

# Staffing and training issues in critical care hyperbaric medicine

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## Abstract

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The integrated chain of treatment of the most severe clinical cases that require hyperbaric oxygen therapy (HBOT) assumes that intensive care is continued while inside the hyperbaric chamber. Such an approach needs to take into account all the risks associated with transportation of the critically ill patient from the ICU to the chamber and back, changing of ventilator circuits and intravascular lines, using different medical devices in a hyperbaric environment, advanced invasive physiological monitoring as well as medical procedures (infusions, drainage, etc) during long or frequently repeated HBOT sessions. Any medical staff who take care of critically ill patients during HBOT should be certified and trained according to both emergency/intensive care and hyperbaric requirements. For any HBOT session, the number of staff needed for any HBOT session depends on both the type of chamber and the patient's status – stable, demanding or critically ill. For a critically ill patient, the standard procedure is a one-to-one patient-staff ratio inside the chamber; however, the final decision whether this is enough is taken after careful risk assessment based on the patient's condition, clinical indication for HBOT, experience of the personnel involved in that treatment and the available equipment.

## Key words

Hyperbaric oxygen treatment, intensive care medicine, education, training, qualifications, safety, review article

## Introduction

Conducting a hyperbaric oxygen treatment (HBOT) in intensive care (IC) mode is a basic requirement for ensuring the continuation of the treatment of the most severe cases. When taking into account the time burden related to HBOT for at least some indications, patients may spend up to 30–40% of a day away from the intensive care unit (ICU) in the chamber or being transported to and fro (Table 1).

Treating ICU patients in a hyperbaric chamber is a clinical challenge that needs to take into account the risks associated with transportation of the critically ill patient from the ICU to the chamber and back (intra- or inter-hospital transportation), changing of ventilator circuits and intravascular lines, using medical devices in a hyperbaric environment, advanced invasive physiological monitoring, as well as continuation of intensive treatment (drugs, fluid therapy, drains, etc.) during long or frequently repeated HBOT sessions. This is a fairly straightforward therapeutic routine for those hospital-based hyperbaric centres which have frequent experience conducting such sessions. For example, of all

ICU patients referred for HBOT, 80% would receive about six intensive care HBOT sessions (e.g., necrotizing soft-tissue infections) and 20% would have had two sessions (e.g., carbon monoxide (CO) poisoning, decompression illness), the weighted mean per ICU patient would be approximately five sessions. There are no hard data but, to be recognised as well-experienced, a hyperbaric centre should treat about 70 ICU patients for approximately 350 HBOT per year. However, if the hyperbaric staff are ICU-trained and keep working in an ICU, about 20 ICU patients for 100 sessions per year should be sufficient to maintain competence. For others, including stand-alone hyperbaric centres, that treat mostly elective, chronic and stable patients, an IC HBOT session, either for severe emergency patients or standard intensive care patients, can be a clinical nightmare.

The risks associated with inter-hospital transportation of critically ill patients have been identified as those related to equipment (technical factors), the transport team (human factors), indications for and organization of the transport (collective factors) and the patients themselves (including clinical stability).<sup>1</sup> Preventive measures for increasing

**Table 1**

Time of a day spent during HBOT for intensive care patients for different clinical indications: COP – carbon monoxide poisoning; NSTI – necrotising soft-tissue infections; DCI – decompression illness

Condition	Sessions per 24 h	Duration of HBOT session (h)	Transportation for hospital-based facility (h)	Transportation for stand-alone facility (h)	HBOT total time per 24 h (h)
COP	2	2	2 x 0.5	2 x 1	5–7
NSTI	3	2	2 x 0.5	2 x 1	7–8
DCI	1	5–8	2 x 0.5	2 x 1	5–10
Other	1	2	2 x 0.5	2 x 1	3–4

safety of the transportation of the critically ill have been proposed, including: the competence and experience of the teams, efficiency (indications and risk-benefit analysis), stabilization and preparation of the patient prior to transportation, anticipation, organization and planning, dedicated transport equipment, standardization of procedures and protocols, including the use of check lists.

