HBOT RESEARCH AND SCIENCE

MOST RECENT RESEARCH

[a] Xavier A. Figueroa, PhD and James K. Wright, MD (Col Ret), USAF Hyperbaric Oxygen: B-Level Evidence in Mild Traumatic Brain Injury Clinical Trials. Neurology® 2016;87:1–7 "There is sufficient evidence for the safety and preliminary efficacy data from clinical studies to support the use of HBOT in mild traumatic brain injury/ persistent post concussive syndrome (mTBI/PPCS). The reported positive outcomes and the durability of those outcomes has been demonstrated at 6 months post HBOT treatment. Given the current policy by Tricare and the VA to allow physicians to prescribe drugs or therapies in an off-label manner for mTBI/PPCS management and reimburse for the treatment, it is past time that HBOT be given the same opportunity. This is now an issue of policy modification and reimbursement, not an issue of scientific proof or preliminary clinical efficacy."

[b] DJ Eve, MR Steele, PR Sanberg, Cesar V Borlongan. Hyperbaric oxygen therapy as a potential treatment for post-traumatic stress disorder associated with traumatic brain injury. Neuropsychiatric Disease and Treatment 2016:12 2689–2705. "A proportion of the returning soldiers also suffer from post-traumatic stress disorder (PTSD), and in some cases, this may be a consequence of TBI. . . . a possible therapeutic candidate is hyperbaric oxygen therapy (HBOT). Some clinical trials have been performed which suggest benefits with regard to survival and disease severity of TBI and/or PTSD. . . . HBOT has been shown to reduce apoptosis, upregulate growth factors, promote antioxidant levels, and inhibit inflammatory cytokines in animal models, and hence, it is likely that HBOT could be advantageous in treating at least the secondary phase of TBI and PTSD."

[c] Amir Hadanny & Shai Efrati (2016): Treatment of persistent post-concussion syndrome due to mild traumatic brain injury: current status and future directions, Expert Review of Neurotherapeutics, DOI: 10.1080/14737175.2016.1205487. Persistent post-concussion syndrome caused by mild traumatic brain injury has become a major cause of morbidity and poor quality of life. Unlike the acute care of concussion, there is no consensus for treatment of chronic symptoms. Moreover, most of the pharmacologic and non-pharmacologic treatments have failed to demonstrate significant efficacy on both the clinical symptoms as well as the pathophysiologic cascade responsible for the permanent brain injury. This article reviews the pathophysiology of PCS, the diagnostic tools and criteria, the current available treatments including pharmacotherapy and different cognitive rehabilitation programs, and promising new treatment directions. A most promising new direction is the use of hyperbaric oxygen therapy, which targets the basic pathological processes responsible for post-concussion symptoms; it is discussed here in depth.

[d] Baughman Shively, S., Iren Horkayne-Szakaly, Robert V Jones, James P Kelly, Regina C Armstrong, Daniel P Perl. Characterisation of interface astroglial scarring in the human brain after blast exposure: a post-mortem case series. The Lancet, Neurology, June 2016. DOI: http://dx.doi.org/10.1016/S1474-4422(16)30057-6. In what is being called a breakthrough study, Dr. Daniel P. Perl and his team at the Uniformed Services University of the Health Sciences in Bethesda, Md., [the medical school run by the Department of Defense], have found evidence of tissue damage caused by blasts alone, not by concussions or other injuries. The New York Times calls it the medical explanation for shell shock: preliminary proof of what medicine has been saying without proof for nearly 100 years -- blasts cause physical damage, and this physical damage leads to psychological problems, i.e., PTSD. The importance of this admission cannot be overstated: this is a DOD discovery with documented evidence that blast injury [IEDs, breeching, whether in training or combat, enemy and/or friendly fire] can lead
directly to physical brain damage and the accompanying effects, many of which have been heretofore diagnosed as "only PTSD."


