The Use of Hyperbaric Oxygen Therapy in Ophthalmic Practice

Essay

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بسم الله الرحمن الرحيم

﴿وَعَلَّمَكَ مَا لَمْ تَكُنْ تَعْلَمُ وَكَانَ فَضْلُ اللَّهِ عَلَيْكَ عَظِيمًا﴾

صدق الله العظيم

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Ahmed Zaki Wahba

List of Contents

Title	Page No.

List of Abbreviations

Abb.	Full term
AGE	Arterial gas embolism
AMD	Age-related macular degeneration
ATA	Atmospheres absolute
BID	Bis in die
CO	Carbon monoxide
CRAO	Central retinal artery occlusion
DCS	Decompression sickness
ERG	Electroretinographic
FDA	Food and drug administration
HBO	Hyperbaric oxygen therapy
ICP	Intracranial pressure
IL-10	Interleukin-10
NO	Nitric oxide
RK	Radial keratotomy
ROS	Reactive oxygen species
TNF-α	Tumor necrosis factor-α
TVF	Temporal visual field
UHMS	Undersea and Hyperbaric Medical Society
UMS	Undersea Medical Society

List of Tables

List of Figures

Fig. No.	Title	Page No.

List of Figures cont…

Abstract

Background: Hyperbaric oxygen therapy is now considered a recognized primary or adjuvant therapeutic technique used in treatment of many acute and chronic diseases. Currently, eye diseases are among the promising use of hyperbaric oxygen however there is increasing evidence showing its safety and efficacy in central retinal artery occlusion, cystoid macular edema secondary to retinal vein occlusion, scleral thinning and necrosis faced after pterygium surgery, orbital rhino-cerebral mucormycosis, non-healing corneal edema, anterior segment ischemia, and diabetic retinopathy.

Objectives: The aim of the study is to evaluate the efficacy and safety of hyperbaric oxygen therapy (HBOT) in treatment of some ophthalmological disorders.

Key words: Hyperbaric oxygen therapy - Atmospheres absolute - Central retinal artery occlusion – Retinitis pigmentosa.

INTRODUCTION

Hyperbaric oxygen therapy (HBOT) is defined by the Undersea and Hyperbaric Medical Society (UHMS) as a treatment in which a patient intermittently breathes 100% oxygen while the treatment chamber is pressurized to a pressure greater than sea level (1 atmosphere absolute, ATA). The pressure increase must be systemic, and may be applied in monoplace (single person) or multiplace chambers. Multiplace chambers are pressurized with air, with oxygen given via face-mask, hood tent or endotracheal tube; while monoplace chambers are pressurized with oxygen.(1)

HBOT is considered a recognized primary or adjuvant therapeutic method used in treatment of various acute and chronic diseases. Eye diseases are are among the off-label use of hyperbaric oxygen However, there is an increasing body of evidence showing its safety and efficacy in central retinal artery occlusion, cystoid macular edema secondary to retinal vein occlusion, scleral thinning and necrosis faced after pterygium surgery, orbital rhino-cerebral mucormucosis, non-healing corneal edema, anterior segment ischemia, and diabetic retinopathy.(2)

HBOT is largely safe when properly administered, although the potential systemic and ocular complications are carefully described. The principal systemic complications are pulmonary, central nervous system and hypertensive effects.

The ocular complications include progressive (but reversible) myopia with repeated treatment sessions, and cataract. The only absolute ocular contraindication to HBOT is the presence of an intraocular gas bubble due to prior surgery or trauma.(3)

There is a growing interest in the use of HBOT in medicine in general, and in ophthalmology in particular. The indications for its use have become clearer, and newer indications have appeared in the literature. The number of HBOT-cabins available throughout the world continues to increase.

AIM OF THE STUDY

The aim of this work is to review literature about basic principles of hyperbaric oxygen therapy and its different uses in ophthalmic practice.