During a one-month prospective observation of 3,444 HBOT sessions conducted in eight European hyperbaric centres, the overall incident rate during HBOT sessions, including transport to and from the referring unit, was approximately ten times greater for sessions with IC modalities compared to elective HBOT sessions (18.6% versus 1.5%). This was not related predominantly to patient problems (55.6% vs. 86.3% respectively), but more to device problems (33.3% vs. 5.9% respectively).<sup>2</sup> Fortunately these incidents led to interruption of treatment in only a small proportion of incidents (5.6% vs. 7.8% respectively), and there was no statistically significant difference in the rates of clinical consequences (27.8% vs. 13.7%).

Standardized checklists for IC HBOT have been proposed recently.<sup>3</sup> To accept intensive care patients and assess their risk-benefit and clinical indication for HBOT, the necessity for either inter- or intra-hospital transportation must be taken into account, as well as the technical capabilities of the facility (e.g., mono- or multiplace chamber), its medical equipment, and the experience of the hyperbaric staff.

The two most important questions concerning medical, nursing and technical staff and their training are the numbers needed for an IC HBOT and how they should be trained?

### Training

The first consideration is how the medical staff who take care of critically ill patients during HBOT should be trained. In Europe at present, there are only two documents referring to this issue. One is ECHM-EDTC Educational and Training Standards (ETS) published in 2011<sup>4</sup> and the other is the EBAss-ECHM Resources Manual (RM) on Education of Nurses, Operators and Technicians in Hyperbaric Facilities in Europe published in 2008.<sup>5</sup>

In the ECHM-EDTC ETS document, which refers to physicians only, there is a requirement that the Hyperbaric Medicine Physician (so called Level 2H) should have appropriate experience in anaesthesia and intensive care in order to manage the HBOT patient, but there is no requirement to be a certified specialist in either to be in compliance with the standards. The appropriate experience is defined as at least six months' work as a medical intern in an intensive/critical care unit. In fact, this clinical experience is enforced by the additional requirement of at least six months' work as medical intern in an approved hyperbaric centre, where this term includes the requirement of having the capability to treat all clinical indications according to

the ECHM list of indications in all patients, including those needing intensive care. In the list of theory modules for the hyperbaric medicine course, there is no specific module related exclusively to ICU patients. However, in several modules there are training objectives requiring that the hyperbaric medicine physician should know the treatment hazards for ICU patients and have the ability to transfer an ICU patient into the chamber with all necessary monitoring and therapeutic equipment.

However, in at least some European countries, the physician providing hyperbaric intensive care must be a registered specialist in this field or at least be able to clinically support such patients during transportation, e.g., a specialist in emergency medicine. This requirement, which is stricter than the ECHM-EDTC guidelines for hyperbaric medicine, can easily be met by hospital-based hyperbaric medicine facilities. However for stand-alone centres, this requirement can be a limiting factor, even if they are functionally linked to general hospital services. In such situations, hyperbaric staff certification and training could be a determining factor in referring a patient to the hyperbaric facility.

In the EBAss-ECHM Resources Manual for non-physician staff, there is a specific module – Hyperbaric Nursing for Intensive Care – dedicated exclusively to registered nurses, who are allowed by national regulations to take care of intensive care patients. This module lasts 40 hours with eight hours of theory and 32 hours of practical training and covers all aspects of conducting IC HBOT sessions. There is no specific module for operators for IC HBOT sessions.

### Staffing

There are no prospective studies validating guidelines for the number of patients that can be managed by a single attendant in a multiplace chamber or for the number of monoplace chambers being operated by one hyperbaric operator at the same time. A general guideline can be proposed, depending on both the type of chamber and the patients' status – stable, demanding or critically ill (Table 2). The standard procedure is for a one-to-one patient-staff ratio for a critically ill patient inside the chamber for both multiplace and monoplace chambers.

If the patient's condition has been assessed and stabilized before starting the HBOT session, the clinical burden during a 243–284 kPa for 60–90 min, or an extended schedule up to 608 kPa for 5–8 hours can be fully met by one person. This fulfills the European criteria of having continuous, one-to-one nursing care for the sickest patients (so-called Level 3, Intensive Care Society levels of care).<sup>6,7</sup> The decision as to whether the attendant is a nurse or a physician depends on the current patient's status, previous HBOT sessions, if any, the skill of the attendant and local policy for attendants. If the attendant is a nurse, there must be a trained physician capable of entering the chamber immediately in case of an emergency.

