

Acute mountain sickness

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Summary

Each year millions of people travel to high altitude regions, i.e. 2500 metres above sea level to explore beautiful places or to realise to accomplish their mountaineering passions. Such high altitudes can induce health-related problems, called acute mountain sickness (AMS). The severity of the disease varies with altitude. The most common symptoms are headaches, weakness, and lack of appetite, which affect individuals living in lowland regions, who are not adjusted to the different mountain environment. The development of AMS can be simply prevented by gradual ascent. Moreover, there are pharmaceutical agents, which help to alleviate the symptoms.

Key words: Acute Mountain Sickness, health risk

Introduction

Since the Ancient Times, high altitude illness has been a mystery. Some believed that it was madness sent by Gods. Greeks climbing Olympus (2917m a.s.l.) were convinced that the mountain was only for Gods. However, it was not Greeks who contributed most to proper understanding of this phenomenon. The phenomenon started to be elucidated in the first half of the 19th century during first balloon flights of French and English travellers. In 1920, the British travellers preparing for exploration of Mount Everest were aware that man could reach 8000 m a.s.l. after gradual acclimatization. In 1953, Sir Edmund Hillary and Tenzing Norgay while in 1978 Reinhold Messner and Peter Habeler reached the peak above 8000m a.s.l. and became convinced that at the altitude above 8000 m a.s.l. the use of artificial oxygen was indispensable [1].

Harmful effects of high altitudes on the body were observed over 2000 years ago by Tseen Hanshoo who described "the mountains of slight and severe headaches". The mountains mentioned by him are likely to be the mountains of the Silk Route located above 4000m a.s.l.. This was the first description of high altitude illness presenting with headache [1,2].

In 1960, Charles Houston described high altitude pulmonary edema (HAPE) as one of life-threatening diseases, which can accompany high altitude illness. The findings of the study carried out in a 21-year-old healthy skier and subsequently in a large population of soldiers stationed in Himalayas were one of the sources to determine the diagnostic criteria of high altitude illnesses [1]. The criteria were established in 1991 by the group of experts and named the Lake Louis Score [1,4,5].

Despite numerous hazards associated with high altitude expeditions, people are not discouraged to explore high altitudes and conquer summits. Due to rapid development of mountain tourism, it is forgotten to follow the rules, i.e. preparing the organism before such expeditions. The human body adjusts relatively slow compared to the pace of

ascent and the adaptive possibilities decrease with altitude. At high altitudes the adjustment to reduced atmospheric pressure without acclimatisation is impossible and may lead to the development of acute mountain sickness [2].

Acute Mountain Sickness (AMS)

Acute mountain sickness is the cluster of symptoms caused by long-term hypoxia and decreased atmospheric pressure. It develops in individuals who cover high altitude differences in short time. AMS can be accompanied by the life threatening high altitude cerebral edema (HACE) and high altitude pulmonary edema (HAPE) [3,6]. There are individual physiological measures predisposing to the adaptation of the organism at high altitudes, which include the ability to constrict the pulmonary blood vessels and disorders of venous inflow. It has been demonstrated that age, gender, medical history, physical stamina do not significantly affect the development of AMS. Otherwise, individuals who repeatedly stay at high altitudes and live in mountainous regions have higher capacities to acclimatise to high altitudes [7].

Classification of altitude and physiological effects [1,8,9]

High altitudes (1500–3500 m a.s.l.)

- Reduced efficiency of the organism, increased lung ventilation,
- Slight disorders of oxygen saturation of arterial blood (SaO₂) and partial oxygen pressure of arterial blood (PaO₂) ranging from 55 to 75 mm Hg,
- Since numerous people stay at such altitudes, the incidence of this disease is found to be the highest one.

Very high altitudes (3500–5500 m a.s.l.)

- SaO₂ decreases to 75% - 85%, PaO₂ is 40–60 mm Hg,
- Increasing hypoxaemia during climbing and sleep, accompanied by high altitude pulmonary edema and lung diseases,

- The most common severe illnesses,
- Too quick ascent can be dangerous, acclimatisation is required.

Extreme altitudes (above 5500 m a.s.l.)

- Severe hypoxia and hypoxaemia; SaO₂ - 58% - 75%; PaO₂ - 28 - 40 mm Hg,
- Progressing loss of physiological functions, without possible acclimatisation,
- Too quick ascent most commonly leads to high altitude illnesses,
- Lack of conditions for live.

