MANAGEMENT OF SERIOUSLY ILL PATIENTS IN THE HYPERBARIC CHAMBER.

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SUMMARY

Some of the diseases included in the generally accepted indications for HBO concern patients in extremely serious and critical situations, that can only be dealt with in a well-trained, hospital-based hyperbaric facility. This is especially the case in type II decompression sickness, arterial gas embolism of the brain, gas gangrene and serious carbon monoxide poisoning. In these diseases, the patient can be seen with a clinical picture of acute respiratory failure, hemodynamic instability, hypovolemia, cardiac arrythmias and neurogenic, toxic and/or cardiogenic shock. In these situations hyperbaric treatment alone does not resolve the emergency situation and in some cases HBO can even be contraindicated. The very important intensive-care treatment these patients receive needs to be continued during hyperbaric oxygen treatment inside the chamber.

This paper reviews the problems in performing correct volumetric or manometric mechanical ventilation inside the chamber, blood transfusions and/or administration of vasoactive substances, control and surveillance of infectious diseases and coordination between the surgical and anaesthesiological procedures the patient may require as often happens in patients with gas gangrene. Problems concerning the medical and nursing staff are also discussed, since these persons are often obliged to stay under pressure. Therefore they need combined training in diving and hyperbaric medicine and in critical care.

KEY WORDS

Intensive care, hyperbaric oxygen therapy, nursing, artificial ventilation, decompression procedures.

INTRODUCTION

Management of seriously ill patients in a hyperbaric medical center can present problems that are sometimes difficult to solve. These problems can be divided into three different categories:

1. The patient him/herself.
2. Medical and nursing staff.
3. Interaction with other hospital activities.

METHODS AND DISCUSSION

1. PROBLEMS RELATED TO THE PATIENT IN THE HYPERBARIC ENVIRONMENT.

Patients with serious diseases in the category "accepted indications" for hyperbaric treatment often suffer from respiratory insufficiency, hemodynamic instability and unconsciousness.

The following measures are then necessary:

a. Intravenous infusion of fluids and vasoactive substances.
   Venous, preferably central venous, and arterial access surgery are necessary. Plastic bags with fluids instead of glass bottles have to be used. Sometimes rapid intravenous infusion is impossible due to the in-chamber pressure. During compression and decompression the infusion rate has to be checked carefully.
b. Blood and plasma infusions.
   In some diseases such as gas gangrene it is advised not to transfuse too much blood in the beginning. Since this is a hemolysing disease, more blood leads to increased hemolysis. The diminished oxygen transport by the anaemia is solved by the increased solubility of oxygen in the blood at higher pressures.
c. Urine catheters.
   These do not raise special problems as long as the balloon is insufflated with fluid and not with air. Also here, special attention during compression and decompression is required.
d. Endotracheal intubation.
   Patients with respiratory insufficiency requiring artificial respiration should be intubated outside the chamber since this is easier than inside the chamber. It can be impossible in a monoplace chamber. Again the balloon has to be filled with fluid and not with air. One has to remember that ganglionic blockers have a shorter half-time when under pressure so that they have to be given more frequently than at sea-level. This can affect the acid-base balance and aggravate hypotension.
e. Blood gas analysis and acid-base equilibrium.
   In most hyperbaric centers blood gases have to be determined outside the chamber so that necessary corrections have to be applied for the pressure. CO_2-, pH- and bicarbonate-values need no corrections. Blood has to be taken as carefully as possible without any air in the receptacle in order to avoid "decompression sickness in vitro".
f. Transcutaneous oxygen measurements.
   Direct blood gas studies can never be replaced by transcutaneous gas measurements. The most reliable method in our experience to notice any failure in the naso-facial

mask or the helmet, and to predict insufficiencies in the mechanical ventilation, is the infra-clavicular implantation of a Clark electrode for tissue oxygen measurements.

g. Mechanical ventilation.
   Most conventional respirators do not work properly under pressure. We use the standard Dräger Oxylog and the Bird respirator. The Oxylog is a volumetric and the Bird a manometric repirator. When using the Oxylog both volume and frequency have to be increased with increasing chamber pressure (Fig. 1, 2 and 3). Since the Bird respirator maintains an initial set tidal volume also under pressure, this has to be corrected with increasing pressures as well. The Bird when installed is relatively easy to use. Its greatest disadvantage is its complex installation inside the chamber due to the complicated air connections.
h. Monitoring apparatus.
   All the necessary apparatus can be installed outside the chamber and through trans-wall connectors connected to the patient. Outside staff can control the readings.
j. Defibrillator.
   Special defibrillators for use under pressure are available.

