



2020

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Recommended Citation

Wiedmann, Jordan A., "Hyperbaric Oxygen Therapy for the Treatment of Traumatic Brain Injuries" (2020).
Physician Assistant Scholarly Project Posters. 241.
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Hyperbaric Oxygen Therapy for the Treatment of Traumatic Brain Injuries

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Abstract

- This research and systematic literature review evaluates the safety and efficacy of Hyperbaric oxygen therapy (HBOT) to improve treatment outcomes in traumatic brain injuries (TBIs). This review included the search of PubMed, Cochrane Review, Clinical Key, and DynaMed. The search included randomized control trials, systematic reviews, and meta-analyses published in the last 20 years.
- Several studies show evidence to support the use of HBOT in TBIs, however the majority of research suggests overall insufficient evidence on the topic. Several studies also address the concern for safety and side effects, as individuals are exposed to increased pressures for long lengths of time.
- Ultimately, more research and studies are needed in order to claim safety and efficacy in the use of HBOT in TBI treatment.
- Key Terms:** hyperbaric oxygen therapy and traumatic brain injuries, hyperbaric oxygen effectiveness, hyperbaric oxygen safety, hyperbaric oxygen side effects, hyperbaric oxygen contraindications, hyperbaric oxygen mechanism of action, and hyperbaric oxygen evidence.

Introduction

- In HBOT, air is pressurized to three times higher than normal atmospheric pressure. These conditions allow for more oxygen to gather in the lungs, which enhances the amount of oxygen your blood can carry and ultimately promotes healing.
- Hyperbaric oxygen therapy has been a well-established, evidence supported treatment for conditions such as decompression sickness, infections, burns, and wounds (Mayo, 2018).
- Hyperbaric oxygen therapy has also been used as an attempt to treat many neurological conditions, such as traumatic brain injuries (TBIs).
- This literature review evaluates several studies, clinical trials, and meta analyses in attempt to prove or disprove the use of HBOT as an effective treatment of TBIs.

Statement of the Problem

- Approximately 2.5 million people suffer from traumatic brain injuries (TBIs) each year, with 80,000 of them suffering permanent disabilities (Brain, 2014).
- Current treatment involves extensive, time-consuming rehab and therapy services, with varying results with many only seeing little improvement (Traumatic, 2019).
- HBOT could be a great adjunct, or alternative, to traditional TBI treatments. Medical providers should be informed of the most recent literature on HBOT in the treatment of TBIs so they can provide their patients with another possible option for treatment.

Research Question

- In adult patients with a traumatic brain injury, does treatment with hyperbaric oxygen therapy as compared to no hyperbaric oxygen therapy improve recovery and cognitive outcomes?

