CASE REPORT

Complications of Steroid Use on Mt Everest

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Steroids are used for the prevention and treatment of high-altitude illnesses. However, these agents can cause significant side effects. We report a case of altered mental status, gastrointestinal bleeding, skin rash, and avascular necrosis in a climber taking prophylactic dexamethasone prior to an attempt to climb Mt Everest. High-altitude cerebral edema (HACE), steroid toxicity, and acute adrenal crisis can have similar clinical presentations. Differentiating between these life-threatening conditions at high altitude is essential for successful treatment.

Key Words: AMS, HACE, HAPE, dexamethasone, steroid toxicity, acute adrenal crisis

A 27-year-old, healthy man from the United States came to Nepal in mid April 2009 in order to climb Mt Everest. He flew to Lukla (2866 m), and as advised by his physician at home, started taking acetazolamide 250 mg twice daily, dexamethasone 4 mg 3 times daily and sustained-release nifedipine 30 mg daily for the prevention of acute mountain sickness, high-altitude cerebral edema, and high-altitude pulmonary edema.^{1,2} In addition, he was also prescribed injectable dexamethasone (1 mg twice daily), which was only to be used on summit day. After summiting, the plan was to stop all of these medications. The three medications were taken for a total of 29 days.

Prior to his first climb above Base Camp (5340 m), the patient noticed the appearance of a diffuse skin rash. Suspecting a drug reaction, he stopped taking all 3 medications. Four days later he arrived in Camp 3 (7010 m); however, he was unable to continue and required assistance to descend due to progressively debilitating fatigue, disorientation and blood in the stool. He was brought back to the base camp in 2 days. Clinical evaluation by the doctors at the Himalayan Rescue Association Base Camp clinic was difficult due to his extreme confusion and fluctuating consciousness. There was no evidence of nausea or vomiting. On examination, he had low blood pressure (85/60 mmHg), a pulse rate of 110/

min, and reduced urine output. A generalized skin rash was noticed (Figure). A formal neurological examination was not possible. Fecal occult blood was positive. Given his history and physical findings, steroid toxicity with possible withdrawal was diagnosed. He was monitored closely by physicians and was treated with oxygen and a bolus of intravenous fluids. Dexamethasone (1 mg 3 times daily) and omeprazole (20 mg twice daily) were administered prior to helicopter evacuation to Kathmandu 5 days later.

On arriving in Kathmandu, he was admitted to Nepal International Clinic (Travel and Mountain Medicine Center), where he complained of weakness, headache, bleeding per rectum, joint pains, widespread paresthesias, and skin rash. He also gave a history of auditory hallucinations, low mood and frequent panic attacks but denied prior history of psychiatric disorder. He vomited 100 ml of fresh blood in the clinic. On examination, he was disoriented, drowsy, and restless with normal blood pressure (130/86 mmHg), oxygen saturation (98%), and a pulse of 100/min. Widespread acneiform papular lesions were noted all over the body. These papules were more prominent on the trunk and upper extremities (Figure). The rest of his physical examination was normal. His white blood cell count was 22.8×10^9 cells per L with a predominance of neutrophils. The hemoglobin concentration was 8.5 g/dl, and hematocrit was 22 (the expected levels of hemoglobin and hematocrit at 4000 m or above for adequately acclimatized people are more

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Figure. Diffuse acne-form papules on the anterior trunk and both arms.

than 18 gm/dl and 54, respectively³). Stool was jet black and positive for occult blood. His platelet count, coagulation profile, liver function tests, blood sugar, creatinine, and chest x-ray were normal.

With the diagnosis of steroid toxicity resulting in disorientation, upper gastrointestinal bleeding, dermatitis, and severe anemia, he was admitted to the intensive care unit in a hospital in Kathmandu the following day. He was treated with low-dose dexamethasone (1 mg 3 times daily tapered over 7 days), intravenous fluids, antibiotics, analgesics, proton pump inhibitors, and transfusion of 7 units of blood. He promptly underwent an upper gastrointestinal endoscopy, which revealed multiple ulcerations in the lower end of the esophagus. Bleeding points were controlled with epinephrine injection. At discharge after 12 days in the hospital he was in a stable condition. His skin rash was slowly disappearing, but he still had frequent panic episodes and he became clinically depressed. On returning home, investigations revealed avascular necrosis of the wrist, knee, and hip joints. One year later, the patient was still undergoing treatment for posttraumatic stress disorder, panic attacks, depression, and avascular necrosis.

Discussion

High-altitude illness is the collective term for acute mountain sickness (AMS), high-altitude cerebral edema (HACE), and high-altitude pulmonary edema (HAPE). Acute mountain sickness is the benign form of altitude illness, whereas high-altitude cerebral edema and high-altitude pulmonary edema can be life-threatening. Acute mountain sickness is characterized by nonspecific symptoms like headache, anorexia, nausea, vomiting, fatigue, dizziness, and sleep disturbance without physical find-

ings. High-altitude cerebral edema, characterized by ataxia and altered consciousness, is widely viewed as the end stage of acute mountain sickness. High-altitude pulmonary edema is a separate form of altitude sickness caused in part by hypoxic pulmonary vasoconstriction, characterized by shortness of breath, cough and inability to maintain oxygen saturation.^{4–8}

