

Indications for HBOT in Civilian and Military Context: The HFM-RTG192 Report

Dr Peter GERMONPRE
Med LtCol
Centre for Hyperbaric Oxygen Therapy - Brussels
BELGIUM

peter.germonpre@mil.be

CHAPTER I. INTRODUCTION

In January 2009, a Exploratory Task Force was formed (HFM-ET-099) with the goal to prepare RTG on Hyperbaric Oxygen Therapy in the Military Setting. This RTG would assemble a group of experts from the nations to share national practices in Hyperbaric Oxygen Therapy (HBOT); to compare medical procedures in order to obtain a common therapeutical pathway for patients. Each participating nation's capabilities in terms of intensive care treatments and ancillary (supportive) treatments would be evaluated. A short-term exchange of hyperbaric personnel would be organized in order to ensure acquaintance with common procedures.

RATIONALE FOR THE RTG

Recognising the differences in HBOT practice in civilian centres within Europe and the US, and recognising the unique position of military experts in HBOT to act as independent, non-commercially oriented specialists in HBOT, it was considered useful to ensure that HBOT could be offered to military personnel injured during military operations, in an optimal and standardised fashion, making use of available resources (i.e. evacuation means and HBOT centres) rather than creating new ones.

The goals of the initial Task force were summarise

- the medical capacities of the hyperbaric system used in participating countries
- the medical expertise with regard to supportive treatments (ICU, medical specialities, rehabilitation treatment,...)
- the technical capabilities of the hyperbaric system used in participating countries
- a comparison of SOP in participating countries
- a harmonisation of SOP's toward a common standard of treatment
- an inventory of evacuation and treatment capabilities of each participating nation

Finally to result in a proposal of a common "evacuation and treatment policy" for optimal use of hyperbaric oxygen therapy in the treatment of wounded (military and associated) personnel from NATO countries, minimizing transit and "time to treatment".

HFM-ET-099

The first meeting of HFM ET-099: “Optimal use of hyperbaric oxygen therapy in military medical facilities”, took place in Brussels, on Dec 11-12, 2008.

Participants from the following countries were present:

- Belgium
- Germany
- Portugal
- Czech Republic

Each country presented information on the current state of affairs of Hyperbaric Oxygen Therapy (HBO Therapy) in their country and presented the existing military hyperbaric structures, its operational use and its mode of operation.

During the discussions, there appeared that in each country, based on international consensus documents, the possible uses of HBO Therapy in military pathologies are considered; however, treatment of military personnel is not frequently undertaken owing to logistic and organizational restraints. Also, it appeared that standards of operation and maintenance are not harmonized among the different countries – although all centres maintain a high level of quality assurance, there are many areas where improvements and harmonisations can be achieved. In order to ensure an optimal use of HBO in support of combat injuries, a multinational approach to evacuation and treatment is needed.

The following key issues were identified:

- NATO countries’ military HBO centres should adhere to comparable indication and treatment plans for HBO therapy, based on Evidence Based Medicine guidelines whenever possible, on Practice Based Medicine guidelines in other cases
- Because expertise in specific pathologies (e.g. burn injuries, diving decompression injuries, complex surgical trauma,...) cannot be expected to be present in each of the hospitals where a military HBO centre is located, an inventory of these specific competencies needs to be made and incorporated in a global evacuation and treatment plan. This plan should aim at selecting the optimal treatment facility for any given patient, on the European territory, and minimizing transit times and “time to treatment”
- Harmonisation in technical equipment and procedures, and common process approval policy is needed in order to ensure optimal quality of treatment all along the “treatment trajectory” of the patient – possible moving from one centre to another. Active participation in European Normalisation Panels may be desirable in order to ensure appropriate consideration of military requirements
- Continuous efforts will be needed to improve the evidence base for HBO indications, by joint research projects and amplification of the patient numbers. It will be necessary to develop common case reporting databases.

- In order to increase the medical efficiency and exchangeability of HBO protocols and treatments, short-term personnel exchange, both medical and technical, may be proposed. Harmonisation of the training and continuous education of each category of HBO centre personnel is needed.

HFM-RTG-192

The works of this ET resulted in the creation of a RTG-192, tasked to propose an Action Plan aimed at optimisation of Hyperbaric Oxygen Therapy as an integrated part of military medical care in operational NATO context. An inventory of each participating nation's capabilities in terms of diving medicine, HBO, intensive care treatments and ancillary (supportive) treatments would be made, and all relevant aspects of the evacuation and treatment chain will be examined and evaluated.

Based on this analysis, the RTG would produce recommendations for harmonization, both in the field of indications, treatment protocols, technical and safety procedures, personnel training and strategic medical evacuation planning (SMEP). For each of these aspects, practical propositions will be formulated.

Participants in RTG-192 were the initial countries of the ET-099, expanded with USA and Turkey. Interest was expressed by Slovenia, Tunisia, Spain and Canada, but their participation did finally not take place.

