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Acute Mountain Sickness: Symptoms, Diagnosis, Risk Factors, Prevention and Treatment

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ABSTRACT

Introduction

High mountain climbing has surged in popularity over the past few decades, attracting a diverse range of participants from professional athletes to even recreational enthusiasts, given that this sport has become commercial and more accessible. While high mountain climbing offers numerous mental and physical benefits, it also presents significant risks, among them one of the most dangerous is acute mountain sickness (AMS). Correct techniques of prevention are absolutely vital for the success of the expedition. To be able to read correctly the symptoms is essential for making the right decision during hike and knowing how to act once AMS occurs is necessary to ensure safety for all climbers.

Aim of the study

The purpose of this narrative is to comprehensively describe information about the prevention, symptoms and instructions concerning further procedure while dealing with acute mountain sickness (AMS).

Materials and methods

The methodology of the literature search involved using the keywords "acute mountain sickness" and adding terms such as "prevention", "symptoms", "diagnosis", "risk factors" and "treatment". The search terms were entered into the PubMed and Google Scholar databases. The review works and clinical trials were taken into account.

Conclusion

Acute mountain climbing occurs above 2500 m. The most important aspects of prevention and treatment is controlled ascent, rapid diagnosis and instant initiation of treatment, meaning descent. The pharmacologic prophylaxis and therapy is not recommended in every case, all of the decisions must be taken individually according to severity of symptoms and general situation in the mountains.

Keywords: acute mountain sickness (AMS), climbing, mountain sports

INTRODUCTION

High mountain climbing, colloquially alpine climbing, is a type of mountaineering that uses any of a broad range of advanced climbing skills, including alpine bouldering, high-elevation sport climbing, ice climbing or mixed climbing, to summit typically large routes anywhere in the alpine zone, or above treeline [1]. This kind of activity requires excellent technique skills, likewise remarkable endurance, given the length of the routes, which sometimes can take several days or even weeks. Because of the danger of alpine environments, such as avalanche, changing weather conditions, rockfall and high altitude, it is essential for climbers to be prepared physically and also mentally. Furthermore, not without its significance is suitable equipment [2]. Understanding the causes and symptoms of acute mountain sickness is critical for both climbers and healthcare providers. In order to undertake good prevention steps, make an accurate diagnosis and start appropriate treatment. It is imperative for climbers to prioritize proper training, conditioning and rest to safeguard against such danger to health and sustain optimal accommodation in the demanding alpine mountains [3]. Finally, the ability to make a decision to quit the venture, meaning not to reach the summit, in risk of health damage sometimes generates numerous difficulties for athletes, which reflects on many controversial expeditions, on which tragically people have even lost their lives [4]. This challenging and exhilarating pursuit places extraordinary strain on the whole body. Essentially, the acute mountain sickness occurs due to the barometric pressure falls generated from increasing altitude, as a consequence it leads to the reduction of the partial pressure of oxygen, which presents a hypoxic challenge [5]. Once the hypoxic stress surpasses the ability to acclimatize, a broad variety of symptoms can occur - from self-limiting acute mountain sickness to even cerebral or pulmonary edema. The incidence and severity depend on ascent rate, attained altitude, amount of time spent at the height, level of physical effort and the individual's physiological susceptibility. A recurring pattern of AMS appearance is a rapid ascent to summits above 3000 m with insufficient time to acclimatize [6].

AIM OF THE STUDY

The primary objective of this narrative is to provide a comprehensive overview of the prevention, symptoms, risk factors and instructions concerning further procedure while dealing with acute mountain sickness (AMS). With the escalating popularity of high mountain climbing, it becomes imperative to disseminate information and heighten awareness regarding

potential risks, while also striving to achieve a comprehensive understanding of the illness to facilitate prevention.

MATERIALS AND METHODOLOGY

The literature search methodology used a comprehensive approach by utilizing the keywords "acute mountain sickness" in conjunction with related terms such as "prevention", "symptoms", "risk factors" and "treatment". These specific search terms were meticulously entered into both the PubMed and Google Scholar databases to ensure a thorough search process. Additionally, the review encompassed relevant clinical trials to provide a comprehensive overview of the topic. The research questions formulated are outlined below:

1. What causes an AMS?
2. What are the indicative symptoms of an AMS?
3. What is the optimal method for diagnosing an AMS?
4. How to grade the AMS severity?
5. What are the most common misdiagnoses of AMS?
6. How to prevent AMS?
7. What are the recommended treatment approaches for an AMS?

