Traumatic Brain Injuries and the Potential of Hyperbaric Oxygen Therapy

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"The cost of Traumatic Brain Injuries (TBI) is approximately $56 billion, and more than 5 million Americans alive today have had TBI related injury resulting in a permanent need for help in performing daily activities. Survivors of TBI are often left with significant cognitive, behavioral, and communicative disabilities, and some patients develop long-term medical complications, such as epilepsy." (National Institutes of Neurological Disorders and Stroke, NIH, 2010)

INTRODUCTION

Traumatic Brain Injuries (TBI) are becoming one of the leading causes of death and life-long disabilities in infants, adolescents, adults and senior citizens [(1)]. Consequently, there is an increasing concern among parents and health care providers regarding the prevalence of brain injuries in commonly practiced sports; car related accidents, worker injuries as well as increasing number of brain-injured soldiers returning from war theaters. Approximately 1.7 million Americans will experience a brain injury annually, with ~80% of those patients diagnosed with mild-to-moderate TBI [(1)]. Limited medical and technological tools to address this urgent concern have created a strong need to develop new approaches to treat TBI sufferers.

Hyperbaric Oxygen Therapy (HBOT) has been used for more than a 100 years to increase oxygen intake in damaged or oxygen-starved tissues. By increasing atmospheric pressure around the damaged tissue and applying 100% oxygen, the total amount of oxygen in the blood and organs increases, ensuring that all cells are supplied with this life sustaining gas.

Evidence of the benefits of HBOT in the treatment of Traumatic Brain Injury has been accumulating for the last 30 years with encouraging results. Recent clinical reports and animal studies support the idea that patients with mild-to-moderate brain injury can greatly accelerate their recovery and reverse damage with HBOT. Currently medications focus on controlling brain injury symptoms rather than brain recovery. HBOT has shown positive benefits for mild-to-moderate TBI now and can reverse damage that is untreatable with drugs.

What is Traumatic Brain Injury?

Traumatic brain injury is defined as brain damage that results in the disruption or loss of some of its functions. One of the reasons for such a broad definition for TBIs is the variety of different accidents that can produce this trauma. Sports injuries, car accidents, work accidents and blast wounds can result in a very complex pattern of brain damage and behavioral changes [(2-6)], making TBI difficult to diagnose and treat.

In the U.S. alone approximately 2 million cases of mild-to-moderate TBI go unreported yearly, with 1.7 million people being admitted into hospitals and resulting in annual deaths of 50,000 per year [(1, 15-18)]. A subset of TBI called Sports Brain Injury (SBI), is responsible for 300,000 hospital admissions [(19)], highlighting the ease by which TBIs can be sustained in everyday sports activities. Not included in the statistics above are armed service men and women that are returning to the nation with serious brain trauma. Current estimates are that 360,000 are now suffering from traumatic brain injuries, creating a significant social and mental health issue (20). To put this in perspective, it is estimated that a minimum of 1% of the U.S. population is suffering from mild-to-moderate TBI [(15, 21)] with inadequate medical support and complete lack of awareness about this national problem.

TBI can be divided into four major types of injury: blunt (a blow to the head), penetrating (material entering past the skull), blast (shock waves compressing the brain) and toxins (chemicals, drugs or gases

directly affecting the brain). Damage caused by TBIs includes, among others, loss of neuronal connections [7-9], brain bruising, swelling, bleeding into the brain [9, 10] and direct disruption of neuron functions [11-14].

For those that suffer from mild-to-moderate TBI, the clinical symptoms may range from depression [22-24], blurred vision [25], headaches, impaired decision making, diminished motor skills [26-28] and post-traumatic stress disorder [29]. Associated with the direct suffering of individuals are the societal and economic costs of TBIs. Current estimates are that $50-60 billion a year are lost due to medical costs and lost productivity [1, 30], coupled to the incalculable emotional turmoil and distress that directly affects the sufferer of TBI and those around them.

Why Use Hyperbaric Oxygen Therapy?

Hyperbaric oxygen therapy (HBOT) has been in use for over 100 years, safely treating a variety of medical condition [31-33]. HBOT is a treatment in which the entire body is exposed to 100 % oxygen under increased pressure. By augmenting total gas pressure, oxygen levels in all body organs can be increased dramatically [31, 33] sparing and maintaining organs that are oxygen deprived, removing obstructions in blood flow caused by gas bubbles, and inhibiting certain types of bacteria [34-36].

Recent studies reveal that HBOT has other beneficial effects. In TBI studies of rats and mice treated with HBOT, behavioral and neurological damage is spared or reversed [37-44]. In humans, clinical reports show similar effects. Armed service personnel that were diagnosed with mild-to-moderate TBI shows that repeated HBOT exposures produce beneficial effects in terms of brain functioning [45, 46]. Single photon emission computer tomography (SPECT) imaging of TBI - affected brain regions reveals improvement in brain blood flow. From a neuro- psychological viewpoint, changes observed in the SPECT imaging of the brain correlates with improved mental conditions [46, 47]. Psychological and cognitive tests taken prior to HBOT reveal improvements in almost all areas during and after HBOT. Symptoms, such as headaches, disturbed sleep and PTSD (Post Traumatic Stress Disorder) are alleviated [45-47] and positive outcomes are long-lasting.

How is it that a single therapy can produce such remarkable changes? Given the role that oxygen plays in the cellular function of the brain, it should not be surprising that HBOT provides healing and protection. HBOT probably produces all these beneficial effects though multiple, parallel pathways. In rats, data demonstrates that HBOT promotes new neuron [48] and blood vessel regrowth [49-51]. Cellular metabolism and cell survival is improved [11, 13, 52] and cellular death [40, 52] is inhibited. Inflammation of the brain after TBI is a common response to damage [53], but inflammation is reduced [54] by HBOT, as well as brain bleeding [55, 56] and brain swelling [14, 57]. It is still not known if these are all the benefits that HBOT provides or just the most obvious that have been observed to date. It seems apparent that the synergistic effect that HBOT has with other treatments [58, 59], strongly suggests that combining therapies with HBOT could yield better results than either alone.

Treating TBI with HBOT

Patients with TBI or SBI have few options for rehabilitation. Drug treatments have been inadequate to provide significant recovery [60, 61], and no proven treatments emerging in the last 30 years have been considered to be effective [21]. In almost all cases, the proper course of action is to provide mental and physical rehabilitation, expecting for healing to occur spontaneously. Doctors and patients are looking for alternative treatments and HBOT is emerging as an attractive and effective alternative. Given the large number of military personnel and civilians suffering from TBI or SBI, the field of HBOT offers a potential to alleviate symptoms and reverse damage with minimal risk. Recent advances in diagnostic tests, brain imaging and telemetry for assessing trauma to the body and brain, will improve targeting specific TBI and SBI lesions for HBOT. In the near future, as advances in drug therapy or other alternatives come into play, the integration of HBOT and drug, physical or behavioral treatments could provide better prognosis for recovery to all forms of TBI that are considered today too severe to heal.

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