Over the course of 4 meetings, recommendations were made as to

- Which indications should be considered “military” indications. It was recognised that even if HBOT has many “non-urgent” indications (see below) these should not be considered a priority in the context of military operations.
- How and with which urgency an evacuation towards a suitable HBOT centre should be sought, if any
- Which is the accepted optimal treatment regimen for each of those indications
- What are the criteria for hospitals and HBO centres to be considered in the Military Medical Planning phase

The following is an informal reporting of the conclusions of the RTG-192 Final Report (which is pending approval); and used here to illustrate the thought process and preliminary conclusions.

CHAPTER II. RTG-192 // BACKGROUND AND JUSTIFICATION

Hyperbaric Oxygen Therapy

Hyperbaric Oxygen Therapy (HBO) has been used for the treatment of various diseases and illnesses since the 1960's. Its use has been progressively expanding, based on experience and scientific studies. It is recognized that these scientific studies are difficult to perform and are generally not unequivocally accepted as “solid scientific proof” – this is partly due to the scarceness and variability of the diseases studied, but also to the lack of suitable therapeutic alternatives for many of these, hindering proper randomization and “sham control”. Also, the use of specific technical apparatus (the hyperbaric chamber) renders “blinding” of

patients difficult if not impossible. Finally, the lack of commercial or government (social security) funding has kept the number of hyperbaric treatment facilities low, and the quality of care delivered in these, variable.

HBO involves respiration of pure oxygen under high atmospheric pressure. In order to be able to breathe any gas at pressures higher than 1 atmosphere, patients must be exposed to the same pressure externally – hence the need for a hyperbaric treatment “chamber” – essentially a pressure vessel.

While smaller and older hyperbaric chambers were filled with pressurized oxygen, most hyperbaric chambers today are using compressed air, while patients breathe oxygen via an orofacial mask, a “hood” (a clear plastic head tent) or via a tracheostomy tube or endotracheal tube.

Guidelines for HBO have been developed by “Scientific Societies”, both in the USA (Undersea and Hyperbaric Medical Society - UHMS) and Europe (European Committee for Hyperbaric Medicine - ECHM). These guidelines encompass both the selection of patients (“Indications for Hyperbaric Oxygen Therapy”) and the proper execution of the treatment (“Code of Good Clinical Practice”).

Accepted indications for HBO

The close link with diving, aviation and space medicine has made hyperbaric medicine slightly better known with the general public over the last couple of years. Most of the clinical applications however lie in the field of complex trauma (combined vascular, muscular and neurological injury), anaerobic infections (gas gangrene), enhancement of wound-healing, decompression illness, acute acoustic trauma and carbon monoxide intoxication. All of these diseases or conditions require (often) urgent, comprehensive (multidisciplinary) hyperbaric treatment to ensure a maximal efficiency.

Although for very few HBO indications a sufficient body of “level I” scientific evidence seems to be present to unequivocally have the treatment modality “accepted” by the entire medical community, “lower levels” of scientific evidence combined with physiological logic and “common sense” have resulted in periodically reviewed guidelines issued by the hyperbaric Scientific Societies. These can be downloaded from their respective websites (www.uhms.org; www.echm.org). A summary is listed below.

Table 1. Accepted indications for HBO according to ECHM

CONDITION	ACCEPTED			NOT ACCEPTED		
	Level of Evidence			Level of Evidence		
	A	B	C	D	E	F
Type I						
CO intoxication		X				
Crush Syndrome		X				
Prevention of Osteoradionecrosis (dental extraction)		X				
Osteoradionecrosis (mandible)		X				
Soft Tissue Radionecrosis (cystitis)		X				
Decompression Accident			X			
Gas Embolism			X			
Anaerobic or Mixed Bacterial Anaerobic Infections			X			
Type II						
Diabetic Foot Lesion		X				
Compromised Skin Graft and Musculocutaneous Flap			X			
Osteoradionecrosis (other bones)			X			
Radio-induced Proctitis / Enteritis			X			
Radio-induced Lesions of Soft Tissues			X			
Surgery and Implant in Irradiated Tissue (preventive action)			X			
Sudden Deafness			X			
Ischemic Ulcer			X			
Refractory Chronic Osteomyelitis			X			
Neuroblastoma Stage IV			X			
Type III						
Post-anoxic Encephalopathy			X			
Larynx Radionecrosis			X			
Radio-induced CNS Lesions			X			
Post-vascular Procedure Reperfusion Syndrome			X			
Limb Re-implantation			X			
Burns >20 % of Surface Area and 2nd degree			X			
Acute Ischemic Ophthalmologic Disorders			X			
Selected Non-healing Wounds secondary to Inflammatory Processes			X			
Pneumatosis Cystoides Intestinalis			X			
Other indications						
Post-sternotomy Mediastinitis				X		
Stroke				X		
Sickle Cell Disease				X		
Malignant Otitis Externa				X		
Acute Myocardial Infarction				X		
Femoral Head Necrosis				X		
Retinitis Pigmentosa					X	
Tinnitus					X	
Interstitial Cystitis					X	
Facial (Bell's) Palsy					X	
Cerebral Palsy						X
Multiple Sclerosis						X
Fetoplacental Insufficiency						X

