**THE INTERNATIONAL MOUNTAINEERING AND CLIMBING FEDERATION**
UNION INTERNATIONALE DES ASSOCIATIONS D'ALPINISME

Office: Monbijoustrasse 61 • Postfach
CH-3000 Berne 23 • SWITZERLAND
Tel.: +41 (0)31 3701828 • Fax: +41 (0)31 3701838
e-mail: office@uiaa.ch

# CONSENSUS STATEMENT

# OF THE

# UIAA MEDICAL COMMISSION

# VOL: 3

## Portable Hyperbaric Chambers

Intended for Doctors, Interested Non-medical Persons and Trekking or Expedition Operators

**Th. Küpper, U. Gieseler, J. Milledge**

**2008**

## Introduction

Portable hyperbaric chambers are designed as lightweight equipment to be used for emergency treatment of severe cases of acute mountain sickness (AMS), high altitude pulmonary oedema (HAPE), and high altitude cerebral oedema (HACE). The devices must be inflated or pressurized by hand or foot pumps. The mechanism of action is a rapid pressurization of the patient (increase of oxygen pressure) which simulates a rapid descent of about 1500 to 2500 m.

## Principles and Safety Management Concerning High Altitude Diseases

- Prevention of altitude diseases is the “Gold Standard”!
    - Prevention is better than the best treatment!
    - Plan for good altitude profiles giving adequate acclimatization!
- Hyperbaric chambers should not be used in cases of mild AMS (prevention or treatment)
    - It slows down acclimatization!
- There is no doubt, that hyperbaric chambers relieve symptoms of severe altitude diseases (AMS, HAPE, HACE)
    - But it does so only for a while.
        - Use that time to retreat from altitude!
        - Be careful to avoid rebound in severe cases! It is preferable that the patient should not walk – not even for a short distance – unless it cannot be avoided for descent and he / she is as exertion-free as possible.
    - It is a procedure for emergency treatment only!
        - It is not a substitute descent or evacuation to lower altitude.
- The strategy in case of severe altitude disease should be as follows:
    1. Descent or evacuation to lower altitude, at least to the altitude where the patient felt well before.
    2. Oxygen / drugs (must be combined with 1.)
    3. Hyperbaric chamber (must be combined with 1. & 2.)
    4. Drugs only (in case that 1.-3. should be impossible)
- Preconditions of the personnel using the chamber:
    - Only trained persons should use the chamber! Severe complications (e.g. severe hypercapnia, eardrum rupture etc.) were reported after use by incompetent persons.
    - A chamber demonstration exercise, followed by all group members performing this exercise under experienced supervision, should be undertaken before ascent.

- Handling a hyperbaric chamber is very strenuous, especially at high altitude. Therefore the upper limit for its use may be at about 7000 m. Above this, treatment with oxygen and drugs is preferred.

**Where to take a hyperbaric chamber?**

- There is no data that supports the belief that a hyperbaric chamber must be carried on each trip at altitude, especially on each commercially organized tour. There are no laws which require chambers, and nor is there any related litigation to date.
- A portable hyperbaric chamber should be especially considered when visiting a high altitude area without a quick and easy possibility of descent to lower regions or the possibility of evacuation by helicopter.
    - It should be considered, for instance, for camps situated in a saddle or valley at high altitude, where a descent is impossible without an ascent.
    - If a chamber is to be taken, normally its position is best at the highest camp for at least two reasons:
        1. The incidence of altitude induced health problems is more likely there, and
        2. Transporting a chamber down to a lower camp is much easier and quicker than ascending with the chamber to a high altitude camp. But this decision is influenced by many other factors and must be integrated into the expedition's safety management.

