BRAIN DAMAGE FROM BLAST AND SONIC WAVE INJURY

DOD/VA/Army medicine confirmed in June 2016 with solid science and objective physical evidence that blast injuries cause physical wounds to the brain. Formerly "invisible wounds" have been revealed through post-mortem autopsies to be both visible damage through Traumatic Brain Injury (TBI) as well as probable cause for secondary symptoms of PTSD and other debilitating, life-altering behavior. The implication of the finding is that those wounds should be and can be healed through application of "wound-healing" protocols in place for decades. And the stunning reality is that there is a treatment that is proved with similar scientific evidence to be an already approved indication for wound healing: Hyperbaric Oxygen Therapy.

Consider: We now know that blast injury is a physical wound to a body organ, the brain. Blast waves to the body, with or without unconsciousness, result in an immediate and significant metabolic crisis for the now wounded brain. Studies are underway to better link the acute pathobiology of blast and sonic wave injury with potential mechanisms of chronic cell death, dysfunction and neurodegeneration. Current findings about blast injury point to disruptions in cellular processes that may underlie long term impairment. In a phrase, blast injuries and concussion are physical wounds which can't yet be "seen" in life, but are accompanied by symptoms which can be observed. Physiological damage -- ripping and tearing and shearing and bleeding and bruising and swelling -- lead to chaos in the head and link to clinical characteristics of concussion: balance problems, migraine symptoms, cognitive impairment and numerous other observable and measurable dysfunctions, and vulnerability to repeat injury. Concussions are physically damaging, a wound that must be treated the way we know how to treat wounds we can see. Treatments of the physical injury that can interrupt this damaging cascade of degeneration should be implemented immediately.

Medicine has well-known explanations of the nature of wounds and the phases in wound healing. The so-called "concussion cascade" that follows the wound to the head creates conditions that impede healing in the closed, heretofore unseen environment inside the skull. A blast or jolt to the head begins a series of negative consequences. These can include: inflammation; interrupted blood flow; oxygen starvation/hypoxia; tissue and nerve fiber ripping and tearing; cell stunning/ inactivation and/or cell death. This insidious biological set of degenerative processes may or may not lead to permanent damage. This acute inflammation phase is the body’s natural response to injury. After initial wounding, the blood vessels in the wound bed contract and a clot is formed. Blood vessels then dilate to allow essential cells, antibodies, white blood cells, growth factors, enzymes and nutrients to reach the wounded area. Unlike with a wound that can be seen, there is solid evidence that this brain inflammation can continue and linger for a long time, impeding healing and increasing the likelihood that more physical damage is occurring and is likely to occur. It has been "common knowledge" that most blast injuries and concussions heal themselves. That is far too simplistic. What may be true is that symptoms abate. Yet damage that can lead to mental and physical degeneration may lead to lingering symptoms and chronic degeneration.

The logical extension of the DOD/VA/Army findings in the LANCET article is that we must treat the wound to the brain using wound-healing protocols.

Wound Healing. The use of Hyperbaric Oxygen Therapy (HBOT) addresses directly this negative cascade of damage and degeneration both in the acute phase of wound stabilization and in the acute and chronic phases of wound healing. Consider the known benefits of using HBOT for wound healing:

- Decreasing levels of inflammatory biochemicals
- Increased oxygenation to functioning mitochondria
- Increases in blood flow independent of new blood vessel formation
- Angiogenesis from the addition of oxygen: (growth of new blood vessels in the acute and chronic phases)
- Up-regulation of key antioxidant enzymes and decreasing oxidative stress
- Increased production of new mitochondria (the energy factories of the cells)
- Neurogenesis: (growth of new neuronal tissue and Remyelination during and after the treatments are completed)
- Bypassing functionally impaired hemoglobin molecules, the result of abnormal porphyrin production, thereby allowing increased delivery of oxygen directly to cells
- Improvement in immune and autoimmune system disorder
- Direct production of stem cells in the brain
- Increases in the production of stem cells in the bone marrow with transfer to the Central Nervous System

The validity of using HBOT for healing the wound to the brain is validated in the most recent research. Unsurprisingly, delivering oxygen under pressure safely and economically leads to effective wound healing. And numerous other interventions for comorbid maladies have a much better chance of effectiveness when the concussion cascade is interrupted and reversed.