- Level A : At least 2 concordant, large, double-blind, controlled randomized studies with no or little methodological bias.
- Level B : Double-blind controlled, randomized studies but with methodological flaws; studies with only small samples, or only a single study.
- Level C : Consensus opinion of experts.
- Level D : Only uncontrolled studies with no consensus opinion of expert.
- Level E : No evidence of beneficial action, or methodological or interpretation bias preclude any conclusion.
- Level F : Existing evidence favors not to use HBO₂.

Table 2: “Accepted indications” for HBO according to UHMS (Source: [])

-
1. Air or Gas Embolism
 2. Carbon Monoxide Poisoning
 3. Carbon Monoxide Poisoning Complicated By Cyanide Poisoning
 4. Clostridial Myositis and Myonecrosis (Gas Gangrene)
 5. Crush Injury, Compartment Syndrome and Other Acute Traumatic Ischemias
 6. Decompression Sickness
 7. Arterial Insufficiencies:
 - Central Retinal Artery Occlusion
 - Enhancement of Healing In Selected Problem Wounds
 8. Severe Anaemia
 9. Intracranial Abscess
 10. Necrotizing Soft Tissue Infections
 11. Osteomyelitis (Refractory)
 12. Delayed Radiation Injury (Soft Tissue and Bony Necrosis)
 13. Compromised Grafts and Flaps
 14. Acute Thermal Burn Injury
 15. Idiopathic Sudden Sensorineural Hearing Loss
-

Specific military indications

Whereas many “chronic” indications have no military specificity, the nature of warfare provides for some injuries which can be classified as “ideal candidates” for hyperbaric treatment. Indeed, trauma with combined bone/soft tissue/neurological injuries and often vascular compromise, infected wounds, decompression illness, altitude illness, thermal burns, carbon monoxide intoxication are frequent consequences of military activity in operation.

Complexity of HBO in military setting

Both European and US scientific hyperbaric organizations have confirmed that complex trauma care needs to be performed in a multidisciplinary setting. Because of the often complex concomitant therapy needed, it would be necessary to direct these patients immediately to the most appropriate hospital offering both HBO and e.g. neurosurgery, trauma care or burn care. The optimal use of HBO and specialized care will result in a faster recovery and a reduction of overall treatment costs.

The relative isolation of military operation theatres, both geographically and because of enemy activity, makes this optimal “treatment path” difficult and often impossible. Hyperbaric chambers can (often) not be deployed close to the injury site (exception made perhaps for ship-mounted HBO chambers for diving operations support), so a primary evacuation to an optimal “combined facility” is, in the vast majority of

cases, not possible. However, a “therapeutic window” can be defined, within which HBO should be started, and attempts should be made to ensure this therapeutic time-frame can be met. Multinational cooperation, as exists already for military operations, including medical support on-site and for evacuation, is the key to this.

CHAPTER III. RTG-192 // OBJECTIVES OF THE REPORT

Define military indications for HBO

Whereas military personnel can benefit from HBO as part of classical healthcare when residing in their home country, the use of this treatment in case of injuries and diseases suffered while on deployment is seriously hampered by logistical difficulties and medical prioritizing. However, it appears that many combat-related injuries could, at least theoretically, benefit substantially from hyperbaric treatment if installed within the useful early timeframe. It has been the objective of this Working Group to define the medical conditions potentially encountered in operations, and also the optimal time frame during which addition of HBO to the “normal” care may be beneficial. The summaries and rationale can be found below and in Annex 1.

Define “conditions for use”

Furthermore, as the addition of any treatment modality cannot be allowed to compromise the quality of the “usual care”, a list of conditions has been formulated for each indication, helping Medical Planning staff to decide whether this is a “viable” option.

In the modern military setting, many if not most of these diseases would happen in remote operational theatres and rapid and coordinated evacuation of these patients to the optimal higher echelon treatment centre is essential. It is unlikely that fully functional military HBO centres can be deployed in close proximity of the operational theatre (bar exceptions, see below), meaning that HBO should be administered early in the evacuation chain back to the home country.

Although in most NATO countries, at least one military hyperbaric centre is available, either in-hospital or in a stand-alone (e.g. naval) setting, few of those centres can offer the various aspects of multidisciplinary care. This implies that wounded soldiers will often not be evacuated to the best treatment facility, and only receive partial care. Although the need for hyperbaric readiness and coordination plans is partially addressed in the context of submarine rescue planning (SMER), a more general approach is needed to encompass other indications for HBO.

