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Review Article

Altitude sickness and Antarctic polar plateau: A review

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Abstract

Antarctica is known for its extreme environmental conditions. It is the best model to study multiple stress factors at a time on human physiological responses. Although the coastal Antarctica is on Sea level but the Antarctic plateau or pole at high altitude. Since Antarctica is also becoming tourist site it is pertinent to have a proper understanding of altitude induced illnesses. In this review we have described the human acclimatization process at high altitude of Antarctic polar plateau and South Pole. The review also highlighted the symptoms, clinical features and prevention of altitude induced diseases.

Introduction

Sojourners traveling over a frozen ice cap of Antarctica to the South Pole with no support would be facing the prospect of being short of breath because of decreased oxygen availability. The decreased oxygen availability is due to the low barometric pressure at Antarctic plateau and South Pole. The partial pressure is only about 510 mm mercury, 30% lower than at the coast and lower than would be predicted from its average altitude of 2,300 m [1,2]. The effective altitude in terms of the partial pressure of oxygen is about 2,800 m (over 9,000 ft). The highest point in Antarctica is at 4093 m above sea level and average temperature in summer is around -25 ^{0}c. Thus sojourners approaching towards South Pole may face decreased oxygen availability along with severe cold and speedy winds which may exacerbate the problems and trigger altitude sickness. About 2% sojourners travelling to South Pole suffers with altitude sickness. In our studies, we found that apart from altitude sickness, hypoxia also affects human immunity [3-6]. We have reported that not only hypoxia but extreme conditions of Antarctica at coastal station Maitri affects human immunity during summer as well as winter overstay [7-12]. For the first time, India launched a scientific expedition to the South Pole on 13th November 2010 from Maitri. The 8 member team reached the South Pole on 22nd November, 2010 and returned to 'Maitri' on 1st December 2010. Thus sojourn to South Pole require a clear understanding about the acclimatization and altitude induced problems. This review emphasizes the altitude sickness may occur at southern polar plateau and it also highlighted the symptoms and prevention strategies of high altitude illnesses.

Acclimatization at High Altitude: When a person is acutely exposed to high altitude, shortly, in minutes after such an acute exposure, a significant drop in oxygen saturation (SaO_2), the concentration of oxygen in the blood occurs, which is approximately 98% - 100% at sea level which decreased to ~75%. If the person is continuously staying in the following days the SaO_2 will increase back to >85% as a result of successful acclimatization [13,14]. Usually blood oxygen levels should remain >80%, otherwise function of the brain and heart might be altered. Concomitantly with the drop in SaO2,

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as one of the acclimatization processes, ventilation will be nearly doubled at altitude as compared to sea level, known as hyperventilation. This will lead to lower alveolar CO_2 concentration, thereby increasing the level of oxygen in lungs. The reduced CO_2 concentration in the lungs will attenuate the acid base balance, leading to alkalosis. This alkalosis triggers an increased bicarbonate excretion via kidney in following days to normalize the pH of blood. Besides hyperventilation, the autonomic nervous system will stimulate cardiovascular response, which includes an increase in heart rate and blood pressure as well as erythropoiesis, triggered by increased erythropoietin (EPO) production and release. The enhanced EPO level causes increased red blood cells and hemoglobin (Hb) concentration, leading to higher oxygen transport capacity of blood. It has been found that an increase of Hb by 3g/l leads to an increase of about 1% in VO2 max. The carotid body plays an important role in sensing the change in the aterial oxygen partial pressure [1,15,16]. The changes are mediated to the brainstem via signal processing in which the hypoxia inducible factor (HIF) is involved. It increases (i) a hypoxic ventilator response (HVR) of the lungs and (ii) cardiac output by increasing heart rate. Altitude induced illness may result in acute mountain sickness (AMS), high altitude pulmonary edema (HAPE) or high altitude cerebral edema (HACE).

High altitude illnesses: At high altitude sojourners may suffer with (I) Acute mountain sickness (AMS): The Exacerbating factors for AMS could be; (i) Previous altitude sickness, (ii) Rapid ascent, (iii) Excessive training early in acclimatization period. The clinical features of AMS is (i) Presence of headache; (ii) Gastrointestinal e.g. anorexia, nausea,vomiting (iii) Fatigue or weakness (iv) Dizziness or light headedness-- Difficulty sleeping. The prevention strategies for AMS may be (i) Ascent rate less than 300 m per day with rest after every 1000 m) ascent. (ii) Avoid ascent with AMS symptoms, (iii) If severe sickness, start acetazolamide in consultation with doctor. The other illness which sojourner can face at high altitude is High altitude cerebral edema (HACE): The exacerbating factor for HACE is similar to AMS such as (i) previous altitude sickness (ii) Rapid ascent (iii) Excessive training early in acclimatization period; The clinical features for HACE is (i) Change in mental status or ataxia (ii) hallucinations, (iii) papilloedema (iv) confusion (v) tachycardia (vi) tachypnoea (vii) cyanosis. The prevention of HACE is possible through early recognition and management of symptoms of AMS. Immediately descent from the altitude. The another severe illness at high altitude is high altitude pulmonary edema (HAPE): the exacerbating factors for HAPE are (i) rapid ascent (ii) pulmonary hypertension (iii) congestive heart failure (iv) chronic obstructive pulmonary disease (v) absence of single pulmonary artery (vi) brisk hypoxic pulmonary vasoconstrictor response (vii) excessive physical exertion and cold (viii) respiratory tract infection. The clinical features of HAPE include (i) crackles/ wheeze in atleast 1 lung field (ii) central cyanosis (iii) tachypnoea (iv) tachycardia and presence of dyspnoea at rest and cough (dry/productive) (v) reduced exercise tolerance or fatigue; (vi) chest tightness. The prevention of HAPE possible by avoiding exertion and ascent rate less than 300 meter paer day with rest after 1000 meter ascent.

Majority of sojourners fly to South Pole from the coast of Antarctic at sea level, and so experience a steep change in oxygen availability and may suffer with altitude sickness. However, venturing on polar plateau by car takes several days to climb the Polar Plateu. Thus slow rate of ascent leads to physiological acclimatization and sojourners do not feel altitude sickness while acutely exposed sojourners may suffer with altitude sickness.

Evidence of Altitude Sickness from initial Antarctic Expeditions: Evidence of altitude sickness is reported by Robert Scott in his diary during the stay at polar plateau. Roald Amundsen noted fatigue from the low oxygen level and difficulty in sleeping. Ernest Shackelton reported headaches and nosebleed in his men [13].

Buzz Aldrin (at the age of 86 years), the second man to walk on the moon was a part of an Antarctica sightseeing tour. The Aldrin was very excited about his adventure to the bottom of the world i.e. South Pole. His team departed from Cape Town, South

Africa to South Pole as a tourist when he fell ill. He was diagnosed with altitude sickness and evacuated by flight to Christchurch from McMurdo Station, a U.S. research center on the Antarctic coast. So, in his case, it appears he was a bit more sensible by properly and immediately being evaluated medically once symptoms arose [14]. That is extremely important in these conditions. However, at the time initial expeditions of Antarctica our understanding about altitude induced human physiological responses and illnesses were very little.

Conclusion

This review highlights that sojourner reaching South Pole by flight may suffer with altitude sickness for at least 2 days after arrival and may have persistent symptoms beyond day 3. Breathlessness, sleep difficulties, headache, and fatigue were the most prominent symptoms reported in several studies at South Pole. The South Pole constitutes a more intense altitude challenge than would be expected based on the physical altitude. Thus equivalent air altitude alone is an inadequate predictor of Hypoxemia in Altitude sojourners.

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