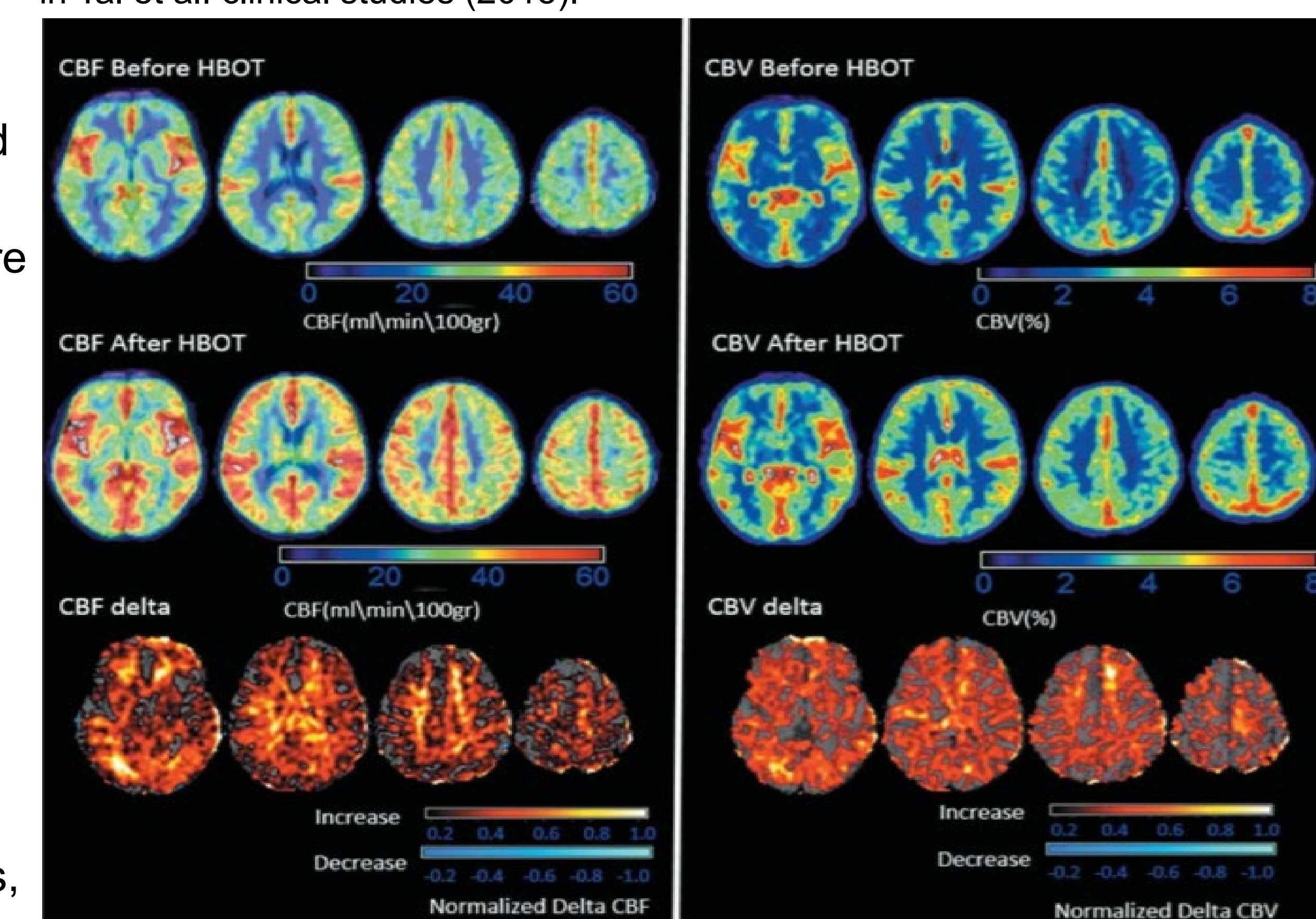
Literature Review

- Mechanism of action of hyperbaric oxygen therapy**
 - HBOT promotes healing by supporting an oxygen-rich supply of blood to the site of injury as well as a driving force for neovascularization (Lam, 2017).
 - HBOT may improve TBIs through increased tissue oxygenation, reduced inflammation, inhibition of apoptosis, reduced intracranial pressure (ICP), and angiogenesis/neurogenesis promotion (HuQ et al., 2016).
 - HBOT reduces swelling in the brain via osmotic effects (Guedes et al., 2016).
- Efficacy of Hyperbaric Oxygen in Traumatic Brain Injuries**
 - Barrett et al.'s 2012 review and Wang et al.'s 2016 review show lower mortality and GCS scores with HBOT, however little evidence supports that survivors have improved outcomes in terms of their TBIs.
 - Crawford et al.'s systemic review in 2017 failed to demonstrate effectiveness in mild TBIs. However, moderate-to-severe TBIs showed mixed results, ultimately favoring HBOT.
 - A systematic review by McDonagh et al. reports the rate of return of consciousness at one month in comatose patients was higher in the HBOT group. Studies also showed lower ICPs and GCS scores (42% HBOT vs 28% control). Ultimately, evidence is insufficient and more studies are needed to prove effectiveness (2004). A limitation to the trials in the review is the failure to include medical factors in each patient that could mask or enhance outcomes.
 - Daly et al.'s 2018 article showed evidence for neuroprotective effects of HBOT after TBI, reporting reduced lesion size, severity, brain water content, and apoptosis.
 - Figuroa et al.'s 2016 article demonstrates B-level evidence for the use of HBOT as an effective treatment in mild to moderate TBIs/persistent post-concussion syndrome (PPCS) at pressures less than 2 ATA. Limitations to this study includes the use of low levels of pressurized air in the placebo/sham groups.
 - HuQ et al.'s review supports neuroprotective effects with HBOT when administered at pressures less than 3 ATA. However, due to the heterogeneity of human TBIs, the efficacy of HBOT remains controversial (2016).
- Safety and Side Effects of Hyperbaric Oxygen Therapy**
 - Ultimately, under 3 ATA of pressure, side effects greatly decreased (HuQ et al. 2016)
 - Seizures, neurologic deterioration, and pulmonary impairment were reported in McDonagh et al.'s systemic review
 - Hadanny et al. identifies central nervous system oxygen toxicity, lung toxicity, and claustrophobia as some possible side effects of HBOT.
 - John Hopkins Medicine identifies common side as fatigue and lightheadedness. Also notes lung damage, middle ear rupture, sinus damage, vision changes, and oxygen poisoning. Preexisting conditions increase the risk of adverse events (history of lung disease, recent viral illness, recent fever, recent ear surgery or injury, and history of claustrophobia) (2019).
 - Mayo Clinic identifies potential risks as myopia, middle ear injuries, barotrauma, seizures, and a risk of fire in the oxygen-rich environment (2018).