HISTORY AND DEVELOPMENT OF HYPERBARIC OXYGEN

Hyperbaric oxygen therapy(HBO) was first documented in 1662, when a British physician called Henshaw built the first hyperbaric chamber, or ‘domicilium’. Since this time, reports of beneficial effects from increased pressure have increased, and by 1877, chambers were used widely for many conditions, though there was little scientific rationale or evidence. In 1879, the surgical application of hyperbaric therapy in prolonging safe anaesthesia was realized and explored.[4]

In 1927, Dr Cunningham, a professor of anesthesia reported improvement in circulatory disorders at sea level and deterioration at altitude, and a patient who was grateful to Cunningham for his recovery after HBO treatment, built the huge ‘steel ball hospital’ chamber, but this was closed when Cunningham failed to produce evidence for its use.[5]

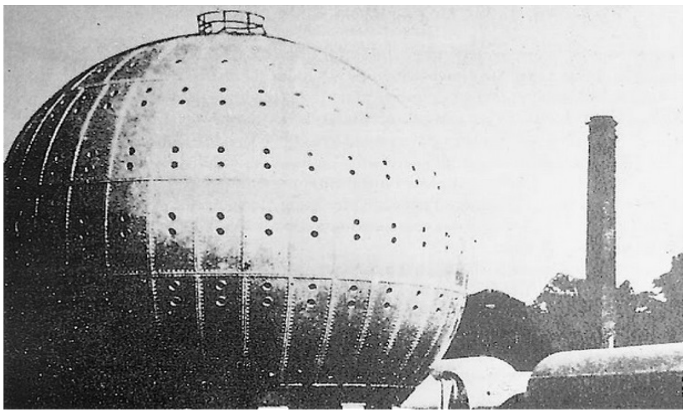

Figure (1): Cunningham’s giant steel ball hyperbaric chamber built in 1928 in Cleveland, Ohaio.[6]

The advent of the use of HBO in modern clinical medicine began in 1955 with the work of Churchhill-Davis, who helped to attenuate the effects of radiation therapy in cancer patients using high-oxygen environments.

That same year, Dr Boerma, a professor of surgery at the University of Amsterdam in Holland, proposed using hyperbaric oxygen (HBO) in cardiac surgery to help prolong the patient's tolerance to circulatory arrest. He conducted surgical operations under pressure, including surgical correction of transposition of the great vessels, tetralogy of Fallot and pulmonic stenosis.[7]

It is frequently said that the history of "hyperbaric oxygenation" goes back "over 300 years," probably referring to the work of Henshaw. This is incorrect, in that oxygen was not discovered until 1775 by Joseph Priestly. All the early chambers were pressurized with compressed air, and oxygen was not a consideration.

Clinical hyperbaric oxygen goes back only about 55 years, beginning with the work of Churchill-Davidson and Boerma.[8]

In 1967 the Undersea Medical Society (UMS) was founded by six U.S. Navy Diving and Submarine medical officers as an organization dedicated to diving and undersea medicine. The UMS was later renamed Undersea and Hyperbaric Medical Society (UHMS) in 1986. This professional society was established for those practicing hyperbaric medicine or diving medicine. They are responsible for publishing approved indication for HBOT.[9]

PHYSIOLOGICAL BASIS OF HYPERBARIC OXYGEN THERAPY

Physics of Hyperbaric Medicine:

The effects of HBO are based on the gas laws, and the physiological and biochemical effects of hyperoxia.[10]

Boyle's law states that at a constant temperature, the pressure and volume of a gas are inversely proportional. This is the basis for many aspects of hyperbaric therapy, including a slight increase in chamber temperature during treatment, and the phenomenon known as 'squeeze', occurring when blocked eustachian tubes prevent equalization of gas pressure, resulting in painful compression of gas in the middle ear. In patients who cannot independently achieve pressure equalization, the placement of tympanostomy tubes should be considered to provide a channel between the inner and outer ear air spaces. Similarly, trapped gas can enlarge dangerously during decompression, such as in the rare example of a pneumothorax occurring at pressure.[11]

Dalton's law states that in a mixed gas each element exerts a pressure proportional to its fraction of the total volume (partial pressure).[12]

Henry's law states that the amount of gas dissolved in a liquid or tissue is proportional to the partial pressure of that gas in contact with the liquid or tissue. This is the basis for