STATE OF KNOWLEDGE

Diagnosis and symptoms

In case of symptoms that indicate AMS in the circumstances of recent ascent to a new altitude should be treated as such until proven otherwise. The most common first demonstration of AMS is high-altitude headache (HAH). High-altitude headache is often present with other symptoms, including insomnia [7], fatigue, anorexia, nausea and dizziness. This type of headache is usually getting worse during nights of physical exertion. The next most frequent complaint is insomnia [8].

The Lake Louise AMS criteria is a functional instrument for analysts to diagnose and grade the severity of acute mountain sickness. AMS according to the above-mentioned scale is defined with a total score of minimum three points from the four symptoms mentioned,

including at least one point for headache in the light of recent gain in altitude. A whole scale for evaluating the acute mountain sickness is developed below.

Headache
0—None at all
1—A mild headache
2—Moderate headache
3—Severe headache, incapacitating
Gastrointestinal symptoms
0—Good appetite
1—Poor appetite or nausea
2—Moderate nausea or vomiting
3—Severe nausea and vomiting, incapacitating
Fatigue and/or weakness
0—Not tired or weak
1—Mild fatigue/weakness
2—Moderate fatigue/weakness
3—Severe fatigue/weakness, incapacitating
Dizziness/light-headedness
0—No dizziness/light-headedness
1—Mild dizziness/light-headedness
2—Moderate dizziness/light-headedness
3—Severe dizziness/light-headedness, incapacitating

Table 1. The Lake Louise AMS criteria [9].

Based on the amount of points assigned, according to the Lake Louise scoring system, it is possible to distinguish three different stages of the disease.

1. Mild AMS as 3-5 points
2. Moderate AMS as 6-9 points
3. Severe AMS as 10-12 points [10].

Although the symptoms of an illness can launch within 6 hours of gaining height, the researchers suggest using the Lake Louise AMS criteria exclusively after 6 hours to evade the mistakes of bad diagnosis, such as travel fatigue or responses to acute hypoxia. Amongst other common misdiagnoses of AMS are alcohol hangover, drug use, dehydration and viral flulike illness. Furthermore, acute mountain sickness cannot be confused with high-altitude cerebral edema (HACE) [11]. Must be remembered that AMS alone is self-limited and shows no neurological manifestation. Comparatively, HACE normally starts between 24 and 72 hours after the ascent and is characterized by mental disorders and/or ataxia. In addition, HACE eventuate in general in the presence of high-altitude pulmonary edema or AMS, and it is always a medical emergency.

AMS	In the setting of recent gain altitude, the presence of headache and at least one of the following symptoms: - gastrointestinal - fatigue or weakness - dizziness or lightheadedness - difficulty sleeping
HACE	Can be considered severe AMS, in the setting of recent altitude gain, either: - change in mental status and/or ataxia in a person with AMS - change in mental status and/or ataxia in a person without AMS

Table 2. The comparison between AMS and HACE [12].

Statistically, AMS remains the most frequent form of high-altitude illness, affecting around 25% of travelers at moderate height and 50% to even 85% of climbers above 4000 m [13]. In contrast to HACE, which happens only up to 4% of people and is habitually not observed beneath 4000 m [14].

Risk factors

Studies show that risk factors of AMS are male sex [13], intense exercise [14], cold temperatures [15], preexisting respiratory infection [16] and a history of AMS in the past [17]. Smoking cigarettes is not proven to increase the risk of AMS [18]. People with lung disease, anemia, heart condition or obstructive sleep apnea should consult their doctors prior to high mountain climbing. Finally, the duration and pace of ascent plays a key role as a risk factor, development is presented in table below.

Risk category	**Description**
High	- History of AMS and ascending to >= m in 1 d - All individuals with prior history of HAPE or HACE - All individuals ascending to > 3,500 m in 1 d - All individuals ascending > 500 $m \cdot d^{-1}$ at altitudes above 3,500 m - Very rapid ascents
Moderate	- Individuals with prior history of AMS and ascending to 2,500 m to 2,800 m in 1 d - No history of AMS, but ascending to > 2,800 m in 1 d - All individuals ascending >500 $m \cdot d^{-1}$ at altitudes above 3,000 m
Low	- Individuals with no prior history of altitude illness and ascending <2,800 m - Individuals taking >= 2 d to arrive at 2,500 to 3,000 m with subsequent increases in sleeping elevation <500 $m \cdot d^{-1}$

Table 3. Risk factors according to duration and pace of ascent [19].