2. PROBLEMS RELATED TO THE MEDICAL AND NURSING STAFF.

Some diseases, especially decompression sickness, require long treatments. If these patients need intensive-care treatment inside the chamber, the medical and nursing staff has to accompany them and stay inside the chamber at the same time. If repeated treatments within 24 hours are necessary, other staff members have to accompany these patients. A hyperbaric center therefore needs numerous and highly skilled medical and nursing staff. If the staff is not breathing oxygen, very long decompression times are necessary to bring them back to the surface.

Two possible strategies can prevent this:

a. The staff can breathe the same gas as the patient, e.g. pure oxygen or heliox.
b. Different teams have to work with one patient in order to minimize the time under pressure for the staff. Both possibilities have their advantages and disadvantages.

3. PROBLEMS RELATED TO INTERACTIONS WITH OTHER HOSPITAL ACTIVITIES.

a. Desinfection, asepsis and antisepsis.
   If the hyperbaric chamber is used for diving operations or for treatment of decompression sickness with the long air tables, problems with hygiene will arise. Some people think that in cases of gas gangrene special measures are necessary for infection prevention. Since, however, the condition of the wound is far more important than the presence of the Clostridium this is not the case. Normal cleaning procedures are enough for the hyperbaric chamber.
b. Coordination of actions.
   Close cooperation between the hyperbaric staff and other hospital staff is necessary when the patient, as in cases of gas gangrene, needs more than one treatment in 24 hours and also debridement and other surgical care in-between.

CONCLUSIONS

Extremely critical patients test the working and organizational capacity of a hyperbaric center and the hospital where the chamber is located. Besides very accurate hyperbaric treatment, special intensive care and surgical care is required as well. All procedures normally performed in the ICU have to be performed inside the hyperbaric chamber as well. All this requires a highly skilled and specially trained medical and nursing staff.

