

High-Altitude Medicine



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KEYWORDS

- High altitude • Acute altitude illness • Acute mountain sickness
- High-altitude cerebral edema • High-altitude pulmonary edema • Prevention

KEY POINTS

- High altitude generally refers to elevations greater than 2000 m, although the risk of acute altitude illness does not increase significantly until individuals travel above 2500 m.
- Hypobaric hypoxia, the defining environmental feature of high altitude, leads to lower oxygen tensions at every point along the body's oxygen transport chain, which triggers multiple important physiologic responses.
- Travelers to high altitude should be prepared to prevent, recognize, and treat the 3 main forms of acute altitude illness: acute mountain sickness, high-altitude cerebral edema, and high-altitude pulmonary edema.
- The mainstay of prevention of acute altitude illness is gradual ascent; descent is the best treatment.
- Pretravel evaluation should include counseling about normal changes people experience at high altitude, the primary forms of acute altitude illness, and a systematic evaluation of the risks posed by any underlying medical conditions.

INTRODUCTION

Because of a growing interest in adventure travel, improved global travel infrastructure, and increased access to sites of historical and cultural significance, increasing numbers of people are traveling to high altitude. Although these individuals often enjoy amazing scenery and unperturbed landscapes, such travel is not without risk. All travelers ascending above 2500 m are susceptible to acute altitude illness, including acute mountain sickness (AMS), high-altitude cerebral edema (HACE), and high-altitude pulmonary edema (HAPE) while individuals with underlying medical conditions, even if

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well compensated before travel, may be at increased risk for complications following ascent.

Given these risks, clinicians may encounter individuals planning high-altitude travel or who had problems on a recent trip. This article outlines a basic framework for counseling, evaluating, and managing these patients.

DEFINING “HIGH ALTITUDE”

Although no consensus definition exists, the term high altitude typically refers to elevations located above 2000 m (~6500 feet). Although observational studies have shown that individuals can develop acute altitude illness at elevations above 2000 m, the risk is not thought to increase substantially until individuals ascend above 2500 m (~8200 feet).^{1,2} For most healthy individuals, it is only when traveling above this latter threshold that the altitude should be taken into account while planning a trip. For individuals with severe underlying medical conditions, such as severe chronic obstructive pulmonary disease (COPD) or pulmonary hypertension, the effect of the altitude may require consideration at lower elevations.

THE ENVIRONMENT AT HIGH ALTITUDE

With increasing altitude there is a nonlinear decrease in barometric pressure, which leads to decreased ambient partial pressure of oxygen (P_{O_2}).³ This process causes a decrease in the P_{O_2} at every point along the oxygen transport cascade from inspired air to the alveolar space, arterial blood, the tissues, and venous blood, which in turn triggers several important physiologic responses.

Other important environmental changes include increased ultraviolet light exposure, decreased humidity, and decreased ambient temperature, which increase susceptibility to sunburn and ultraviolet keratitis, dehydration, and hypothermia, respectively.

PHYSIOLOGIC RESPONSES TO HIGH ALTITUDE

Hypobaric hypoxia causes many physiologic responses across multiple organ systems, such as hypoxic pulmonary vasoconstriction, increased minute ventilation, and increased cardiac output (**Table 1**).³ The magnitude of these responses varies between individuals, and this variability affects individual tolerance of hypobaric hypoxia and susceptibility to acute altitude illness.

As a result of some of these physiologic responses, travelers feel different at rest and with exertion at high altitude in comparison with lower elevations (**Box 1**). Reviewing these differences is a key component of pretravel counseling, as it can prevent misinterpretation of normal responses as evidence of illness and facilitate identification of individuals who are truly becoming ill.

ACUTE ALTITUDE ILLNESS

For most individuals, the risk of altitude illness begins with ascent to higher than 2500 m. Because health care providers may not be available for consultation during travel, all travelers should be able to recognize AMS, HACE, and HAPE, and respond appropriately if these conditions develop.

Acute Mountain Sickness and High-Altitude Cerebral Edema

Definitions and clinical features

AMS is a clinical syndrome characterized by headache plus one of several other symptoms including anorexia, nausea, dizziness, malaise, or sleep disturbance. It

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