The recent studies indicate that persons who are accustomed to high altitude, meaning people who live above 2500 m or who have traveled recently to high mountains, are less vulnerable to altitude illness [20].

Preventation

The most important starting point of preventing the AMS is controlled ascent. The process of acclimatization consists in a series of adjustments in the human body to meet the demands of hypoxemia [21]. Slow gain of altitude rate of 300 to 350 m per day above 2500 m is recommended [22]. An additional day for acclimatization should be added for every 600 to 1200 m above 2500 m. These instructions also include sleeping height - aim for less than 400 m difference between each night [23]. Not without its significance is also preacclimatization, meaning regular exposure to altitude and a gradual ascent [24].

For low-risk cases [Table 3], prophylactic intake of medication is not recommended, but moderate- and high-risk cases do justify their use. Multiple studies have shown the benefits of acetazolamide use in prevention of AMS [25, 26]. The most frequent side effects of acetazolamide are diminished exercise tolerance, paresthesias and a taste aversion to high carbonated beverages. Nevertheless, intake of acetazolamide is prohibited in patients with anaphylactic shock from sulfonamides in the past, due to the homologous structure of these two medications. Use of acetazolamide can be justified for patients with milder sulfonamide allergies, although this decision should be made individually. Another medication with proven value for AMS prevention is dexamethasone, nonetheless its prophylactic use is limited, because of severe adverse effects, such as glucocorticoid toxicity and a rebound of altitude sickness symptoms in case of cessation of therapy [27]. In the midst of other medication with potential profit for acute mountain sickness are medroxyprogesterone [28], phosphodiesterase 5 inhibitors (sildenafil and tadalafil) [29, 20, 31], selective 5-hydroxytryptamine antagonist (sumatriptan) [32], iron therapy [33, 34], gingko biloba [35, 36, 37, 38], magnesium [39], theophylline [40,41] and loop diuretics (furosemide or aldosterone antagonists) [42, 43], yet more studies must be conducted to include them in guidelines of AMS treatment. In addition, the adequate hydration and absence of alcohol are major prevention steps [44].

Treatment

The primary and instantaneous strategy is to increase ventilation. The most significant measure in treatment of worsening acute mountain sickness is early identification and simply descent, if it is a viable option, until symptoms disappear [45]. Substantial changeability among individuals is noticeable, but in most cases, at least 300 m but no more

than 1000 m descent is mandatory. If safe reduction of height is not conceivable, there are other interventions that can be used for treatment. A supplementary oxygen is capable of raising SpO_2 > 90%, which will securely prevent hypoxemia. Nevertheless, to sustain a climber for a long period, requires a significant quantity of oxygen, which is problematic due to the physical limitations of transport [46]. Dexamethasone is effective in improving symptoms of AMS, when ordered at onset and is recommended in case of impossible descent. On the other hand, acetazolamide has a proven impact for treatment at higher doses, yet the effect is delayed, so its use is less efficient for the therapy.

Indication	**Medication**	**Route**	**Prevention dose**	**Treatment dose**
AMS	Acetazolamide	Oral	125 or 250 mg twice a day	250 mg twice a day
AMS	Dexamethasone	Oral, IM or IV	2 mg every 6 h or 4 mg every 12 h	4 mg every 6 h

Table 4. The dosing of acetazolamide and dexamethasone in AMS [47].

The alternative for pharmacologic approach are portable hyperbaric chambers, which are proven to be efficacious in severe AMS [48]. However, they present a considerable challenge, both logistic and economic, given their size and price. Another disadvantage of portable hyperbaric chambers is their limitation in case of patients with claustrophobia or vomiting, which provides high risk of choking. Moreover, use of portable hyperbaric chambers should not in any case delay descent [49]. Some of the scientific work has shown that reduction of symptoms of AMS can be achieved also by a high-carbohydrate diet [50].

CONCLUSION

Acute mountain sickness (AMS) occurs while performing activity above 2500 m and is able to profoundly change the course of high mountain expeditions and if not properly taken care of, poses a realistic risk of health damage. The most significant aspects of prevention and treatment continue to be ascent, quick recognition of symptoms and simply controlled descent, if feasible. The pharmacologic prophylactic is recommended for moderate- and high-risk cases. New studies are being conducted, therefore our understanding of disease is

improving, we will presumably have more effective prevention and treatment options in the future, which will guarantee greater safety for alpine climbers.

DISCLOSURE

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Not applicable.

2. Data were obtained from

PubMed and Google Scholar.

3. Author's contribution:

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