[a] 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 from personal weapons and such systems as the Carl Gustav recoilless rifle] can lead directly to physical brain damage and the accompanying effects, many of which have been heretofore diagnosed as "only PTSD."

[Commentary on above: Robert F. Worth."What if PTSD is More Physical Than Psychological?," The New York Times Magazine, June 10, 2016. http://nyti.ms/1TYYp6U **A new study supports what a small group of military researchers has suspected for decades: that modern warfare destroys the brain.**

[Additional commentary on above]: Alexander, Caroline. "Mystery of How Battlefield Blasts Injure the Brain May Be Solved. **A landmark study sheds new light on the damage caused by "blast shock"—the signature injury of wars for more than a century."** *National Geographic.* JUNE 9, 2016 http://news.nationalgeographic.com/2016/06/blast-shock-tbi-ptsd-ied-shell-shock-world-war-one/

[b] 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."**

[c] Wang F, et al. *Hyperbaric oxygen therapy for the treatment of traumatic brain injury: a meta-analysis.* Neurol Sci. 2016 Jan 8. PubMed PMID: 26746238. **"Compelling evidence suggests the advantage of hyperbaric oxygen therapy (HBOT) in traumatic brain injury. …Patients undergoing hyperbaric therapy achieved significant improvement….with a lower overall mortality, suggesting its utility as a standard intensive care regimen in traumatic brain injury."**

[d] 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.]

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

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.

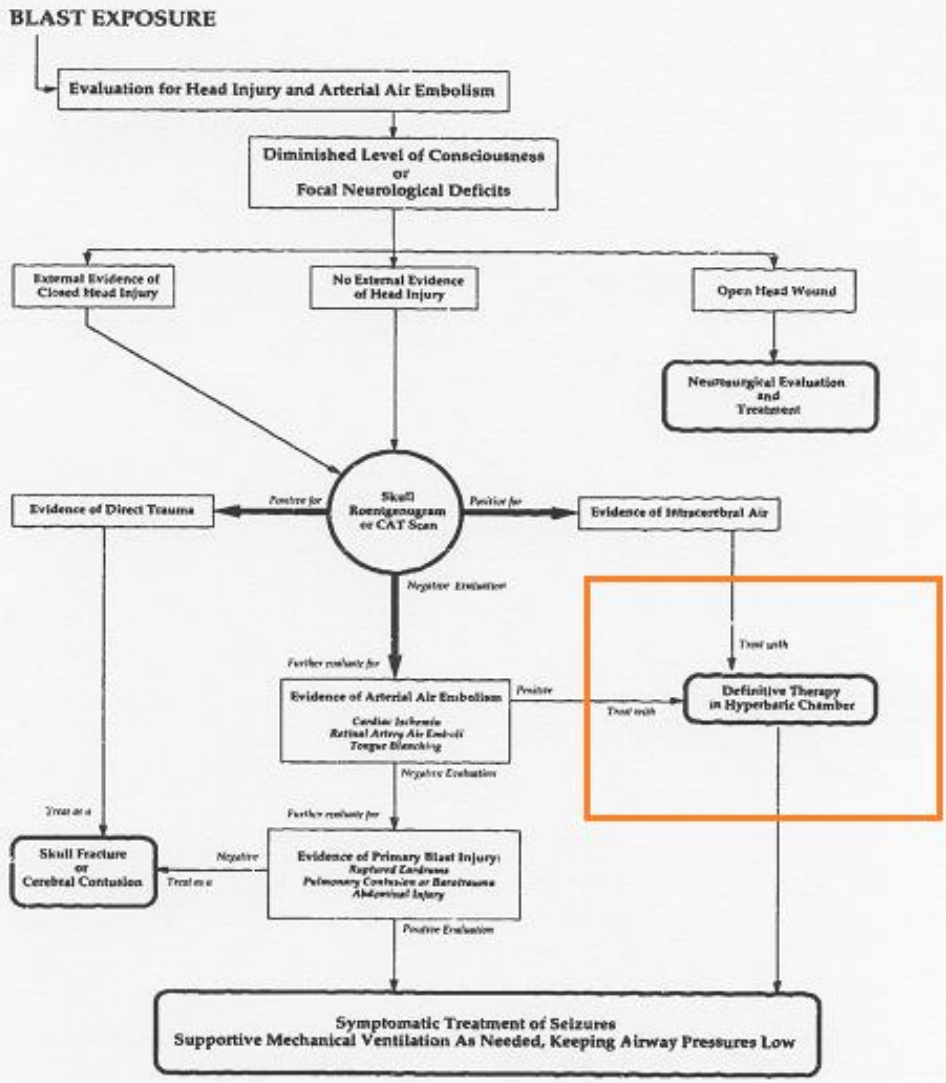

Fig. 9-10 Algorithm for the evaluation of neurological abnormalities in a blast casualty