Also, there is as yet no formal coordination between the various NATO countries’ military hyperbaric centres, neither regarding clinical protocols nor operating or safety procedures, nor personnel training and education. Because of this lack of interoperability, collaboration in the context of multinational operations is difficult to organize.

By working towards a concerted action, NATO countries will be able to specifically focus the available hyperbaric medicine capacity of each member nation towards an optimal utilization in times of need. More practical, patients referred to one of the member nation’s hyperbaric centres will be guaranteed a standardized approach, both medical and administrative, and will thus minimize the time to optimal treatment, and reduce medical and evacuation costs for each NATO country.

Among the “conditions for use”, criteria have been developed to aid in identifying the suitable hospitals with (military and civilian) HBO facilities beforehand, so that evacuation routes, military-medical supervision and financial agreements may be elaborated during the planning phase of the medical support operation.

Propose procedure for treatment of military injuries

Finally, this report will propose a “general workflow” for HBO treatment of military injuries, which can serve as a framework onto which specific procedures can be developed. Also, it is proposed to organize a “Lecture Series” for military (para)medical NATO personnel, with the aim of providing a basic knowledge of HBO and its potential use in military setting.

CHAPTER IV. RTG-192 // MILITARY INDICATIONS FOR HBOT

For each of the following diseases or conditions, the relevant characteristics have been summarized. Diseases and conditions have been listed roughly alphabetically; the order of discussion does not reflect relative importance or frequency of occurrence.

Annex 1 elaborates for each condition the scientific rationale and available evidence. Because this report does not pretend to be scientifically complete, reference is made to published reviews.

Definitions used in this summary:

Vital or not vital emergency:

Determines whether the condition or its immediate to short-term evolution may or may not compromise the victim’s life. Conditions that may have a severe functional impact (e.g. necessitating major amputations) are - in this military operational setting - NOT CLASSIFIED as “life-threatening” – this is opposed to standard NATO P-classification (see below)

Maximum delay of useful HBO therapy for this condition:

Determines directly the decision to evacuate or not, depending on the local possibilities. If HBO is started beyond this time point, the added benefit of the treatment probably does not outweigh the extra effort or (healthcare or tactical) risks of evacuating the patient.

Condition of evacuation:

Here, NATO classification is adhered to, as far as Priority (NATO Priority - P-factor) and Medical Support needed (NATO Dependency - D-factor). Also, special considerations for transport may be listed.

NATO Priority

P1 Life-threatening : life, limb, eyesight

Aircraft launch < 12hrs – pt return to Europe < 24hrs

P2 Priority

Aircraft launch < 24hrs– pt return 24-48hrs

P3 Routine

Aircraft launch > 24hrs

NATO Dependency

D1 – Full intensive care support (ICU) needed

D2 – Intermediate care (full monitoring, perfusions, drains,...) needs (para)medical care during flight

D3 – Low care (urine catheter, IV, pain meds...) need (para)medical attention

D4 – No care (ambulatory)

Conditions for HBO Therapy:

In this item is determined whether the HBO treatment should be performed (or capable of being performed) with intensive care support (ICU) or not; whether the patient would be mandatorily hospitalized for care or could be ambulatory; and finally an estimate of the expected maximal duration of emergency HBO - after this, the patient either would not need further HBO or could be transferred further, implying an interruption of daily HBO for a number of days.

Minimal specialized medicine needed:

As HBO is in many cases an adjunctive treatment, it is important that patients receive proper “classical” medical care as a priority. Whether this “specialized medical care” is needed on site - in the institution/hospital that provides HBO - or not (available for outpatient consultation), is listed in the next item.

Type of hyperbaric facility (see CGP):

Reference is made here to the definitions of HBO facilities as described in the European Code of Good Practice in HBO (CGT), published by ECHM and available for download on www.echm.org. In short, a Hyperbaric Chamber system consists of the hyperbaric chamber(s) including the support equipment (gas and energy supplies, etc). A Hyperbaric Facility consists of the therapeutic hyperbaric system(s) together with associated plant, buildings, staff (both technical and medical), and a specific administrative organization. Two kinds of hyperbaric facilities exist: hospital based and standalone. However, in each and every hyperbaric facility there should be an area adequately equipped to receive and care for medical emergencies. A Centre for Hyperbaric Medicine is a medical facility that provides HBO for patients and additional treatments, surveillance and attention to the medical conditions of the patient. The centre for hyperbaric medicine must be physically located in or functionally linked to a hospital.

Recommended HBO protocol:

Although pressure and duration of HBO sessions may vary dependent on the country, local possibilities and personal rationale, it is possible to define a “standard” HBO session as

- having a duration of minimum 60 minutes of oxygen breathing at pressure (note: commonly used protocols have between 70-90 minutes of oxygen breathing)
- at a pressure of minimum 2.4 atmospheres absolute pressure (ATA) (note: commonly used protocols vary between 2.4 and 2.5 ATA).
- with a maximum of two “air breaks” during the session (short periods where the oxygen mask or hood is taken off, so that the patient can breathe freely, but breathes air, not oxygen).

