Original Scientific Paper

RECOMPRESSION THERAPY OF MOUNTAIN SICKNESS

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This paper describes the treatment of a severe case of acute mountain sickness with a portable hyperbaric chamber. A 37-year old climber was treated for acute high altitude pulmonary oedema, which developed on the North Col of Mount Everest, at an altitude of 7,060 m. The treatment in the portable Gamow bag hyperbaric chamber lasted two hours, with a bag pressure of 103 mm Hg (0.136 kg/cm^2 or 2 psig) using ambient air, without the addition of oxygen. With this pressure increase, the hyperbaric chamber lowered the patient's effective ambient altitude from 6,050 to 4,400 m. The treatment was successful and the pulmonary oedema disappeared. Outside the hyperbaric chamber, the patient recovered fully when he reached the altitude of 2,000 m. Portable hyperbaric chamber is recommended for the treatment of severe cases of acute mountain sickness, as well as for risky descent to lower altitudes.

KEY WORDS: *climbers, Gamow bag, hyperbaric chamber, mountaineering, pulmonary oedema*

About 40 million people all over the world live at altitudes over 2,500 m, and probably even more people visit mountain areas every year, including the top of the world, the 8,848 m high Mount Everest (1). Many of these visitors will suffer from some manifestation of high-altitude illness, that is, mountain sickness. Beginning at altitudes of 2,000 to 3,000 m, some people suffer headache, exhaustion, anxiety, dyspnoea and insomnia (2, 3). According to *Dickinson and co-workers* (4), about 53% of visitors to an altitude over 5,000 m such as Andes or Himalayas will experience a certain degree of acute mountain sickness. A minority or 4.3% will develop life-threatening illness.

The principal cause of mountain sickness is the decrease in partial pressure of oxygen at high altitudes. Pathophysiologically speaking, impaired production of energy leads to intracellular and extracellular swelling. There are three main manifestations of mountain sickness; acute mountain sickness (AMS) with general symptoms (mild headache, nausea, fatigue, dyspnoea, and sleep disturbance), high-altitude pulmonary oedema (HAPE) with predominantly pulmonary symptoms (irritable and productive cough, often bloody sputum, cyanosis, tachycardia, increasing dyspnoea, and later coma), and high-altitude cerebral oedema (HACE) with predominantly cerebral symptoms (severe headache, ataxia, mental confusion, hallucination, and later coma). These manifestations of mountain sickness are not separate entities, but a continuum which is dominated by one of them. For more details, we recommend other sources (5, 6, 7).

Usually the prevention of mountain sickness through long-term oxygen inhalation is not

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feasible for technical reasons. In ordinary high-altitude climbing the only practical method to prevent AMS is gradual acclimatisation. However, this method has its limits. Until now AMS has best been treated by a rapid descent into a valley or by a decrease in altitude of at least 300 m. However, climbing in the Himalayas, particularly in Tibet, entails specific problems, as it is necessary to walk some 20 km or more to achieve the 300-metre decrease in altitude. In a case of HACE, this is usually impossible. Helicopter evacuation at altitudes over 6,000 m is not feasible, as the air is too thin to provide adequate lift (5).

In 1988, the American inventor Igor Gamow, constructed a lightweight, portable low-volume hyperbaric chamber made of PVC which has been named the "Gamow bag" (Chinook Medical Gear Inc, Eagle, CO-USA). The chamber is ideal for the treatment of severe AMS manifestations in high-altitude camps and expedition base camps. Together with a transport bag and an air pump, the Gamow bag weighs 6.76 kg. When inflated, its volume is 0.476 m^3. The maximal bag pressure of 103 mm Hg (2 psig) is achieved with a foot powered air pump or an electric pump. Ventilation is accomplished with 10 to 20 pumping cycles per minute (3).

Our experience

The expedition "Everest 97", organized by the Croatian Mountain Association, spent 38 days on the Tibetan side of Mount Everest at altitudes over 5,200 m, of which 30 days were spent at altitudes over 6,500 m in severe weather conditions (6). At altitudes over 8,000 m, climbers had to breathe oxygen-poor air and suffer continuous strong winds bringing temperatures from -15 ˚C to -60 ˚C every day. No wonder that members of the expedition had numerous medical problems, of whom 10 suffered from AMS. The expedition was equipped with a portable hyperbaric chamber, the so called Gamow bag, owned by the Baromedical Polyclinic OXY from Pula, Croatia. The chamber was provided specifically for that expedition, and by good fortune, it was needed for the treatment of one patient only. The other nine patients with moderate AMS were treated by inhalation of medical oxygen, diuretics and corticosteroids.

