TREATMENT OF MOUNTAIN SICKNESS WITH A STATIONARY HYPERBARIC CHAMBER

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Introduction

Kumtor gold mine is located at 3800-4200m above sea level in Kyrgyz Republic, Central Tien-Shan.

Kumtor mine was not developed during the Soviet Era in view of the many problems related to high altitude mining. Acute Mountain Sickness (AMS) is the most common medical problem at Kumtor
(1,2). A previous study of AMS incidence at Kumtor mine site (3800-4200 M) that was done among workers of the Soviet geological team (1988-1989) revealed AMS in 52.5% of workers.

Treatment of AMS

Treatment of AMS is fully described in high altitude medical articles. AMS and more severe manifestations of altitude illness (HACE and HAPE) are managed by treatment with oxygen, descent, dexamethasone and nifedipine (3, 4). Nevertherless there are some new trends towards prophylactic and treatment of AMS. They are:

1.Oxygenation of the living quarters. There are studies describing oxygen enrichment of the room air up to 28% on altitude. Examples include a few mines and telescope facilities in Chile.
Oxygen may be utilized by means of liquid oxygen supply or use of oxygen concentrators (5, 6, 7).

2.Using hyperbaric chamber with ambient air has been known for many years among climbers. They use portable hyperbaric chambers, which are bags inflated by foot pump, eg. Gamow Bag (8). This system is effective and reliable, but cannot be used among big populations. For example: at Kumtor, the workforce increased substantially from about 1,500 employees in early 1996 to more than 2,300 as the project reached peak construction (9).

Since January 1998 we have been using a stationary multiplace hyperbaric chamber (10) with ambient air (fabricator: Southern Oceanics, South Africa). Hyperbaric treatment has been known for years in surgery, aviation and diving medicine. Our search in the literature revealed no references using *stationary multiplace hyperbaric chambers (SMHC)* for the treatment of AMS. With hyperbaric treatment we can artificially reduce the altitude down to sea level. This enables us to treat most of the effects of altitude exposure, therefore minimizing the need for evacuation of a patient to a lower altitude. Our data shows improve in the results of treatment of AMS and decrease of number of AMS related evacuations from mine site.

Brief technical description:
SMHC looks like a big fenestrated steel container with 4 electrical compressors. There are 6 stationary beds, chair and desk. The patient is able to move, do office

work and communicate through intercom with medical personnel. All monitoring equipment is also available inside (ECG, breathalyzer, etc). Altimeter and manometer on the front panel show altitude and pressure inside the chamber. We set intake flow to 200 L/min, and maintain pressure by regulating the outflow valve to desired level.

Exhaust valve starts automatically as soon as excessive pressure builds up to 400 mbar.

The patient is monitored constantly. Table 1 shows pressures/altitudes ratio inside the SMHC. To prevent patient from AMS recurrence we descend the patient to an intermediate level before discharge.

Table 1: Useful Pressures/Altitudes	
sea level	360 mbar
2000 ft	290 mbar
4000 ft	225 mbar (intermediate level)
6000 ft	160 mbar
8000 ft	100 mbar

Treatment protocol.
We evaluated treatment protocols of 72 pts (both sexes, aged from 22 to 55 yrs) with AMS at Kumtor mine site. Protocol included routine check of vital functions (eg. blood pressure check, pulse rate and oximetry, respiration rate, CBC, ECG) and Lake-Louise Self Assessment Questionnaire (11).

The average session time was 4 hours. The follow-up of patients after 12 and 24 hours was done.

All patients were divided into 3 categories, based on prevalence of certain symptoms:

1. AMS (general: poor sleep, fatigue, no appetite, headache) - 47 pts.
2. HAPE (respiratory) - 16 pts.
3. HACE (cerebral) - 9 pts.

Second and third group basically included patients with clinical signs of high altitude pulmonary and cerebral edema respectively.

We realize that using a hyperbaric chamber is not a new mode of treatment, we have just applied old principles to a modern technique. Anyway, I would be interested to hear other peoples opinion of using stationary multiplace hyperbaric chamber for treatment of AMS.

My particular interest is emergency care (EC) at high altitude mines. Using this opportunity in publishing at the ISMM newsletter I would like to request everybody, who involved in EC to send me their statistics on emergency care at high altitude

mines in the world.

Clinical results and discussion:
1. Complete recovery from AMS - 57 patients.
2. Recurrent AMS after 6 to 12 hours - 9 patients, mostly with neurological manifestation: headache, dizziness etc. These patients received additional treatment with acetozolamide, oxygen, decadron and pain medications.
3. No effect of treatment - 6 patients, all with HAPE (high altitude pulmonary edema confirmed on chest X-ray and ECG). Patients were pressurized in the chamber to sea level with excellent results after 5 to 10 hours stay, but rapidly deteriorated after release.

In terms of side effects, patients have been complaining of temporary ear pain, so they are now educated about equilisation to relieve it. We did not see side effects such as otic barotrauma, excessive carbon dioxide exposure or pulmonary hyperexpansion. No patients had claustrophobia.

Medical evacuations (ME) from mine site.
The main referral center from the mine site is about 6 hours drive by Ambulance. With implementation of the hyperbaric chamber in early 1998 ME were reduced by 50%. In comparison with the last year (12) the ratio of ME/AMS was 87/17 and 57/8 respectively.

Summary
AMS is common problem at altitude. Factors responsible for AMS are: rapid ascent, increased physical activity, congenital absence of right pulmonary artery etc. The illness is managed by treatment with oxygen, descent, dexamethasone and nifedipine. In addition to these methods we also have been using stationary multiplace hyperbaric chamber (SMHC). With SMHC we treat most of the effects of altitude exposure, therefore minimizing the need for evacuation of a patient to a lower altitude.

The treatment itself is harmless, as no artificial gases or chemicals are added. Patients can be assured that they can exit from the chamber at any time if they so wish. There is no maximum time limit for treatment.
Hyperbaric treatment has been a very helpful treatment of AMS and for temporary stabilizing condition of patients with HAPE, when descent is not immediately possible, for instance in poor weather/ road/ transport conditions.

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