Medical Therapy of High Altitude Illness

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WE WERE CLIMBING UNROPED on steep terrain near the top of the West Rib of Denali. We had made good progress initially after an early start from our camp at 16,000 feet, but the higher we climbed, the slower we moved. I took comfort in the fact that my four partners were leaning on their ice axes and panting every few steps because I was doing the same with increasing frequency. It had been a week since we had started up the initial couloir that gained the West Rib from the head of the northeast fork of the Kahiltna Glacier, and we were all feeling the effects of the altitude. As we neared the summit plateau at 19,000 feet, I noticed that one member of our expedition was starting to stagger. By the time we reached the easier terrain of the plateau, he was slurring his speech and complaining of a headache. It was clear that he could not go on, and by the time we stopped to help him into a sleeping bag, he was nauseous and had vomited. After resting a while and sipping on a hot drink, he was able to descend the West Buttress with us. Subsequently he recovered uneventfully after a night's rest several thousand feet lower.

The above scenario occurred on my first trip to Denali in 1982. That was my first big mountain and I wasn't yet a doctor. In the eleven years that have passed since then, I have seen many climbers with altitude illness on big mountains in various parts of the world and I have returned to Denali several times to work as a doctor at the 14,000-foot medical camp on the West Buttress. I often reflect on that experience on the summit plateau in 1982 and wonder what would have happened if we had not been able to descend. In retrospect, the ill member of our group had severe acute mountain sickness (AMS) that was progressing to high altitude cerebral edema (HACE). If we had not been able to descend because of bad weather or because he had become incapacitated, it would have been imperative to have other treatment options at our disposal.

Descent is still the standard treatment for severe altitude illness, but other pharmacological options are available as an aid to descent or for use as definitive treatment when weather and terrain conditions preclude descent. Climbers need to be aware of the options for treating the spectrum of altitude illness from mild to severe because medical care is not immediately available on a high mountain

in a remote area. Having the ability to recognize altitude illness in yourself or your partner, and having the knowledge of the appropriate intervention, may save a life. This article will present for climbers the most recent knowledge regarding pharmacological treatment of acute mountain sickness (AMS) and the more severe high altitude pulmonary edema (HAPE) and high altitude cerebral edema (HACE).

Acute Mountain Sickness. Acute mountain sickness is the most common form of altitude illness and is seen a few hours to a few days after ascent to altitudes over 2500 meters (8200 feet). In the milder forms, the symptoms include headache, dizziness, decreased appetite, nausea, difficulty in sleeping and decreased energy. Swelling of the hands and swelling around the eyes caused by fluid retention are also observed in some individuals. The milder form of AMS usually resolves within a few days if ascent is halted.

More severe AMS primarily affects the brain, but it may also involve the lung. A person may have difficulty with balance and walk as if he or she were drunk: a condition called *ataxia* in medical terms. This is due to increased swelling in the brain, called cerebral edema. When the amount of swelling in the brain becomes severe, high altitude cerebral edema results. In severe AMS, a person may also experience shortness of breath after minimal exertion. This is caused by a lower blood oxygen level than normal, which may be due to increased fluid in the lung that is interfering with the diffusion of oxygen from the lung to the blood. It is not yet known whether this represents a mild form of HAPE, but some individuals with severe AMS and shortness of breath do develop HAPE.

AMS is most certainly a precursor to HACE and may be a precursor to HAPE. Because both increased brain fluid and increased lung fluid occur in AMS, it is not surprising that as AMS progresses to more severe high alitude illness, HAPE and HACE sometimes occur together.

The best prevention for AMS is gradual ascent. Climbing high and sleeping low and limiting the rate of ascent to 1000 feet (300 meters) per day at higher altitudes are both effective in allowing the body adequate time for acclimatization. Gradual ascent may not be practical, however, during an alpine-style ascent of a higher mountain. In this case, a prolonged acclimatization period before the alpine-style ascent is recommended.

Acetazolamide (trade name Diamox) is the drug of first choice to prevent AMS and acts by increasing breathing and improving the oxygen level in the blood in individuals climbing to high altitude. Acetazolamide may be taken starting the day of ascent at a dose of 125 mg twice a day. This lower dose of acetazolamide (125 mg or half a 250 mg tablet) is recommended because recent studies suggest that it is as effective as the higher dose and will result in less diuresis (increased urination resulting in fluid loss). Acetazolamide should be continued during the ascent but may be stopped after one or two days at the same altitude. Upon further ascent, acetazolamide may be restarted again to prevent AMS at higher altitudes.