**Table 2**

Required number of personnel (chamber operators, internal medical attendants and hyperbaric physicians) for hyperbaric sessions

Type of chamber	Staffing requirements	Patient condition		
		Stable	Demanding	Critically ill
Monoplace	Chamber operators per chambers	1:3	1:2	1:1
Monoplace	Hyperbaric physician per facility	1	1	1
Multiplace	Chamber operators per chambers	1:1	1:1	1:1
Multiplace	Internal attendants per patients	1:12	1:5	1:1 or 2:1
Multiplace	Hyperbaric physician per facility	1	1	1 or 2 *

\* Second physician in the facility can be requested if the first must enter the chamber and stay for any length of time (see text for explanation)

On rare occasions the patient may need to be attended inside the hyperbaric chamber by at least two staff members, a physician and a nurse. Such situations include those sessions during which the clinical burden is overwhelming for one person. This can happen for example during emergency indications for HBOT, like carbon monoxide intoxication, when time to start the session matters and the patient's status quickly improves during HBOT. Because this improvement in general status can coexist with a transient period of confusion concerning time and place or even a delirious state, heavy sedation or conversion to general anesthesia while under pressure may be necessary. Alternatively, but generally not desirable, could be partial discontinuation of intensive therapy, including extubation, during the HBOT session. In both situations one staff member may find it difficult to control the patient's behaviour within the confined space of the hyperbaric chamber. If there is any need for the hyperbaric physician to enter the chamber for any emergency situation and stay there for an extended time, another hyperbaric physician should be summoned to supervise the session. Whatever the local policy for such cases, it should be clearly stated in the standard operating procedures. In some countries, there is also a requirement that artificial ventilation must be directly supervised by a respiratory therapist (or equivalent), which means additional personnel inside the hyperbaric chamber.

In some hyperbaric facilities there are also operating procedures that allow remote attendance of the intensive care patient inside the hyperbaric chamber by medical personnel outside the chamber. The intent is to decrease the decompression burden of the medical personnel and is based on the similarity to those medical procedures that preclude direct presence of medical personnel, e.g., MRI scanning. Because of lack of direct supervision and the inability to perform an immediate action in case of need, this is not a preferred method.

Theoretically, in certain circumstances when ordered by a specialist experienced in both intensive care and hyperbaric medicine, it could work after fulfilling several requirements. First, compression and decompression are conducted in direct attendance mode, which means that the patient attendant leaves the chamber only once the

treatment pressure has been reached and after control of respiratory and haemodynamic parameters; this should not be the first HBOT session for the patient, so that ventilator settings have been correctly established and the patient's condition was stable during previous sessions and before this particular session. Second, the patient is fully sedated, anesthetized or sometimes even paralyzed in order to avoid any unexpected movement leading to disconnection either of the ventilator circuit or intravenous/intra-arterial lines. Third, full monitoring of physiological parameters, including oxygenation and carbon dioxide levels, must be available. Finally, there is a staff member present who is able to immediately enter the hyperbaric chamber. The term 'immediate' means equivalent to the time required within the ICU. From this list of requirements, it is clear that, in practice, it is virtually impossible for most hyperbaric centres to ensure the safety of an intensive care patient left alone in a multiplace chamber. Even the advantage of decreased decompression burden for one medical attendant will be lost by necessity of ensuring several fast compressions for other staff members.

In all cases of critically ill patients being treated with HBOT, the decision on number and position of the hyperbaric staff member taking care of the patient while they are in the chamber is left to the physician's discretion after careful risk assessment that takes into account the patient's condition, clinical indication for HBOT, experience of the personnel involved in that treatment and the available equipment. In order to make decisions simpler, every HBOT centre that treats critically ill patients must develop their own local policies for conducting such sessions.

### Conclusion

The number of available trained hyperbaric staff and their experience is an important factor in estimating the risk/benefit balance for the intensive care patient and their clinical indication for HBOT. Mono- or multiplace hyperbaric centres that treat emergency and critically ill patients should have at least one physician certified either in emergency medicine or intensive care and trained in hyperbaric medicine.

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