Blast traumatic brain injury

- Advancing next-generation brain organoid platforms for investigating traumatic brain injury from repeated blast exposures
- Identification of Serum Biomarkers for Blast-induced Traumatic Brain Injuries: Low vs. High-intensity Exposure in a Rat Model
- Assessment of White Matter Changes Using Quantitative T1rho Mapping in an Open-Field Low-Intensity Blast Mouse Model of Mild Traumatic Brain Injury (mTBI)
- Association between traumatic brain injury and risk of developing infections in the central nervous system and periphery
- Post-Concussion Syndrome Following Blast Injury: A Cross-Sectional Study of Beirut Blast Casualties
- Metabolic Imaging of Hyperpolarized [1-(13)C]Pyruvate in a Ferret Model of Traumatic Brain Injury
- Repeated Exposures to Air Travel-Relevant Hypobaria Induce Anxiety-Like Behavior and Alter Functional Connectivity and White Matter Integrity in a Ferret Model of Traumatic Brain Injury
- The Essential Role of Immunomodulatory Tregs in Visual Deficits After Military-Relevant Trauma

“Blast traumatic brain injury,” often abbreviated as “bTBI,” refers to a type of brain injury that occurs as a result of exposure to a blast or explosion. This injury happens when the force of the blast wave, shockwave, or other effects of the explosion impact the head and cause damage to the brain. It's a specialized area of study within traumatic brain injuries because the mechanisms and effects of blast-related injuries can be different from those caused by other types of accidents or trauma.

Epidemiology

Per Defense and Veterans Brain Injury Center [1]. (DVBIC) statistics, 383 947 individuals within the Department of Defense (DoD) sustained a TBI from 2001 to 2018, more than one-third of whom were exposed to a blast event [2] [3].

Mechanism of injury

In blast traumatic brain injuries, the brain can be injured in various ways, including:

Direct Impact: The force of the blast can cause the brain to collide with the inside of the skull, leading to damage.

Pressure Changes: The rapid change in air pressure during an explosion can affect the brain's function and structure.

Secondary Injuries: Flying debris, shrapnel, or objects propelled by the blast can also cause head injuries and contribute to brain damage.

Tertiary Injuries: Individuals may be thrown or displaced by the force of the blast, resulting in additional injuries, including head trauma.

These injuries can range from mild concussions to severe and life-threatening brain damage. Studying blast traumatic brain injuries is important for developing better treatments and prevention strategies, especially for military personnel, first responders, and individuals exposed to explosive events.

Blast traumatic brain injury (bTBI) affects civilians, soldiers, and veterans worldwide and presents significant health concerns. The mechanisms of neurodegeneration following bTBI remain elusive and current therapies are largely ineffective.

Injury mechanism and treatment of blast traumatic brain injury has not made a breakthrough so far. Previous reports demonstrate autophagy is involved in regulating the pathophysiological process after traumatic brain injury. Therefore, a study explored whether autophagy was activated after blast traumatic brain injury. A total of 108 mice were divided randomly into six groups: 6 h, 1 d, 3 d, 7 d, 14 d after bTBI groups and sham group. The protein levels of anti-microtubule associated protein 1 light chain 3B (LC3B, hereafter referred to as LC3), beclin1, and p62 were detected using western blot. Moreover, HO-1 and Nrf2 were localized using histologic staining. Immunofluorescence of LC3 and immunohistochemistry of beclin1 were performed. The autophagy-related ultrastructure was observed by TEM. LC3-II and beclin1 reached their peak on day 3 after bTBI, while p62 showed a continuous downward trend. Immunofluorescence and immunohistochemistry also confirmed that the expression levels of LC3 and beclin1 were the highest at 3 days after bTBI. Autophagic vesicles containing lysosomes or digestive residual structures were observed then. Autophagy was induced in the frontal lobe tissues of bTBI mice induced by moderate-intensity explosion, with a peak at 3d and a gradual decline thereafter [4)].

Modeling this disease in rodents to pre-clinically evaluate potential therapeutics has been challenging because of inconsistency between models. Although the effects of primary blast wave injury have been extensively studied, little is known regarding the effects of noncontact rotational TBIs independent of the blast wave. To model this type of injury, Sabbagh et al., generated an air cannon system that does not produce a blast wave, but generates enough air pressure to cause rotational TBI. Mice exposed to this type of injury showed deficits in cognitive and motor task acquisition within 1-2 weeks post-injury, but mice tested 7-8 weeks post-injury did not retain any deficits. This suggests that the effects of a single, noncontact rotational TBI are not long lasting. Despite the transient nature of the behavioral deficits, increased levels of phosphorylated tau were observed at 2 and 8 weeks post-injury; however, this tau did not adopt typical pathological structures that have been observed in other TBI models that incorporate blast waves. This was possibly attributed to the fact that this injury was insufficient to induce changes in microglial activation, which was not affected at 2 or 8 weeks post-injury. Taken together, these data suggest that exposure to noncontact, rotational head injury only produces transient cognitive anomalies, but elicits some minor lasting neuropathological changes [5)].

Miller et al. utilized rat organotypic hippocampal slice cultures (OHCs) as an in vitro system to model bTBI. OHCs were exposed to either 138 ± 22 kPa (low) or 273 ± 23 kPa (high) overpressures using an open-ended helium-driven shock tube, or were assigned to sham control group. At 2 hours (h) following injury, we have characterized the astrocytic response to a blast overpressure.

Immunostaining against the astrocytic marker glial fibrillary acidic protein (GFAP) revealed acute shearing and morphological changes in astrocytes, including clasmatodendrosis. Moreover, overlap of GFAP immunostaining and propidium iodide (PI) indicated astrocytic death. Quantification of the number of dead astrocytes per counting area in the hippocampal cornu Ammonis 1 region (CA1), demonstrated a significant increase in dead astrocytes in the low- and high-blast, compared to sham control OHCs. However only a small number of GFAP-expressing astrocytes were co-labeled with the apoptotic marker Annexin V, suggesting necrosis as the primary type of cell death in the acute phase following blast exposure. Moreover, western blot analyses revealed calpain mediated breakdown of GFAP. The dextran exclusion additionally indicated membrane disruption as a potential mechanism of acute astrocytic death. Furthermore, although blast exposure did not evoke significant changes in glutamate transporter 1 (GLT-1) expression, loss of GLT-1-expressing astrocytes suggests dysregulation of glutamate uptake following injury. Our data illustrate the profound effect of blast overpressure on astrocytes in OHCs at 2 h following injury and suggest increased calpain activity and membrane disruption as potential underlying mechanisms [6)].

Case series

Following an explosion in the civilian setting, 65 patients (38%) with GCS scores of 3 to 14 did not experience severe traumatic brain injury. The proportion of patients with severe TBI and severe TBI in need of a neurosurgical intervention were similar in patients presenting with GCS scores of 3 to 8 and GCS scores of 9 to 14. GCS and Simplified Motor Score did not help identify patients with severe TBI in need of a neurosurgical intervention [7)].

Blast mild traumatic brain injury

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