Chapter 1 – BACKGROUND AND JUSTIFICATION

1.1 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").

1.2 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 (multi-disciplinary) 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 1-1: Accepted Indications for HBO According to ECHM (Source: [www.achobel.be]).

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 HBO_2.

Table 1-2: "Accepted Indications" for HBO According to UHMS (Source: [www.uhms.org]).

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

1.3 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.

1.4 COMPLEXITY OF HBO IN MILITARY SETTINGS

Both European and US scientific hyperbaric organizations have confirmed that complex trauma care needs to be performed in a multi-disciplinary 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, for example, 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. Multi-national cooperation, as exists already for military operations, including medical support on-site and for evacuation, is the key to this.