Textbook of Military Medicine - Series on Combat Casualty Care Part 1 Volume 6 pg 313 Conventional Warfare : Ballistics Blast and Burn Injuries Published by the Office of the Surgeon General Department of the Army, United States of America- Editor in Chief Colonel Russ Zajtchuk, MC U S Army, Deputy Commander, Walter Reed Army Medical Centre . Managing Editor Donald P Jenkins PhD Uniformed Services University of the Health Sciences.
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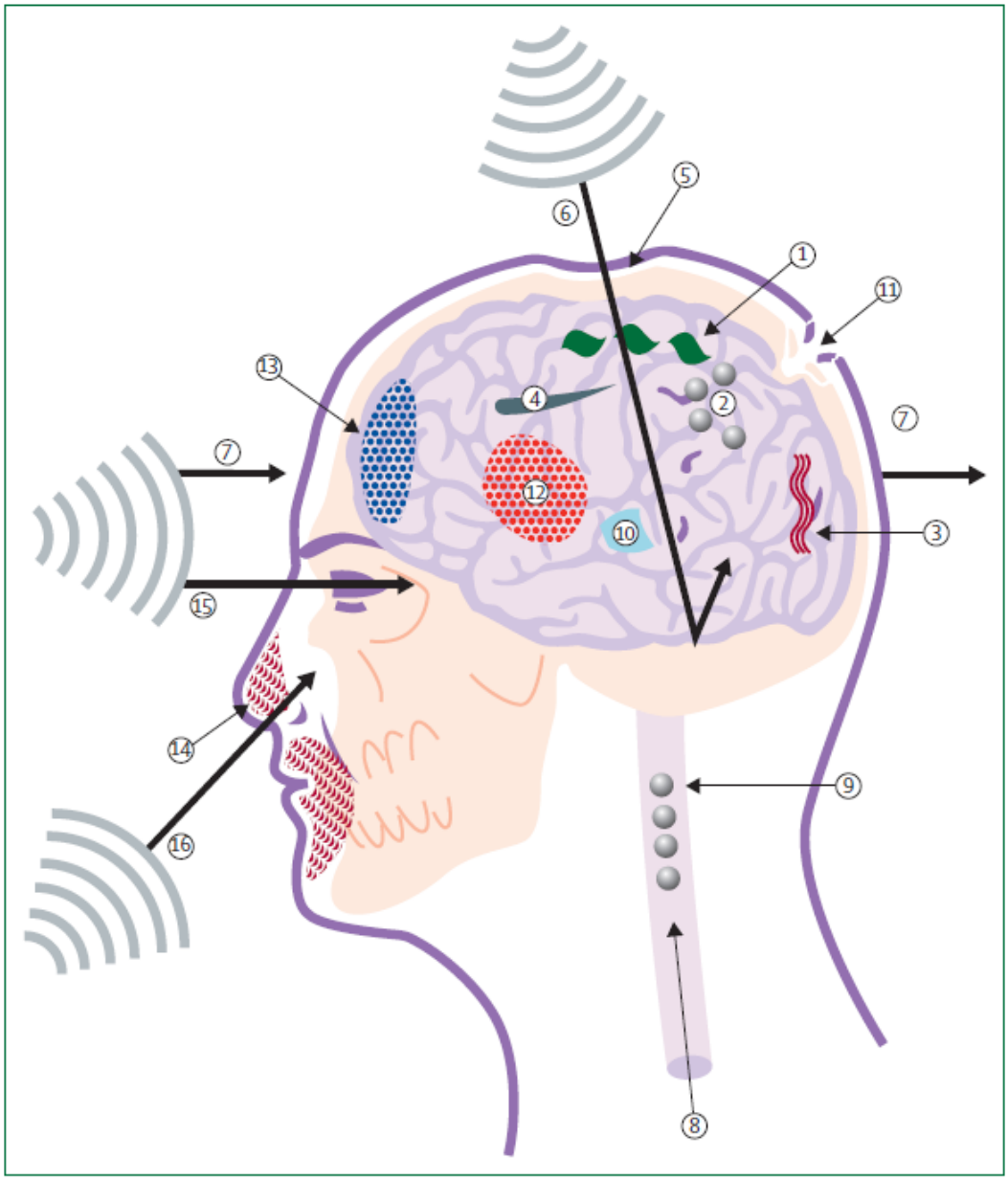
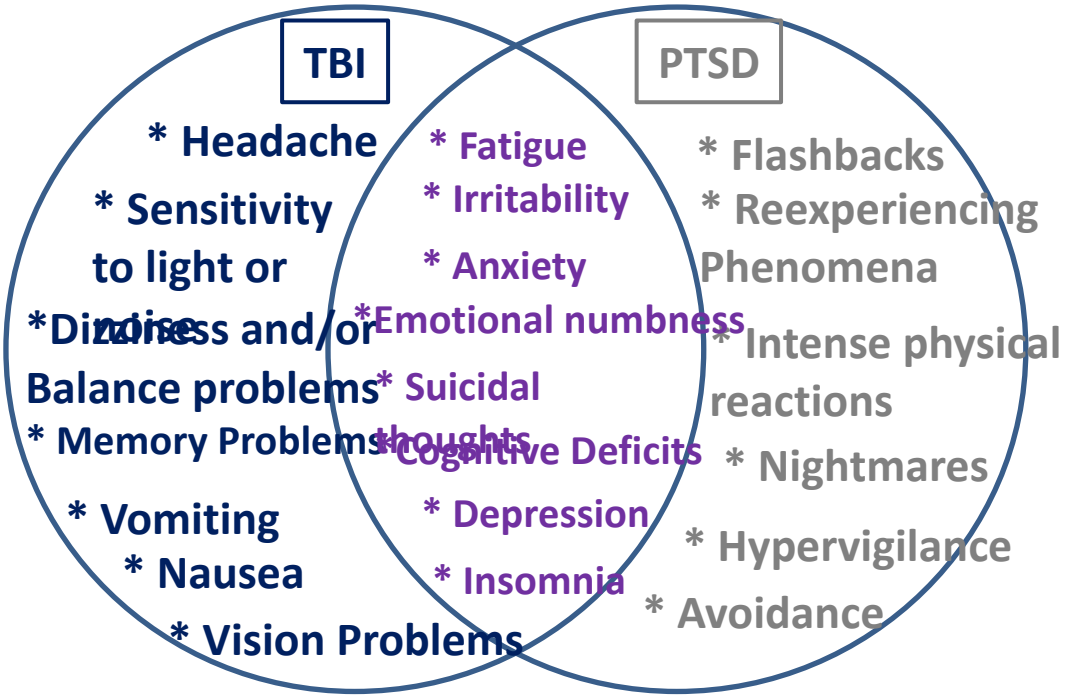