There are no reliable data regarding how many people attempt to climb Mt Everest annually. It is estimated that nearly 40,000 trekkers enter the Everest region from the Nepal side in a year. The incidence and prevalence of mountain sickness among Everest climbers remains unknown. One survey in the Swiss Alps found that the incidence of acute mountain sickness ranges from 9% at 2850 m to 53% at 4559 m among nonacclimatized people.⁹ The sinister forms, high-altitude cerebral or pulmonary edema, may range from 0.01% to over 15% in sojourners depending on the altitude and the rate of ascent.^{2,4}

Current prevention and treatment guidelines for all forms of altitude sickness are well established.¹⁰ Gradual ascents, with adequate time for acclimatization, are the best method for the prevention of altitude illness. Once above approximately 2500 m (8000 ft), the general rule of thumb is not to ascend more than 300 m (1000 ft) per day. The risk of acute mountain sickness depends on the ascent rate, the altitude reached, and sleeping altitude. As this case demonstrates, it is preferable for the climber to acclimatize without drugs. If necessary, acetazolamide should be used for acclimatization and prevention of acute mountain sickness. Acetazolamide (125–250 mg twice daily), administered for 1 day before ascent and continued for 2 or 3 days, is effective in 50 to 70% of cases.^{4,11} Sustained-release nifedipine (30 mg), given once or twice daily, prevents high-altitude pulmonary edema in susceptible people who must ascend rapidly.¹²

Dexamethasone has been shown to be effective in the prevention and treatment of acute mountain sickness and high-altitude cerebral edema, and recently even in the prevention of high-altitude pulmonary edema.¹³ It can be useful as an alternative to acetazolamide for only a few days for prophylaxis, and when immediate descent is not possible for treatment of acute mountain sickness.¹⁴ The recommended adult doses for prophylaxis are 2 mg every 6 hours or 4 mg every 12 hours. The duration of use should not exceed 10 days to prevent glucocorticoid toxicity or adrenal suppression. Dexamethasone 8 mg stat, then 4 mg every 6 hours, until resolution of symptoms, is the recommended dosage for treating HACE.¹⁰ Based on Levine's chamber study, the drug may reduce brain swelling which can develop at high altitude, but there is no evidence that it aids acclimatization.¹⁵ More sojourners use acetazolamide than dexamethasone for

Table. Distinguishing between high altitude cerebral edema [HACE], steroid toxicity, and acute adrenal crisis

Characteristics	HACE (effect of high altitude)	Steroid Toxicity (effect of excess steroid)	Acute Adrenal Crisis (abrupt withdrawal of steroid)
Clinical presentation			
Insomnia	Yes	Yes	No
Delirium	Yes	Yes	Yes
Skin rash	No	Yes	No
Nausea/vomiting	Yes	No	Yes
GI bleeding	No	Yes	No
Blood pressure	Minimal effect	Increased	Normal or low
Tandem gait	Abnormal	Normal	Normal
Laboratory findings			
Blood sugar	Minimal effect	Increased	Normal or low
Neutrophil count	Normal	Increased	Normal
ACTH/cortisol level	Normal	Decreased	Normal or low
Treatment options			
Descent	Yes	Yes	Yes
Supplemental oxygen	Yes	No	Yes
Hyperbaric chamber	Yes	No	No
Dexamethasone	Yes	No	Yes, in tapered dose

the prevention of AMS. How many of the latter suffer from side effects of steroids, in the mountains, is unknown. With regards to our case, combination prophylaxis for long duration clearly proved hazardous.

Concerns regarding the side effects limit the use of dexamethasone. It is almost 78% bioavailable with a half-life of 36 to 54 hours after oral administration.¹⁶ Side effects associated with short-term use (less than 7 days) include fatigue, depression, euphoria, irritability, lightheadedness, hyperglycemia, mania, delirium, insomnia, headache, leg cramps, and heartburn. Long-term use (more than 2 weeks) leads to weight gain, systemic hypertension, acne, dermatitis, myopathy, thinning of blood vessels and connective tissues, risk of infection, avascular necrosis of bones, ulceration in the gastrointestinal tract, and long-term psychiatric disturbances.¹⁷ Many of these systemic effects were observed in the patient.

Long-term use of exogenous steroids leads to feedback pituitary inhibition followed by adrenal suppression, which results in reduced release of regular body cortisol. Sudden stopping of the steroid can cause acute adrenal insufficiency, which manifests as hypotension, severe vomiting, and diarrhea, leading to dehydration, hyperkalemia, muscle cramps, fatigue, and even loss of consciousness. Therefore, gradual tapering is recommended to avoid such a life-threatening situation.^{18,19}

Using dexamethasone for the prevention of high-altitude illnesses has the potential for harm. Not only can its use be directly damaging, but its side effects can be

confused with other conditions. In the case described here, the symptoms of fatigue and disorientation could have been mistaken for acute mountain sickness (AMS) or high-altitude cerebral edema (HACE). Only by obtaining a thorough history and performing a comprehensive medical examination can these conditions be distinguished (Table).

As adventure travel increases and growing numbers of people ascend to high altitude, the demand for effective means of preventing and treating high-altitude illnesses will increase. As new medications become available, their side effects will need to be clearly understood by patients and their care providers. As yet, the safest way to approach the mountains is to ascend slowly and cautiously, avoiding any of the medications that are currently available.

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