Acetazolamide is recommended for prevention of AMS in those individuals who experience symptoms recurrently upon ascent to high altitude. For individuals without a history of recurrent AMS on ascent to high altitude, acetazolamide may be taken prophylactically (to prevent AMS) or may be taken once symptoms occur to treat AMS. (See discussion of treatment of AMS below.) Many climbers prefer to continue taking 125 mg of acetazolamide prior to sleep at altitudes higher than 13,000 feet (4000 meters) because it prevents periodic breathing during sleep at high altitude. This breathing pattern disturbs the sleep of some individuals and results in periods of low oxygen levels in the blood during sleep for everyone. Acetazolamide should not be taken by those allergic to sulfa drugs.

Dexamethasone (trade name Decadron) is an alternative to acetazolamide for the prevention of AMS. The dose is 4 mg every 6 to 8 hours starting the day of ascent. Dexamethasone is a steroid and may cause many of the side effects of this class of drugs, including depression or euphoria, bizarre dreams and fluid retention. Dexamethasone is not an anabolic steroid, the kind used by some athletes to enhance performance. Unlike acetazolamide, the use of dexamethasone for more than a few days is not recommended because of more serious long-term effects of the drug (after weeks to months of use, weight gain, decreased bone density, and suppression of the normal hormone system occur.) Dexamethasone is a good option for prevention of AMS in those individuals allergic to sulfa drugs. One instance where a combination of acetazolamide and dexamethasone might be used for prevention of AMS is in rescue workers transported to altitudes greater than 10,000 feet (3000 meters) where more than one day at the higher altitude is anticipated.

Acetazolamide or dexamethasone may also be used to treat, as opposed to prevent, AMS. This means that the drug is not used until the symptoms of AMS occur. As for prevention, acetazolamide is the recommended drug for the treatment of AMS because of the fewer side effects and because it increases breathing, which aids in acclimatization. (The primary mechanism of acclimatization during the first few days at altitude is increased breathing.) The recommended dose for the treatment of AMS is 250 mg twice a day, higher than that recommended for prevention. The higher dose of acetazolamide will cause a greater fluid loss from urination, which may be beneficial. This is because fluid retention is part of the complex reactions in the body that lead to AMS. If increased urination requiring frequent trips out of a warm sleeping bag at night prevents adequate sleep, then a dose of 125 mg in the evening and 250 mg in the morning may be preferable for the treatment of AMS. When used for treatment, acetazolamide may be continued until symptoms resolve, then stopped and restarted again if symptoms recur at a higher altitude. Dexamethasone may also be used to treat AMS at the same dose as used for prevention, 4 mg every 6 to 8 hours, until symptoms resolve. An assured cure for AMS is descent to a lower altitude, which is recommended if symptoms progress suggesting the development of HAPE or HACE, but in mild to moderate cases, drug therapy will shorten the duration of illness and make further ascent possible. Analgesics,

such as ibuprofen or acetaminophen and anti-nausea drugs are appropriate adjuncts to the therapy of AMS.

High Altitude Pulmonary Edema. I awoke from a restless night's sleep in our well-sheltered camp placed in the bergschrund at Windy Corner, an exposed area at 13,000 feet on the West Buttress of Denali. I felt weak and tired, as if I had the flu. As we packed up camp, I was breathing a lot harder than usual. Just shouldering my heavy pack was an ordeal and we hadn't gone far out of camp that morning before Kitty and John had taken the bulk of my load. The climbers' camp at 14,000 feet (4275 meters) was just a few hours away, but at the rate I was moving it would take us most of the day to get there. As we moved higher, I had to stop more frequently because of coughing episodes and to allow myself to gasp for more air. It was 1985, I was young and fit, and I had HAPE.