**How to use hyperbaric chambers**

- Hyperbaric chamber treatment should be performed as follows:
    - Combine with drug therapy (dexamethasone for severe AMS / HACE, nifedipine slow release for HAPE)
    - Check the patient's ability to pressurize his / hers ears before entering the chamber! ENT problems are common at altitude. Inflate slowly and check whether the patient pressurizes the ears (if not: slow down!).
        - If the patient reports ear problems to the pressurized chamber use decongestant spray before entering the bag, wait 5 –10 min until the onset of the spray's effectiveness takes place, and take the spray into the bag.
    - Patients should urinate or defecate before entering the chamber (if necessary).
    - Position patient in chamber so they can see you and you can see the patient's pulse oximeter (if applicable).
    - Patients should be instructed to breathe normally inside the chamber and to "pop" their ears while the chamber is inflated. In case of problems with pressure equalizing of the ears take decongestant nasal spray before inflating the chamber (e.g. Xylometazolin Spray).

  - Pressurize for 60 to 120 minutes. After 120 minutes no further improvement can be expected. For pressurization pump the bag until the pop-off valve hisses.
  - Always take care to pump permanent additional air into the pressurized chamber (about 40 l/min, rsp. pump 8 – 12 times / min)! This does not only provide constant pressure but also high oxygen and low carbon dioxide partial pressure to avoid $CO_2$ intoxication.
  - Survey the patient's $SaO_2$ with pulse oximeter (if available). The device should be visible through the bag's window.
  - HAPE patients may not be able to tolerate lying down in a flat body position. Use the terrain to support their body at an angle of about 30° with their head uphill.
  - In severe cases additional oxygen breathing inside the chamber at a flow- rate of 4 – 6 l/min from a bottle inside the bag may further improve the symptoms (inside the chamber this causes no danger of fire or explosion).
  - If symptoms are reduced after 60 to 120 minutes, try to descend. Take the hyperbaric chamber with you for an additional chamber session in case the symptoms should worsen again!
  - If symptoms are not reduced after 120 minutes, complications or additional diagnoses must be considered (thromboembolism, infection, sunstroke, hypothermia, severe dehydration, and others).
  - In case of doubt, treatment with hyperbaric chamber can be tried, because there is no contraindication except situations of resuscitation.
  - Unconsciousness is not a contraindication if the body position is appropriate (recovery position).
  - If the patient reports pressure or pain inside the ears while deflating the chamber, slow down immediately.
- Therapy with oxygen and drugs is always preferred, especially in the case of unconsciousness (easier to perform and better patient survey).
  - **Note:** The amount of oxygen available is limited whereas the use of the hyperbaric chamber is only limited by the human power to pressurize and to ventilate it!
- Ensure a comfortable temperature!
  - Always insulate the chamber from ground, cold or frozen surfaces! In cold environment the patient must be insulated from cold inside the chamber by sleeping bag or clothes.
  - Do not use down clothes to insulate the patient inside the chamber. Because of the high humidity inside the bag. Fleece material should be preferred.
  - Avoid direct sunshine or provide shadow! Sunshine may heat the chamber significantly to very uncomfortable conditions.

- In case the chamber should suddenly deflate by accident, the patient should exhale and avoid breath holding.
- Always keep in contact with the patient! Inside the bag it may be psychologically stressful. The patient should know always what is happening around or with him or her.
- Ensure an adequate supply of fresh air. Do not use the bag inside closed tents, especially if stoves or fuel fired lamps are used there.

**Results of treatment / further proceeding**

- Controlled and uncontrolled studies show a rapid and – in most cases – a decrease of symptoms which lasts for some hours.
- However, when staying at altitude, most patients will suffer from a rebound, in most cases within 12 hours.
- To date, there is a lack of controlled studies of severe cases of HAPE or HACE, but field results coincidentally show good results even in severe cases.
- After some days of complete recovery a careful re-ascent can be tried (e.g. [1].
    - Take care for perfect acclimatization. The altitude profile should be more “defensive” than it was before.
    - Monitor any symptom of altitude disease and descent immediately to the last altitude where you felt completely well if symptoms should arise.
    - Never re-ascent while taking any drugs which may mask symptoms of altitude disease