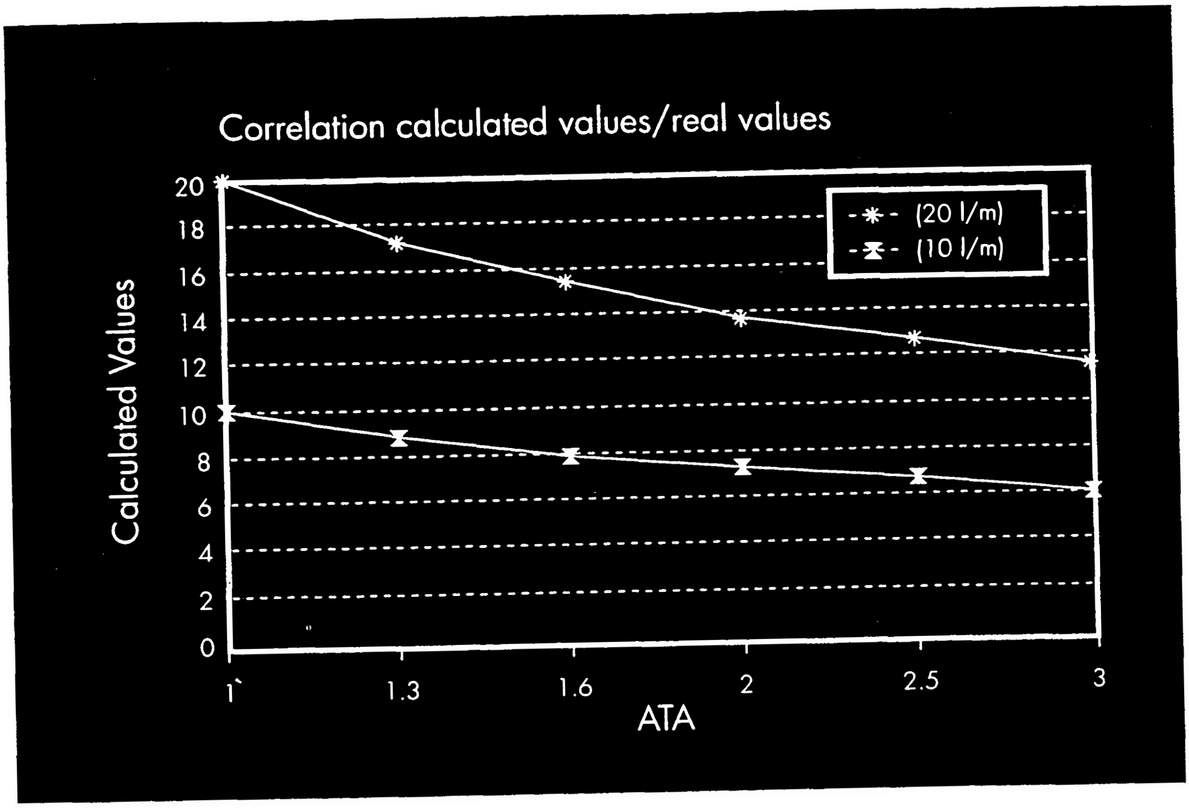

Figure 1: Variation in volume/minute of the Oxylog with increasing pressure.