For diving emergencies and certain anaerobic infections, different schedules are available, and this is indicated when appropriate. The frequency and duration of HBO, as well as short recommendations for adjunctive treatments that are considered essential, are given.

Directions for future research:

As indicated above, often there is only a limited volume of high-grade scientific evidence for the efficacy of HBO in these (any) conditions. The treatment of military patients presents a unique opportunity to increase the data volume, and contribution of patient data to existing registries should be done whenever possible. In case no specific data collection exists, it is recommended to document each case as completely as possible, for future pooling and analysis.

Acoustic Trauma

- i. *Vital or non vital emergency ?*
Non vital
- ii. *Maximum delay of useful HBO therapy for this condition ?*
HBO treatment should be started < 48 Hrs
- iii. *Condition of evacuation ?*
 - a. P3 (but P2 if already available transport < 48Hrs)
 - b. D4
- iv. *Conditions for HBO therapy:*
 - a. Type of HBO sessions (ICU or non ICU): Non ICU
 - b. Status of patient: Ambulatory
 - c. Expected duration of emergency HBO: < 10 days
- v. *Minimal specialized medicine needed:*
ENT
- vi. *Specialized medicine needed on site:*
None
- vii. *Type of hyperbaric facility (see CGP):*
Facility
- viii. *Recommended HBO protocol:*
 - a. 1 standard HBO treatment per day
 - b. Add treatment with high dose cortisone from day 1
- ix. *Scientific rationale:* see Annex 1
- x. *Directions for future research:*
Inclusion in on-going RCT on AAT (pilot: Centre for Hyperbaric Oxygen Therapy, Brussels, Belgium - medhyper@mil.be)

(iatrogenic) Arterial Gas Embolism

- i. *Vital or not vital emergency ?*
Vital
- ii. *Maximum delay of useful HBO therapy for this condition ?*
HBO treatment should be started ASAP, <48Hrs
- iii. *Condition of evacuation ?*
 - a. Priority = life saving interventions
 - b. P2 – D1 Emergency evacuation
- iv. *Conditions for HBO therapy:*
 - a. Type of HBO sessions (ICU or non ICU): ICU
 - b. Status of patient: ICU hospitalization
 - c. Expected duration of emergency HBO: 2-3 days
- v. *Minimal specialized medicine needed:*
Intensive care
- vi. *Specialized medicine needed on site:*
Intensive care
- vii. *Type of hyperbaric facility (see CGP):*
Centre
- viii. *Recommended HBO protocol:*
USN TT6 or equivalent
- ix. *Scientific rationale:* see Annex 1
- x. *Directions for future research:*
Collect clinical data in systematic way

Burn Injury – life-threatening (high TBSA or respiratory burns)

- i. *Vital or not vital emergency ?*
Vital
- ii. *Maximum delay of useful HBO therapy for this condition ?*
HBO treatment should be started within 12Hrs, or not at all (Forward or Tactical Evacuation only)
- iii. *Condition of evacuation ?*
 - a. P1/P2 – D1
 - b. Emergency evacuation : prioritization = life-saving, not HBO
- iv. *Conditions for HBO therapy:*

- a. Type of HBO sessions (ICU or non ICU): ICU
- b. Status of patient: ICU Burn ward hospitalization
- c. Expected duration of emergency HBO: 3-4 days
- v. *Minimal specialized medicine needed:*
Burn centre
- vi. *Specialized medicine needed on site:*
Burn centre
- vii. *Type of hyperbaric facility (see CGP):*
Centre
- viii. *Recommended HBO protocol:*
2 standard HBO sessions per day for the first 2-3 days
- ix. *Scientific rationale:* see Annex 1
- x. *Directions for future research:*
 - a. Systematic data collection coordination between participating burn centers (outcome parameters comparison between HBO and non-HBO treated patients)

Burn Injury – non life-threatening

- i. *Vital or not vital emergency ?*
Not vital
- ii. *Maximum delay of useful HBO therapy for this condition ?*
HBO treatment should be started ASAP, < 5 days
- iii. *Condition of evacuation ?*
 - a. P2 – D2-D3
 - b. Emergency evacuation only if risk of permanent disability (face, hands, perineum)
- iv. *Conditions for HBO therapy:*
 - a. Type of HBO sessions (ICU or non ICU): Non ICU
 - b. Status of patient: Burn ward hospitalization
 - c. Expected duration of emergency HBO: < 7 days
- v. *Minimal specialized medicine needed:*
Burn specialist
- vi. *Specialized medicine needed on site:*
None
- vii. *Type of hyperbaric facility (see CGP):* Facility
- viii. *Recommended HBO protocol:*
2 standard HBO sessions / day if possible

- ix. *Scientific rationale*: see Annex 1
- x. *Directions for future research*:
 - a. Collect clinical data in systematic way
 - b. Data collection coordination between participating burn centers (outcome parameters comparison between HBO and non-HBO treated patients)

