMS, are more likely to have a communication barrier to telling you how they feel, and may even actively hide their symptoms if they fear losing their job due to illness. For those of you who will be trekking in Nepal, please look at the [AMS questionnaire with phonetic Nepali translations](#) (based on the Lake Louise AMS scoring criteria).

For more information, see the [physician's section on AMS](#). Thanks to Dr. David Shlim at the [CIWEC Clinic](#) in Kathmandu for originating the idea of the "Golden Rules of Altitude Sickness."

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