Clinical symptoms and diagnosis of AMS

At high altitudes, the major reaction of the organism to the changing pressure and amount of oxygen is headache. The specific symptoms occur most commonly two/three days after reaching high altitudes and persist for about five days [6]. The characteristic symptoms that increase with the altitudes reached and physical efforts include:

- Headache,
- Appetite disorders,
- Nausea and vomiting,
- Sleep difficulties,
- Weakness,
- Effort dyspnoea,
- Tachycardia,
- Apathy [3,10,11].

The clinical diagnosis of acute mountain sickness can be based on the Lake Louise Score (Table 1). The score includes eight open questions, first five of which are self-reported score while the remaining ones are symptom score. The disease is diagnosed in patients with the score 3 for questions 1-5 and at least 5 for questions 1-8 [12].

Table 1. The Lake Louise AMS score

Symptoms	Severity	Score
1. Headache	No pain	0
	Mild pain	1
	Moderate pain	2
	Severe	3
2. Gastrointestinal disorders	No disorders	0
	Lack of appetite/nausea	1
	Nausea/vomiting	2
	Severe nausea/vomiting	3
3. Weakness/fatigue	No	0
	Mild	1
	Moderate	2
	Severe	3
4. Dizziness	Lack	0
	Mild	1
	Moderate	2
	Severe	3
5. Sleep difficulties	Good sleep, as usual	0
	Not good, as usual	1
	Frequent waking up	2
	Insomnia	3
6. Changes in mental status	No changes	0
	Lassitude	1
	Disorientation	2
	Semi-consciousness	3
7. Ataxia	No	0
	Manoeuvres to maintain balance	1
	Steps off the line	2
	Falls Incapacity to stand	4
8. Oedema	No	0
	One location	1
	Several locations	2

Pathophysiology of AMS

The theory, which currently prevails, says that the disease process takes place in the Central Nervous System. Hackett and Roch claim that the disease is caused by increased permeability of the blood-brain barrier, and its damage by hypoxia as well as increased perfusion pressure in the brain leading to distension of cerebral vessels and brain oedema (Fig.1)[6,13]. Harmful conditions, i.e. unavailability of fresh food, strong physical effort, increased ultraviolet radiation, can stimulate the antioxidative enzymatic system leading to oxidative stress - increased production of reactive oxygen species using antioxidants. Reactive oxygen species produced suddenly in the body result in many adverse phenomena, such as damage to the lipid layer of cell membranes or nucleic acids. The changes at the cellular level lead to systemic changes, i.e. malaise, reduced physical efficiency. Increased oxidative stress is believed to be one of the factors causing AMS [14].



Fig.1 Pathophysiology of AMS

Na rycinie – reduced oxygen pressure in blood, increased cerebral blood flow, increased volume of cerebral blood, increased permeability of blood-brain barrier, brain enlargement, insufficient flow of cerebral fluid, AMS.

AMS-Adaptive mechanisms

Based on the studies in ingenious populations of mountain regions, the human environment-adaptive processes can be elucidated. The studies were carried out amongst inhabitants of Andes, Tibet and Ethiopia. Due to decreasing atmospheric pressure and increased altitudes, the organism has to adapt to the conditions by suitable oxygenation of tissues. According to the findings presented by Cyntia M. Beall from the University of Cleveland (Ohio, USA), in Bolivia, in the regions situated at 4000m a.s.l., the natives had the haemoglobin level higher by 25% compared to people living in lowland regions. This increase is a result of compensation for hypoxia by the formation of higher amounts of oxygen “carriers” [15].

The study performed in inhabitants of Tibet (4000 m a.s.l.) demonstrate that the human body can adapt to very high altitudes by limiting the expiration of nitrous oxide (NO). The control group living in the sea-level regions expire higher amounts of NO. The gas

affects the smooth muscle relaxation decreasing blood pressure and thus preventing hypoxia [15].

No adaptive mechanisms to environmental conditions have been observed amongst the inhabitants of mountain regions of Ethiopia (3500 m a.s.l.) [15].