Discussion

- In adult patients with a traumatic brain injury, does treatment with hyperbaric oxygen therapy as compared to no hyperbaric oxygen therapy improve recovery and cognitive outcomes?
- Supportive of efficacy**
 - Barrett et al. demonstrated efficacy of HBOT through a decrease in unfavorable outcomes and death as well as lower ICPs.
 - Crawford et al. concluded that HBOT showed no efficacy in those with mild TBIs, however moderate-severe TBIs showed mixed results that ultimately favored HBOT compared to "standard care" (2017).
 - Daly et al. notes evidence for neuroprotective effects of HBOT after TBI, reporting reduced lesion size, severity, brain water content, apoptosis, reduce blood-brain barrier permeability, increased neuronal density, neuronal integrity, neurogenesis, and axonal integrity (2018).
 - Figuroa et al. demonstrates B-level evidence for less than 2 ATA HBOT as an effective treatment in mild to moderate TBIs showing protective measures against neuronal loss (2016).
- Unsupportive of efficacy and lacking evidence**
 - McDonagh et al. in 2004 as well as Wolf et al. in 2015 failed to show statistical differences between the groups exposed to HBOT and the control group through evaluation of cognitive testing, brain checkers, and PTSD checklists.
 - A 2016 Wang et al. study reported that GCS scores were increased in the HBOT group as compared to the control group however PTSD scores had no significant change.
 - Huq et al. and Guedes et al. identified neuroprotective effects at pressures less than 3 ATA in clinical trials of TBIs, however after extensive trials the efficacy of HBOT still remains controversial. Both note the use of HBOT in TBI patients is lacking evidence of clinical effectiveness at this time (2016).
- The review of the literature ultimately demonstrates that although some studies show improvement of TBIs with the use of HBOT, there is not yet enough consistent evidence to claim the overall efficacy of HBOT in the treatment of TBIs.**

Figure 1. MRI Improvement of CBF, CBV, and MTT shown before and after HBOT in Tal et al. clinical studies (2015).



Tal, S., Hadanny, A., Berkovitz, N., & Sasson, E. (2015). Hyperbaric oxygen may induce angiogenesis in patients suffering from prolonged post-concussion syndrome due to traumatic brain injury. *Restorative Neurology and Neuroscience*, 33(6), 943-951. <https://doi.org/10.3233/rnn-150585>

Applicability to Clinical Practice

- TBIs can be very difficult to treat due to their complexity, thus further knowledge of potential treatment options, such as HBOT, is important.
- HBOT may not be a first-line treatment for TBIs, but it can be considered as a possible adjunct or alternative when rehabilitation and therapy are not providing patients with their desired results.
- Despite insufficient evidence to support the use of HBOT in TBIs, many patients have found benefit from HBOT as an adjunct or primary treatment for treating their head injury.
- Patient need to be educated on the possible side effects and risks, as they are very real and can decrease quality of life.
- If patients are appropriately educated and informed of what HBOT entails, HBOT will remain an experimental treatment that can be trialed in those hoping to see an overall improvement in their recovery and cognitive function after suffering from a traumatic brain injury.

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