***Figure 1*: Schematic diagram of the mechanisms of blast-related traumatic brain injury**
Figure shows local effects (1–7) and systemic effects (8, 9) of primary blast injury, secondary blast injury (10–12), tertiary blast injury (13), quaternary blast injury (14), and portals for blast wave transmission to the brain (15, 16). (1) Acoustic impedance mismatch causes spallation. (2) Shock-bubble interaction. (3) Shear stress causing diffuse axonal injury. (4) Cavitation. (5) Skull deformation with elastic rebound. (6) Reflection of the blast wave within the skull. (7) Bobblehead effect of acceleration–deceleration. (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. (14) Burns. (15) Blast wave transmitted through the orbits. (16) Blast wave transmitted through the nasal sinuses.

Blast-related traumatic brain injury. Jeffrey V Rosenfeld, et al ***Lancet Neurol*** 2013; 12: 882–93 July 22, 2013 http://dx.doi.org/10.1016/S1474-4422(13)70161-3

TBI and PTSD



Traumatic Brain Injury (TBI) is now recognized as a causative factor for hormonal deficiencies associated with PTSD and personality changes. Psychological, physiological, and physical manifestations in addition to above include: mood swings, bouts of anger, inability to concentrate, learning disabilities, sleep deprivation, increased risk for heart attacks, strokes, high blood pressure, diabetes, loss of libido, menstrual irregularities, pre-mature menopause, obesity, loss of lean body mass, muscular weakness, and a number of other medical conditions that can arise subsequent to head trauma.