Prevention

The simplest measure to prevent acute mountain sickness is acclimatisation and gradual ascent. Acclimatisation involves an increase in altitude followed by a decrease in altitude by descending [16]. In most cases, acclimatization takes about 3 weeks to reach such a number red blood cells to ensure proper oxygen transport through blood at high altitudes preventing long-term complaints associated with increasing altitudes [3]. One of the essential rules regarding gradual increases of altitudes states that at altitudes higher than 3000m a.s.l. the night should be spent at the altitude not higher than 300m compared to the altitude during the previous night – “climb high, sleep low”. After reaching 3000 m a.s.l. one day of resting is recommended, i.e. acclimatisation, which should be repeated every 2-3 days or every 1000 m a.s.l. [6, 17]. If the pace of ascent is considered a relevant element, it is assumed that the differences between subsequent overnight places should not exceed 600 m. Hence, the ascending pace can exceed the recommended value while the altitude difference during nights should be absolutely maintained. When symptoms do not regress, the altitudes should not be increased; when the complaints increase, the altitude should be reduced [6,17].

Pharmacological prophylactics

The development of high altitude sickness in cases of quick ascent above 3000 m a.s.l. can be prevented by using pharmacological prophylactics. The use of various pharmaceuticals for prevention of AMS was studied by Dumont et al. The drugs analysed included dexamethasone, acetazolamide and Ginkgo biloba extract [18].

Dexamethasone is a synthetic glucocorticosteroids of potent anti-inflammatory, immunosuppressive and anti-allergic properties. It was initially used due to its relation to high altitude cerebral oedema with high altitude sickness. Prophylactically, 8 mg of dexamethasone a day were administered, divided into doses. When starting the ascent, 2-4 mg were used. Such doses were continued for three subsequent days and gradually reduced during the next days [6]. At present, dexamethasone is recommended during evacuation to improve cooperation or when the descent is impossible [5]. Considering numerous adverse side effects, the administration of the drug is presently restricted and it is replaced by acetazolamide or combination of both drugs [13].

The most effective drug for AMS prevention is acetazolamide. It is an inhibitor of carbonate anhidrosis. Despite its confirmed efficacy for prevention and alleviation of AMS symptoms, the optimal dose has not

been determined [19]. Generally, 250 mg/day are administered since the first day of ascent and continued for another 3-5 days. The dose can be divided and climbers can take 125 mg twice a day [20]. The clinical trials demonstrate that the dose of 500 mg/day is effective to prevent AMS [20,21]. By inhibiting carbonate anhidrosis in kidneys, acetazolamide induces metabolic acidification, which results in quicker reactions of chemoreceptors to hypoxia associated with high altitudes. Moreover, the drug has been shown to stimulate ventilation by decreasing the concentration of bicarbonates reducing pH in the cerebrospinal fluid [5]. The most common side effects of the drug include nausea and lack of appetite. The drug should not be used in pregnant women, except for life-threatening cases [22].

Ginkgo biloba is a plant of increasingly wide interests. The Ginkgo biloba extract is used for the treatment of old age problems, particularly cardiovascular and memory-related ones. Dried leaves contain flavone glycosides and terpene lactones as well as bilobalide [23]. Ginkgo biloba was demonstrated to be essential for AMS prevention. The pre-ascent use of Ginkgo biloba in a dose of 60mg three times a day reduced the severity of AMS symptoms. However, researchers failed to show that the substance reduced the incidence of AMS [24]. The efficacy of Ginkgo biloba is lower than that of acetazolamide [25].

Incidence of AMS

Acute mountain sickness develops in about 25% of mountain climbers at the altitudes between 1850 - 2750 m a.s.l. [3]. The study in soldiers staying at 2000- 3960 m a.s.l. revealed that symptoms of AMS occurred in 70% of them [26]. Another study in recruits staying in Chile at the altitude of 3550 m a.s.l. found AMS in almost 60% of the population. Three months later when soldiers descended to the lowland for over a week and re-ascended, the symptoms of AMS were noted in 55% [27]. Still another study in tourists climbing Kilimanjaro the symptoms of acute mountain sickness were observed in 9% of participants at the altitude of 2743 m a.s.l. With an increase in altitude, the percentage of individuals with AMS symptoms increased; at 4700-5500 m a.s.l. AMS symptoms were found in almost 70% of individuals. Furthermore, the AMS symptoms were demonstrated to decrease together with acclimatization for 2 days. The symptoms subside about 5 days after high altitude stays [27, 28].

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