HAPE is a condition where the tiny air sacs in the lungs, called alveoli, fill with fluid, which impairs the diffusion of oxygen from the lungs to the blood. As my own case illustrates, HAPE is characterized by increasing shortness of breath both at rest and with exercise and a dry cough that progresses to a cough productive of a pink, frothy sputum. A climbing partner who is moving slower than usual, breathing with more difficulty and coughing may be developing HAPE. As the lung fluid increases, the affected individual may be able to walk only short distances without resting, and gurgling may be heard if the ear is placed against the chest wall. A purplish discoloration of the lips and fingernails caused by a low oxygen level in the blood may also be observed. Death may occur within hours if HAPE is left untreated.

The best treatment for HAPE is early recognition and descent to a lower altitude. At the first indication that HAPE is developing, descent should be undertaken while the individual can still walk, rappel or down-climb under his or her own power. Descent of as little as 2000 or 3000 feet (650 to 1000 meters) usually results in marked improvement and may be life-saving.

Oxygen, if available, is also an effective treatment for HAPE; 3 or 4 liters per minute should be administered via nasal cannula in milder cases, and 8 to 10 liters per minute administered via facemask in more severe cases. Experience treating climbers with HAPE at 14,000 feet on Denali suggests that treatment with oxygen for a few hours or overnight results in enough improvement so that the individual may descend on his or her own. An oxygen tank may also be placed in a pack for use while descending. A portable hyperbaric chamber (Gamow Bag) is also effective treatment for HAPE but should never be used in a situation where it delays descent. When an ill climber comes out of the Gamow Bag, he or she is still at the same altitude and HAPE may continue to progress. The most useful situation for a Gamow Bag or oxygen in treating HAPE is when descent is impossible because of weather or terrain conditions.

A recent development in the prevention and treatment of HAPE is the use of the drug nifedipine (trade name Procardia) that lowers blood pressure in the circulation to the lung. Nifedipine has been shown to be beneficial in preventing HAPE in those individuals who recurrently develop HAPE upon ascent to high altitude, and it has been shown to be effective in treating HAPE once it occurs.

Lowering the blood pressure in the circulation to the lung appears to decrease the amount of fluid leaking from the blood into the alveoli. Nifedipine, however, may also reduce blood pressure in the rest of the body to the point where an individual feels dizzy or might pass out. Because of these serious potential side effects, nifedipine should only be administered by a physician. Oxygen, if available, should always be used first to treat a climber with HAPE. Nifedipine might also be useful as a supplement to oxygen therapy in a climber who is incapacitated with HAPE and cannot descend. In this case, nifedipine might improve climbers with HAPE enough so that they can descend on their own. Nifedipine should not standardly be used to prevent HAPE either, except by those climbers who recurrently develop HAPE after ascent to altitude. Most climbers with a history of HAPE in the past, though, will not have recurrent HAPE on subsequent climbs if a gradual ascent is undertaken, and thus they do not need to take nifedipine.

High Altitude Cerebral Edema. High altitude cerebral edema should be suspected in persons who have progressive deterioration in their level of consciousness. Individuals with AMS who walk as if they were drunk and become increasingly confused and disoriented are developing HACE. Left untreated, HACE will progress from drowsiness to coma, and ultimately death. Immediate descent to a lower altitude is imperative in someone with HACE. Oxygen, if available, is helpful but is no substitute for descent. Dexamethasone is also helpful at a dose of 4 mg by mouth or injected intramuscularly every six hours. Although dexamethasone has never been studied in a controlled fashion in individuals with HACE, it is very useful in decreasing cerebral edema from certain causes in hospitalized patients. Isolated reports on the use of dexamethasone to treat climbers with HACE suggest that it has helped, and it is therefore recommended as a treatment for climbers with HACE.

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Summary. Although various effective treatment options for high altitude illness have been discussed, there is no panacea. The best treatment for high altitude illness is still prevention, a gradual ascent allowing time for acclimatization. When altitude illness does occur, descent is the first treatment option that should be considered. In more severe forms of altitude illness, such as HAPE and HACE, descent is imperative if the conditions permit. Mild to moderate AMS, however, may be treated and resolved while staying at the same altitude. Of the drug treatment options available, acetazolamide and dexamethasone may be used to treat AMS. For HAPE, descent is the treatment of first choice, while oxygen or a portable hyperbaric chamber (Gamow Bag) may be used as a temporizing measure. In the right situation as judged by a physician, nifedipine is also effective treatment for HAPE. For HACE, immediate descent and the administration of dexamethasone are recommended, while oxygen may be used if available.

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