[f] E.G. Wolf, L.M. Baugh, C.M.S. Kabban, et al. Cognitive function in a traumatic brain injury hyperbaric oxygen randomized trial. UHM 2015, Vol. 42, No. 4, 2015. Dr. Wolf is a principle co-author of the first Army study. This recent USAF paper reanalyzing the data in the cornerstone DOD/VA/Army study concludes: "This pilot study demonstrated no obvious harm [and] both groups showed improvement in scores and thus a benefit. Subgroup analysis of cognitive changes and PCL-M results regarding PTSD demonstrated a relative risk of improvement . . . . There is a potential gain and no potential loss. The VA/Clinical Practice Guidelines define a “B evidence rating” as “a recommendation that clinicians provide (the service) to eligible patients. At least fair evidence was found that the intervention improves health outcomes and concludes that benefits outweigh harm. . . .[emphasis added] Hyperbaric oxygen therapy for mild traumatic brain injury and PTSD should be considered a legitimate adjunct therapy if future studies demonstrate similar findings or show comparable improvement to standard-of-care or research-related treatment modalities."
[NOTE: subsequent worldwide studies already published and those underway show comparable improvements.]

[g] Leila H Eadie (editorial). New technology and potential for telemedicine in battlefield brain injury diagnostics. Concussion (2016) 1(4), CNC22. "In severe cases, [TBI] injury occurs due to bleeding and inflammation, having several different effects: contact with blood causes brain tissue to swell (cerebral edema), and pooled blood within the confines of the skull also puts pressure on nearby tissue, constricting blood flow and depriving the brain of oxygen, killing neurons and leading to a chemical cascade that reinforces the injury. . . . People suffering from TBI can deteriorate suddenly and die, and in some cases swift treatment can help reduce mortality. Others will have minor initial symptoms, yet untreated brain hemorrhage can have insidious long-term effects. The etiology of postconcussive syndrome is debated, but may be caused by diffuse axonal injury or persistent metabolic alterations resulting in neuronal dysfunction and develops in 38–80% of patients with TBI...."

indicate progression of symptom severity beyond one year after injury . . . . We believe that by being informed from longitudinal studies such as this one, the medical community can be proactive in combating the potentially negative and extremely costly effect of these wartime injuries."


Groundbreaking research from Washington State University found that hyperbaric oxygen treatment (HBOT) can halve the pain and symptoms of opiate withdrawal/detox.

1. Peer-reviewed published articles


2. **Data from NBIRR-01 observational study**

3. **Peer-reviewed Israeli research on stroke and TBI, neurogenesis and angiogenesis**
[a] Hyperbaric Oxygen Therapy Can Improve Post Concussion Syndrome Years after Mild Traumatic Brain Injury - Randomized Prospective Trial
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0079995

[b] Hyperbaric Oxygen Induces Late Neuroplasticity in Post Stroke Patients - Randomized, Prospective Trial
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0053716


[e] Reflections on the neurotherapeutic effects of hyperbaric oxygen

4. **Animal studies showing positive effects of HBOT on brain injury**
http://online.liebertpub.com/doi/abs/10.1089/neu.2012.2510


5. Expert Opinion

[a] "What the *Bleep* is going on with Hyperbaric Oxygen Therapy?" Brain Health and Healing Foundation. Xavier Figueroa. PhD has been performing neurological clinical research since 1995 in the field of Alzheimer’s research, as well as basic research in neuron biology, cancer research, bioengineering and the biophysics of water in cells. He has a long history of involvement with research using hyperbaric oxygen therapy for brain injury.

** http://brainjury.org/blog/2014/05/01/what-the-bleep-is-going-on-with-hyperbaric-oxygen-therapy/
** http://brainjury.org/blog/2014/07/03/what-the-bleep-is-wrong-with-the-dodva-hbot-studies/

[b] UHM 2012, Vol. 39, No. 4 – How many deaths will it take? AN EDITORIAL PERSPECTIVE. Undersea & Hyperbaric Medical Society, Inc. How many deaths will it take till they know? Monkeys, madmen and the standard of evidence. George Mychashkiw II, DO, FAAP, FACOP, Editor-in-Chief Chair, Department of Anesthesiology, Nemours Children’s Hospital, Orlando, Florida USA. The Journal of Hyperbaric Medicine is the most prestigious journal on Hyperbaric Medicine in the world. . . . . ."Hyperbaric oxygen is a safe, easily used treatment that, in many cases, has resulted in a dramatic improvement in the symptoms of patients with [TBI]. Every day we are.... gathering more data validating its efficacy.... I feel , as do many of my colleagues, that there is sufficient clinical and research evidence to justify the use of [HBOT] as a standard-of-care treatment for [TBI] that should be reimbursed by CMS and Tricare.... I have no doubt that, over the next several years, [HBOT] will be proven beyond a reasonable doubt to be one of the most effective treatments for [TBI].... There is a preponderance of evidence now to justify the use and funding for the treatment....”


