



Original Article

Hyperbaric Oxygen Therapy for the Management of Mild and Moderate Traumatic Brain Injury: A Single-Center Experience

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Background

Hyperbaric oxygen therapy (HBOT) has been shown to be an effective modality in the management of a variety of conditions. However, its role in the treatment of traumatic brain injury (TBI) remains an area of controversy. This study aims to evaluate the safety and outcomes of HBOT in managing the long-term sequelae of TBI.

Methods

The records of TBI patients who underwent increments of 40 sessions of HBOT at 1.5 atmosphere absolute at a single medical center were reviewed. The outcome measures included physical, cognitive (i.e., Trail Making Test, parts A and B; U.S. Department of

Veterans Affairs' Evaluation of Cognitive Impairment and Subjective Symptoms tool), and single-photon emission computed tomography findings. The complications and withdrawals were recorded.

Results

During the study period, 17 patients underwent HBOT to manage the long-term sequelae of their TBI. Of the 17 patients, 12 (70.6%) completed 120 HBOT sessions and were evaluated 3 months after treatment. All 12 patients had statistically significant improvements in their Trail Making Test, parts A and B, and U.S. Department of Veterans Affairs' Evaluation of Cognitive Impairment and Subjective Symptoms scores ($P < 0.05$). Additionally, single-photon emission computed tomography depicted increased cerebral blood flow and oxygen metabolism among studied subjects compared with the baseline values. A total of 5 patients withdrew from the study, which was related to new-onset headaches associated with HBOT for 1 patient.

Conclusions

HBOT using 1.5 atmosphere absolute in increments of 40 sessions was found to be a safe and effective modality in the management of the long-term sequelae of TBI. HBOT should be considered in the management of this patient population.

Introduction

Despite the technological advances and management of patients with traumatic brain injury (TBI), TBI continues to be a significant cause of mortality and morbidity in the United States (U.S.).¹ It is estimated that 4.1 million TBIs occur annually, with ~80,000 people becoming disabled from TBIs in the U.S. each year and 5.3 million Americans requiring assistance with activities of daily living because of TBI.^{2, 3, 4} Therefore, TBI and its consequences result in substantial public health and economic burdens on societies, with an estimated \$76.5 billion annually spent on TBI management.^{5,6} Ischemia has been implicated as a significant factor in the pathogenesis of TBI.⁷ The lack of oxygenation causes a shift from aerobic to anaerobic metabolism, resulting in acidosis and depletion of cellular energy. A cascade of events eventually manifests itself in a myriad of symptoms attributed to TBI.⁸

Hyperbaric oxygen therapy (HBOT) is a novel method for managing poorly healed wounds, decompression sickness, and carbon monoxide poisoning, among others.⁹ The high oxygen tension is believed to aid in healing by improving tissue oxygenation, angiogenesis, anti-inflammatory properties, and enhancing neuroplasticity.^{10, 11, 12, 13, 14, 15} Various studies have delineated HBOT efficacy in the management of mild and severe TBI.^{16, 17, 18, 19} Although randomized clinical trials showed contradictory results regarding HBOT's role and efficacy in TBI, significant limitations remain regarding their methodologic designs and biases.²⁰ The use of HBOT for TBI is not a new concept; its use can be traced back to the 1960s, when it was first introduced to treat cerebral gas and/or air embolism.^{21, 22, 23} The selection of hyperbaric pressure and the number of sessions used for TBI patients was based on early studies that reported success with a pressure of 1.5 atmosphere absolute (ATA) and 40 sessions, with few variations.^{24,25}

In the present study, we aim to delineate the efficacy and safety of HBOT in managing the long-term sequelae of patients with TBI. We describe our protocol, report our clinical, cognitive, and radiologic outcomes, and add to the growing body of literature on this emerging topic.

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Section snippets

Patient Population, Study Objectives, and Treatment Protocol

Using our institutional database, we retrospectively reviewed patients with TBI who underwent HBOT at Jupiter Medical Center between 2012 and 2019. The institutional review board approved the present study (approval no. 20180334), and all included patients provided written informed consent. Supplemental patient records and electronic medical records were reviewed to evaluate the patients' clinical history, imaging findings, and outcomes. Patients with isolated mild and moderate TBI (defined

Patient Population

During the study period, a single-arm, case series of 18 patients with mild and moderate TBI were enrolled in the study without a control group. The present study included 12 men (66.7%) and 6 women (33.3%), with a mean age of 49.8 ± 15.9 years. The interval from TBI to beginning HBOT ranged from 1 to 32 years. One patient voluntarily withdrew early from the study after enrollment because of a diagnosis of Alzheimer's disease. The other 17 patients underwent baseline assessments and 40 HBOT ...

Discussion

TBI is a prevalent condition with significant lifelong effects on patients, economies, and healthcare systems.^{2,30,31} To date, no proven treatments are available to address the long-term cognitive, mental, emotional, and physical outcomes associated with TBI. Various modalities have been investigated and reported in the literature, each with inherent advantages and limitations. HBOT has been approved by the Food and Drug Administration for use in many conditions, including nonhealing wounds, ...

Conclusions

Our study provides promising results for the use of HBOT in managing the sequelae of mild and moderate TBI. The study found that HBOT was effective in improving physical, cognitive, and SPECT outcomes for the majority of patients who underwent HBOT, with significant improvements in the Trail Making Test and VAECI scores after HBOT. SPECT imaging also demonstrated increased cerebral blood flow and brain metabolism among our patients after HBOT sessions compared with that at baseline. These ...

CRedit AUTHORSHIP CONTRIBUTION STATEMENT

Barry M. Miskin, Conception and design, study supervision, data collection, statistical analysis, critical revision, final approval. Lee A. Fox, Conception and design, data collection, statistical analysis, critical revision, final approval. Hussam Abou-Al-Shaar, Statistical analysis, writing – original draft, critical revision, final approval. Othman Bin-

Alamer, Writing – original draft, critical revision, final approval. Aaron Goertz, Data collection, critical revision, final approval. Conner ...

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