Carbon Monoxide Poisoning (where HBO is indicated – see Scientific Rationale)

- i. *Vital or not vital emergency ?*
Vital, in case of
 - a. Impaired consciousness
 - b. Cardiac instability
 - c. Pregnancy
- ii. *Maximum delay of useful HBO therapy for this condition ?*
6 Hrs from diagnosis and initiation of treatment with normobaric oxygen
- iii. *Condition of evacuation ?*
Emergency evacuation 100%O₂ (Forward & Tactical Evacuation only)
- iv. *Conditions for HBO therapy*:
 - a. Type of HBO sessions (ICU or non ICU): ICU
 - b. Status of patient: Hospitalized (medium care or ICU)
 - c. Expected duration of emergency HBO: <2 days
- v. *Minimal specialized medicine needed*:
Emergency medicine
- vi. *Specialized medicine needed on site*:
Emergency medicine
- vii. *Type of hyperbaric facility (see CGP)*:
Facility
- viii. *Recommended HBO protocol*:
 - a. Standard HBO protocol, one or two sessions depending on the neurologic recovery
 - b. Consider combined toxicological exposure (e.g. CN, EtOH,...) and treat accordingly
 - c. Recommend formal neurologic follow-up for late neurological effects
- ix. *Scientific rationale*: see Annex 1
- x. *Directions for future research*:
Collect clinical data in systematic way

Crush Injury (combined trauma to bones, soft tissue, vessels, or nerves)

- i. *Vital or not vital emergency ?*
Not vital
- ii. *Maximum delay of useful HBO therapy for this condition ?*
HBO treatment should be started at maximum 48 Hrs
- iii. *Condition of evacuation ?*
Emergency evacuation only if risk of permanent disability P2 – D2 D3
- iv. *Conditions for HBO therapy:*
 - a. Type of HBO sessions (ICU or non ICU): Non ICU (but depends on general condition)
 - b. Status of patient: Hospitalized (surgery ward)
 - c. Expected duration of emergency HBO: < 7 days
- v. *Minimal specialized medicine needed:*
Trauma centre
- vi. *Specialized medicine needed on site:*
No, unless life-threatening injury
- vii. *Type of hyperbaric facility (see CGP):*
Depends on the condition of the patient
- viii. *Recommended HBO protocol:*
2 standard HBO treatments / day for 2-3 days, then 1 treatment / day
- ix. *Scientific rationale:* see Annex 1
- x. *Directions for future research:*
 - a. Collect clinical data in systematic way
 - b. Classify patients according to international trauma scores (Gustilo)
 - c. Adding (anonymous) data to German Trauma Net database (coordinator: Centre for Hyperbaric Oxygen - Military Hospital Ulm, Germany)

Decompression Illness – life-threatening

- i. *Vital or not vital emergency ?*
Vital
- ii. *Maximum delay of useful HBO therapy for this condition ?*
HBO treatment should be started ASAP, < 48Hrs
- iii. *Condition of evacuation ?*
 - a. P1 – D1 Emergency evacuation indicated (Forward and Tactical Evacuation)
 - b. Transfer with 100% oxygen and maximum pressurization (< 1500 ft cabin altitude)

- iv. *Conditions for HBO therapy:*
 - a. Type of HBO sessions (ICU or non ICU): ICU
 - b. Status of patient: Hospitalized ICU
 - c. Expected duration of emergency HBO: <7 days
- v. *Minimal specialized medicine needed:*
Intensive care
- vi. *Specialized medicine needed on site:*
Intensive care
- vii. *Type of hyperbaric facility (see CGP):*
Centre
- viii. *Recommended HBO protocol:*
 - a. Follow directions in ADivP 2
 - b. Minimum treatment pressure 2.8 ATA
 - c. Aggressive fluid management needed
- ix. *Scientific rationale:* see Annex 1
- x. *Directions for future research:*
 - a. Collect clinical data in systematic way

Decompression Illness – not life-threatening

- i. *Vital or not vital emergency ?*
Not vital
- ii. *Maximum delay of useful HBO therapy for this condition ?*
HBO treatment should be started ASAP, < 5 days
- iii. *Condition of evacuation ?*
 - a. P2-3 – D2-3 (Emergency evacuation only if risk of permanent disability)
 - b. Transfer while breathing 100% oxygen and cabin altitude restriction (< 1500 ft cabin pressure)
- iv. *Conditions for HBO therapy:*
 - a. Type of HBO sessions (ICU or non ICU): Non ICU
 - b. Status of patient: Preferably in-patient
 - c. Expected duration of emergency HBO: < 3 days
- v. *Minimal specialized medicine needed:*
Medical imaging (chest X ray) (MS: why? pulm. barotrauma then 2)
- vi. *Specialized medicine needed on site:*
None