6. Data from DoD/Army studies, with responses

Summary of positive findings in Army Studies: Army medicine has run trials investigating the use of Hyperbaric Oxygen to treat and help heal Traumatic Brain Injury. They have shown that HBOT is both safe and effective: "Randomization to the chamber . . . . offered statistical and in some measures clinically significant improvement over local routine TBI care." Also: ".... total scores for [both] groups revealed significant improvement over the course of the study for both the sham-control group .... and the HBO2 group......" Expert outside consultants to DOD declared that "[HBOT] is a healing environment."

http://biawa.org/docs/pdf/MTBI%20PCS%20%20Neurotrauma%202012.pdf


7. Validating SPECT Scans to diagnose HBOT treatment before-and-after brain states

8. BLAST INJURY BIBLIOGRAPHY


Fox, TM. *Reflections on Blast Incident*, September 2014. Correspondence.

Hooker, D.H. *Physiological Effects of Air Conussion*. The American Journal of Physiology, Vol 67, No. 2. From the Physiological Laboratory of Johns Hopkins University, Baltimore MD, January 1, 1924.


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Johns Hopkins reports that the brains of Iraq and Afghanistan combat veterans who survived blasts from improvised explosive devices and died later of other causes show a honeycomb of broken and swollen nerve fibers in critical brain regions, including those that control executive function. The pattern is different from brain damage caused by car crashes, drug overdoses or collision sports, and may be the never-before-reported signature of 'shell shock' suffered by World War I soldiers. http://www.sciencedaily.com/releases/2015/01/150114140600.htm

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Blast injury, and the accompanying role of air embolism in invisible wounds to the brain, is still not widely studied and thus seldom treated. Hyperbaric Oxygen Therapy is recognized worldwide as the definitive treatment for air embolism. **Air/gas embolism is already an on-label, approved indication for HBOT.**
This is a page out of the Textbook of Military Medicine, updated in 2006; this same algorithm is in the textbook in the 1980s. The "definitive therapy" then and is HBOT treatment for TBI.

**The Management of Primary Blast Injury**

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**Fig. 9-10** Algorithm for the evaluation of neurological abnormalities in a blast casualty

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Textbook of Military Medicine - Series on Combat Casualty Care Part 1 Volume 6 pg 511 Conventional Warfare: Ballisticos Blast and Burn injuries authored by the office of the Surgeon General Department of the Army, United States Armed Forces Medical Corps

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Printed in the United States 2006
Figure 1: Schematic diagram of the mechanisms of blast-related traumatic brain injury

Figure shows local effects (1–7) and systemic effects (8, 9) of primary blast injury, secondary blast injury (10–12), tertiary blast injury (13), quaternary blast injury (14), and portals for blast wave transmission to the brain (15, 16).

1. Acoustic impedance mismatch causes spallation.
2. Shock-bubble interaction.
4. Cavitition.
5. Skull deformation with elastic rebound.
6. Reflection of the blast wave within the skull.
8. Blood surge from the torso damages the microvasculature.
9. Air embolism from blast lung injury.
10. Penetrating fragments.
11. Compound fractured skull.
12. Intracerebral haemorrhage.
13. Contrecoup contusion.
15. Blast wave transmitted through the orbits.
16. Blast wave transmitted through the nasal sinuses.

14 on-label indications for HBOT are already approved and insured

1. **Air or Gas Embolism**
2. **Carbon Monoxide Poisoning**
   Carbon Monoxide Poisoning Complicated By Cyanide Poisoning
3. **Crush Injury, Compartment Syndrome and Other Acute Traumatic Ischemias**
4. **Decompression Sickness**
5. Arterial Insufficiencies:
   - **Central Retinal Artery Occlusion**
5.1. Enhancement of Healing In Selected Problem Wounds
6. Clostridial Myositis and Myonecrosis (Gas Gangrene)
7. Severe Anemia
8. Intracranial Abscess
9. Necrotizing Soft Tissue Infections
10. Osteomyelitis (Refractory)
11. Delayed Radiation Injury (Soft Tissue and Bony Necrosis)
12. Compromised Grafts and Flaps
13. Acute Thermal Burn Injury
14. Idiopathic Sudden Sensorineural Hearing Loss (Approved on October 8, 2011 by the UHMS Board of Directors)

** These indications are similar to conditions found in brain injury