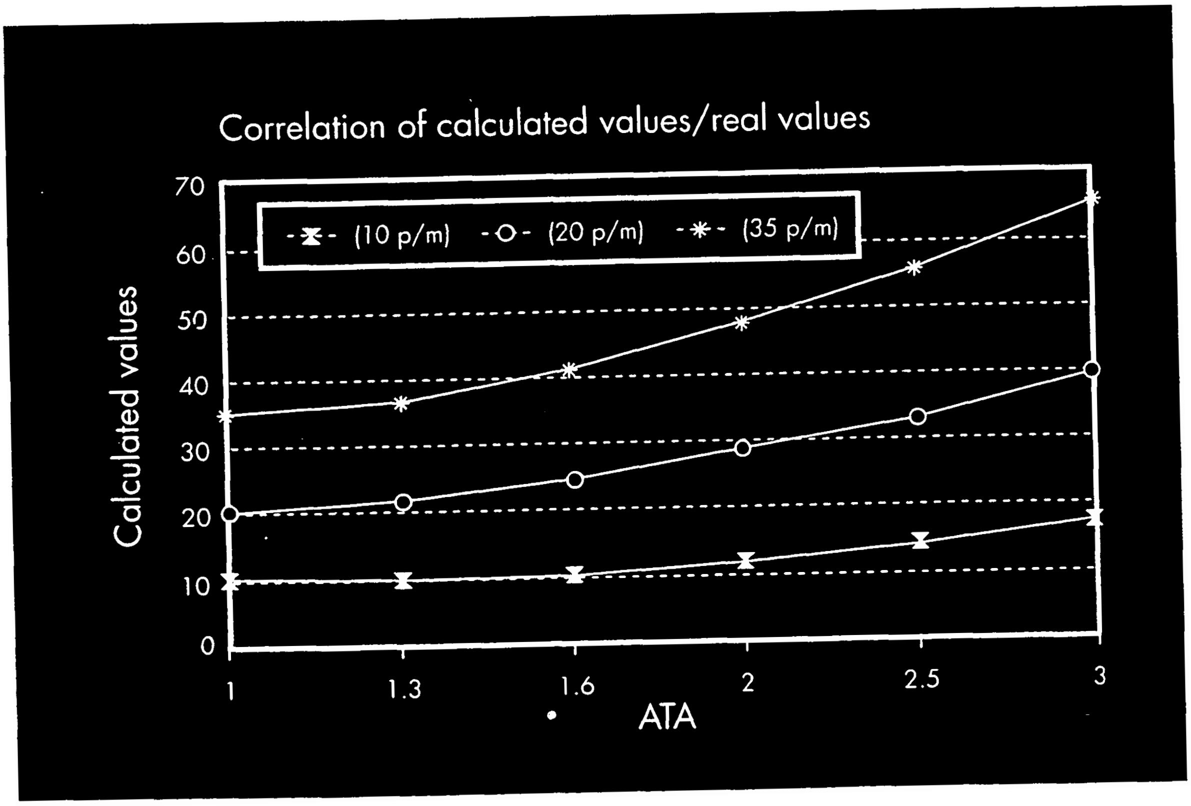

Figure 2: Variation in frequency of the Oxylog with increasing pressure.

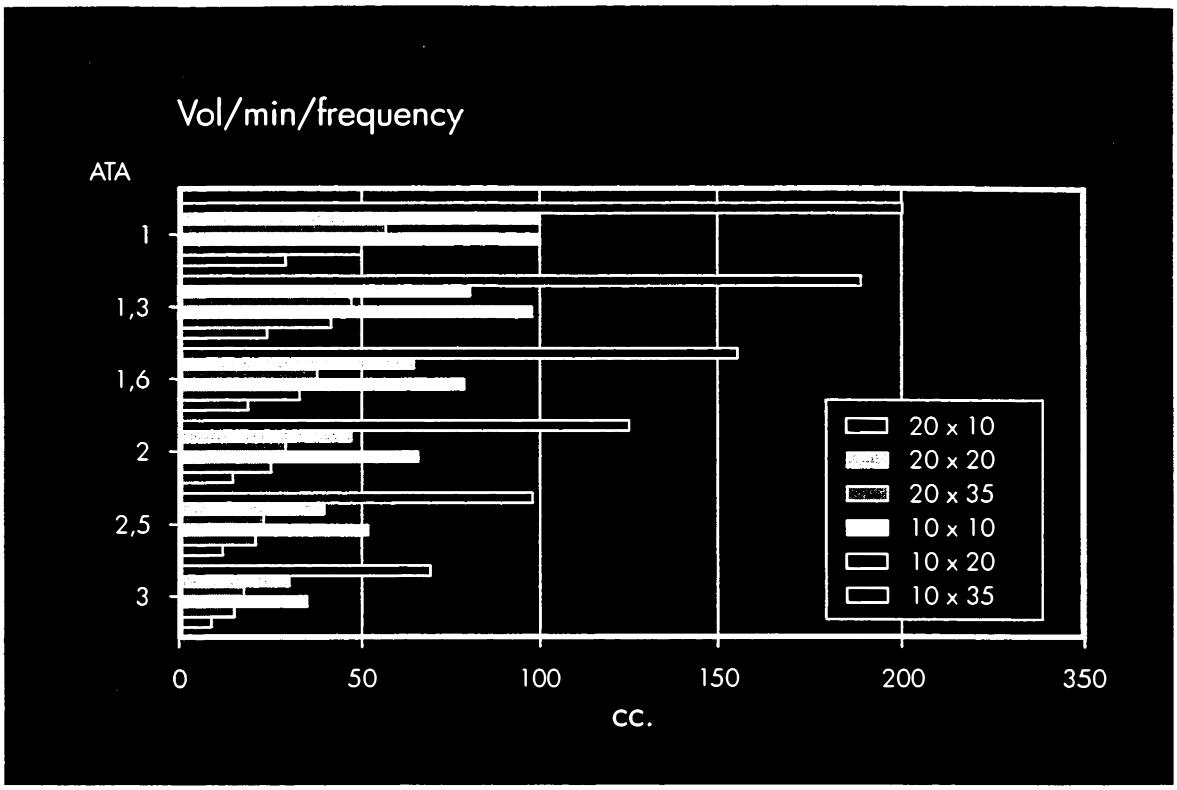

Figure 3: Variation in tidal volume of the Oxylog with increasing pressure.

HYPERBARIC MEDICINE PROCEEDINGS

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