- vii. *Type of hyperbaric facility (see CGP):*
Facility
- viii. *Recommended HBO protocol:*
 - a. Follow directions in ADivP 2
 - b. Minimum treatment pressure 2.8 ATA
- ix. *Scientific rationale:* see Annex 1
- x. *Directions for future research:*
 - a. Collect clinical data in systematic way
 - b. Implement or at least, collect sufficient clinical data, to categorize patients according to different injury severity scoring systems (e.g. the Boussuges scale scoring system for DCS)

Frostbite

- i. *Vital or not vital emergency ?*
Non-vital
- ii. *Maximum delay of useful HBO therapy for this condition ?*
HBO treatment should be started within 2-3 days
- iii. *Condition of evacuation ?*
P2 – D2 D3
- iv. *Conditions for HBO therapy:*
 - a. Type of HBO sessions (ICU or non ICU): non ICU
 - b. Status of patient: In-patient
 - c. Expected duration of emergency HBO: 5-7 days
- v. *Minimal specialized medicine needed:*
Surgery
- vi. *Specialized medicine needed on site:*
No
- vii. *Type of hyperbaric facility (see CGP):*
Facility
- viii. *Recommended HBO protocol:*
2 standard HBO treatments /day for 2-3 days, then once daily
- ix. *Scientific rationale:* see Annex 1
- x. *Directions for future research:*
 - a. Collect clinical data in systematic way

Soft Tissue Infections - life threatening

- i. *Vital or not vital emergency ?*
Vital
- ii. *Maximum delay of useful HBO therapy for this condition ?*
HBO treatment should be started ASAP; < 48 Hrs
- iii. *Condition of evacuation ?*
P1 – D1
- iv. *Conditions for HBO therapy:*
 - a. Type of HBO sessions (ICU or non ICU): ICU
 - b. Status of patient: Hospitalized in ICU department
 - c. Expected duration of emergency HBO: 7 days
- v. *Minimal specialized medicine needed:*
 - a. Intensive care with infectious isolation
 - b. (Septic) surgery
- vi. *Specialized medicine needed on site:*
 - a. Intensive care
 - b. (Septic) surgery
- vii. *Type of hyperbaric facility (see CGP):*
Centre
- viii. *Recommended HBO protocol:*
 - a. Boerema schedule (3 ATA) if gas gangrene suspected and patient in vital compromise for the first session
 - b. 2 standard HBO treatments / day for 2-3 days, then 1 treatment / day
 - c. Bacterial culture in order to adapt antibiotic treatment accordingly (anaerobic germs !)
- ix. *Scientific rationale:* see Annex 1
- x. *Directions for future research:*
 - a. Collect clinical data in systematic way
 - b. Gram test on wound fluid should be reported

CHAPTER V. RTG-192 // CONDITIONS FOR OPTIMAL USE

In order to aid Medevac Planners in selecting appropriate HBO treatment facilities based on the summary listing above, a description has been provided of the necessary capabilities of a HBO Centre. This will enable a selection of HBO facilities by type of indication, permitting a quick evaluation whether evacuation for HBO is feasible and practical.

First, the definition of “hospital-based” HBO chambers need further detail. The categories of HBO chambers, as defined in the CGP, fall slightly short on the actual characteristics: a Hyperbaric Facility may or may not be “hospital-based”, and the next category would then be a “Centre for Hyperbaric Medicine”.

For the purpose of military HBO indications, four categories have been defined:

- 0 : The HBO Facility is located outside of the premises of a hospital, or physically distant on the hospital grounds (e.g. another building on the hospital campus grounds) so that ambulance transport is necessary to bring the patient from the ward to the HBO Facility
- I : The HBO Facility is based in a small, local hospital, which may or may not have a limited intensive care facility, but without the possibility of intensive care support during the HBO
- II : The HBO Facility / Centre is based in a larger, regional hospital with full EMS (emergency medical services) and intensive care ward(s); intensive care support is possible during HBO
- III : The HBO Facility / centre is based in a larger hospital as in II., but the hospital provides additional specialized care

Intensive care support during HBO needs to be defined as well; for the purpose of this document, a working definition of “ICU HBO” has been made:

- A mechanical ventilator for providing artificial respiration is placed inside the HBO chamber, and is adapted or designed for functioning in hyperbaric environments
- Hyperbaric-tested or -designed drug infusion pump(s) are placed inside the HBO chamber
- During the HBO, a minimum of the following patient parameters can be monitored continuously: ECG, blood pressure
- Arterial Blood Gas measurements can be taken inside the HBO chamber, during treatment, and can be analyzed on-site
- ICU-competent HBO personnel (as defined in the EBAss curriculum for HBO-ICU-nurse - www.ebass.org - or an ICU-competent MD) is present inside the HBO chamber during the complete treatment
- Advanced Life Support (ALS) equipment is readily available at the site of the HBO chamber

Finally, for each condition discussed above, the required hospital capabilities can be defined.