CASE REPORT

A 37-year-old member of the expedition developed a life-threatening pulmonary oedema during his ascent to an upper camp. On 3 May 1997, he arrived to Camp IV at 7,060 m on the North Col of Mt Everest, showing symptoms of HAPE after heavy physical exertion: dyspnoea, shortness of breath, dry cough, and later the appearance of foamy sputum. The expedition physician was called over the mobile telephone, and he soon climbed the glacier accompanied by one climber. They brought the first aid kit and a cylinder of medical oxygen, reserved solely for medical treatment. They met the patient descending slowly, assisted by another climber, at the altitude of 6,650 m. The night was falling and the air temperature dropped to -20 ˚C. The patient was dyspnoeic and had rattled breathing, rendering auscultation practically impossible. At the meeting point he was given 100% oxygen via a full-face mask, two 400 mg pills of pentoxifylline orally (Trental, Belupo, Koprivnica, Croatia), and 16 mg of corticosteroids intravenously (Dexamethason, Krka, Novo Mesto, Slovenia). After a 15-minute rest, the evacuation was resumed toward the advanced base camp at 6,450 m. The patient was immediately placed in the Gamow bag and treated according to the reference tables provided by *Igor Gamow* (3). After two minutes of treatment, he was exposed to an absolute pressure of 437 mm Hg (which equals the pressure at the altitude of 4,400 m), instead of the base camp air pressure of 333 mm Hg (6,450 m).

After two hours of treatment, the symptoms of pulmonary oedema were significantly relieved. Full recovery took some time, with additional medical care later including pentoxifylline pills t. i. d. in the month that followed. Eighteen days later, that experienced climber tried to climb the top again despite the physician's caution against it, and his health deteriorated during that attempt. The second exposure to the altitude of over 7,000 m caused severe circulatory problems in his legs and probable peripheral nerve disturbances with chilblains and painful muscle cramps, resistant to therapy. His condition did not improve until he returned to Katmandu (1,350 m), and he completely recovered only after he returned home a month later.

DISCUSSION

In high mountains, climbers frequently manifest different AMS symptoms. *Dickinson and co-workers* in a paper describing seven fatalities among trekkers in the Himalayas stress that in all of them the cause of AMS was the rapid ascent without acclimatisation (4). Ascents of over 5,000 m require acclimatization of at least seven days, and the climbing of peaks of over 7,000 m is recommended several weeks acclimatisation (5). The diuretic acetazolamide is usual in the treatment and prevention of HAPE and HACE. Allegedly, this drug has been shown to decrease the incidence of AMS (5, 7, 8). More recently, corticosteroid therapy has been suggested, as has oxygen breathing using a full-face mask which has an exhalation valve with increased resistance (8). However, no treatment equals rapid descent to an altitude of at least 300-500 m below the level at which the AMS symptoms appeared.

Medical literature on mountaineering has recorded eight uses of the Gamow bag in which seven patients were treated altogether. All of them participated in expeditions to Mount Everest. The highest point at which the chamber has been used was on the Nepalese South Col at 8,004 m. Five physicians have used the chamber and all treatments were successful (3).

In the patient presented here the chamber was used for first time in the history of Croatian mountaineering medicine (6). Again the chamber proved effective in the treatment of AMS.

The main motives for choosing the Gamow bag to equip the 1997 Mount Everest expedition for emergency were its price, simplicity of use, and above all, its portability.

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Sažetak

LIJEČENJE VISINSKE BOLESTI NADTLAKOM

Alpinist obolio na Himalaji na nadmorskoj visini od 7.060 m od teškog stupnja visinske bolesti s izraženim edemom pluća liječen je u laganoj prenosivoj hiperbaričnoj komori u najbližem baznome kampu na nadmorskoj visini od 6.050 m. Liječenje u prenosivoj hiperbaričnoj komori nazvanoj "Gamowova vreća" (engl. *Gamow bag*) trajalo je dva sata pod nadtlakom od 103 mm Hg. Za tlačenje hiperbarične komore upotrijebljen je ambijentalni zrak bez dodavanja kisika. S tim nadtlakom bolesniku se efektivna nadmorska visina od 6.050 praktično snizila na 4.400 m. Tijekom tretmana simptomi i klinički znakovi edema pluća su nestali. Bolesnik se potpuno oporavio silaskom na nadmorsku visinu od 2.000 m. Sugerira se tretman u prenosivoj hiperbaričnoj komori za teže slučajeve akutne visinske bolesti i kao alternativa rizičnomu spuštanju na nižu nadmorsku visinu.

KLJUČNE RIJEČI: *planinarenje, edem pluća, Gamowova vreća, hiperbarična komora*

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