**Problems with hyperbaric chambers**

- $CO_2$-intoxication may result from low airflow
    - Ensure adequate ventilation of the chamber (>40 l/min, see above)!
- AMS / HACE: nausea and vomiting inside the bag.
    - Take a plastic bag inside the chamber
    - Anti-emetic drugs may be used before entering the chamber
- HAPE: patients may not tolerate flat position.
    - Use the terrain to put the upper body in elevated position
- Anxiety / claustrophobia
    - Keep in permanent visible and auditable contact with the patient
    - Place the bag and the patient in a position that the patient can look outside at any time and in a comfortable position.

    - Try to explain him / her that the situation may be psychologically uncomfortable for a while, but altitude disease may be life threatening. This means: the chamber is the better one of two options.
- Pumping requires a considerable effort at altitude to maintain pressure and airflow.
- Leakage of the zipper, valves, or the bag itself
    - Carry the chamber with care and handle it properly.
    - Test the bag before every trip
    - Take duct/gaffer tape for repairs

**Types of chambers**

- GAMOW Bag
    - Cylindrical shaped, 2.5 x 0.6 m
    - Inflation / ventilation by foot pump
    - 12 pump strokes / min required to maintain pressure (+104 mmHg / +139 mbar) and to avoid $CO_2$ intoxication
    - Weight: 6.5 kg
    - Not easy to enter by a severely ill patient.
    - For details about costs etc. see www.chinookmed.com
- CERTEC Bag
    - Conical shaped, 2.2 x 0.65 m
    - Inflation / ventilation by hand pump
    - 8 pump strokes / min required to maintain pressure (+165 mmHg / +220 mbar) and to avoid $CO_2$ intoxication
    - Weight: 4.8 kg
    - Of all constructions this is the easiest to enter by a severe ill patient
    - For details about costs etc. see www.certec.eu.com
- Portable Altitude Chamber (PAC)
    - Mummy shape, otherwise (pressure / pumping) comparable to GAMOW bag (no pressure gauge).
    - Weight (incl. pump etc.) 8 kg
    - Entering the bag may be difficult for a non-cooperative patient.
    - For details about costs etc. see www.trecsafe.com.au
- TAR helmet (not yet available, but may be an alternative in future)
    - Small lightweight device (complete system less than 1 kg, pump included), under development (prototypes successfully tested).

- Since there are not yet sufficient data available, UIAA MedCom decided to wait before including a statement about the system.

## References

1. Litch, J.A. and R.A. Bishop, *Reascent following resolution of high altitude pulmonary edema (HAPE).* High Alt Med Biol, 2001. 2(1): p. 53-5.

**Members of UIAA MedCom** (in alphabetical order)
C. Angelini (Italy), B. Basnyat (Nepal), J. Bogg (Sweden), A.R. Chioconi (Argentina), S. Ferrandis (Spain), U. Gieseler (Germany), U. Hefti (Switzerland), D. Hillebrandt (U.K.), J. Holmgren (Sweden), M. Horii (Japan), D. Jean (France), A. Koukoutsi (Greece), J. Kubalova (Czech Republic), T. Kuepper (Germany), H. Meijer (Netherlands), J. Milledge (U.K.), A. Morrison (U.K.), H. Mosaedian (Iran), S. Omori (Japan), I. Rotman (Czech Republic), V. Schoeffl (Germany), J. Shahbazi (Iran), J. Windsor (U.K.)

## History of this recommendation paper

The first edition was written by P. Baertsch, F. Berghold, J.P. Herry, and O. Oelz (2000). During the same year it was modified by J. Milledge. At the UIAA MedCom Meeting at Snowdonia in 2006 the commission decided to update all their recommendations. The version presented here was approved at the UIAA MedCom Meeting at Adršpach – Zdoňov / Czech Republic in 2008.