Table 3: Required hospital capabilities for treatment of military HBO indications

Condition	Hosp based (0-I-II-III)	ICU HBO	24/24 HBO	7/7 HBO	Special “capabilities” of the treating hospital
1. Acoustic Trauma	0	-	-	+	-
2. Iatrogenic AGE	II	+	+	+	
3. Burns – life threatening	III	+	+	+	Burn Centre
4. Burns – not life threatening	0	-	+	+	III - Burn Centre
5. CO-intoxication	I or II	- or +	+	+	
6. Crush	0 or III	- or +	+	+	III - Trauma centre
7. DCI – life threatening	II	+	+	+	
8. DCI – not life threatening	0	-	+	+	-
9. Frostbite (extremities)	0	-	-	+	Surgery
10. Soft Tissue Infections - life threatening	III	+	+	+	Septic surgery

Annex 2 lists the hospitals that have been identified as of December 2012 with their capabilities to treat the indications/conditions discussed above. This list is a) not necessarily complete and b) not static, meaning that it can only serve as a starting point for Evacuation Planners to identify for each projected military support contingency plan the most appropriate HBO Facility and hospital.

Annex 3 lists contact information for regional or national reference persons/institutions in order to provide a quick and easy way for obtaining up-to-date information regarding existence and availability of these HBO Centres. Likewise, Annex 3 needs to be updated itself as time goes by, however, web links may persist for a longer time.

CHAPTER VI. RTG-192 // RECOMMENDATIONS

Planning

On NATO level, nations usually either perform planning and Airevac operations with their own means and assets, or collaborate in a more or less structured way with partner nations for “burden sharing”. This can be only for a specific mission or on a more permanent basis. An example is the AECC (Aeromedical Evacuation Control Centre) set up within EATC (European Air Transport Command), a multinational command (Netherlands, Belgium, France, Germany and Luxemburg) established in 2010 with the goal of providing a single headquarters for air transport, air-to-air refueling and aeromedical evacuation, thus setting an example of successful military Pooling and Sharing in Europe. Within EATC, the AECC is capable of planning and executing medical evacuations in a fast and efficient way. Within the participating nations, a PECC (Patient Evacuation Control Centre) is both at the “requesting end” and at the “receiving end” of the patient evacuation chain, with AECC organizing the most efficient means and schedule of transport.

Whether the contingency plan for medical evacuation is established through EATC/AECC or independently by individual NATO countries, preliminary contacts should be made between the (military or civilian) HBO centers and the military Medevac Planner.

As “emergency transfer for HBO” needs to be considered a “primary” emergency, this should possibly be included in existing NATO agreements between partners.

As the medical-surgical and HBO capabilities of a HBO Centre and/or its associated hospital may change, a systematic yearly renewal of the agreement must be provided for. The agreement should include costs for hospitalization and HBO treatment, and must include an obligation to report back to the recognized military HBO expert of the patient’s nation.

Routing

For each military operation where any NATO country sends troops, and by extension for each NATO country over whose territory possible Medevac of any other NATO country’s military personnel might take place, it is recommended that evacuation route(s) be established to the selected / appropriate HBO Centers.

The responsibility for establishing these routes lies with the Patient Evacuation Coordination Centre (PECC) of each (potential) patient’s Nation if such a PECC exists. Alternatively, the coordinating Nation may prospectively establish the shortest (fastest) route and most appropriate transport means from the receiving airfield to the HBO Centre. In Annex 3, the current military HBO experts from most European Nations are listed, as a reference. This list needs annual updating.

Other resources available to PECC or equivalent include the following websites

www.echm.org

www.uhms.org

www.eubs.org

www.oxynet.org

PRACTICAL ISSUES TO BE RESOLVED

Evacuation Routing

As availability of civilian and military HBO centres and their associated hospitals may vary in time, no fixed routes can be proposed. For each military operation theatre, these routes need to be prepared and reconnoitred case by case. However, once a suitable HBO facility has been identified, organizing this routing should, in western countries, not pose significant problems.

Financial Agreements

Existing financial agreements between NATO countries Defence Departments and civilian health care institutions should encompass the emergency HBO care of wounded military personnel, as they would emergency neurosurgery or burn wound care.

The responsibility for these financial agreements should thus be transferred from the Medevac planners to each nation's Defence Department. However, in the process of planning, it is recommended to negotiate a fixed day-price for medical care, including HBO therapy, beforehand. In the current context of civilian health care financing, most civilian hospitals would not oppose such an "a priori" agreement.

Evaluation of Efficacy

As for most of the "accepted HBO indications", the scientific Level of Evidence (LOE) can still be improved, it is recommended that a systematic data collection be undertaken for each treated case. In cases where no HBO can be administered, ideally the same information should be collected in order to ultimately permit a post-hoc analysis of efficacy of treatment. While this can not replace a true randomized controlled prospective trial, it is acknowledged that in the specific military context with multinational – multi-theatre patients, such trials are unrealistic.

