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MULTISCALE MODELING OF BLAST INDUCED TRAUMATIC BRAIN INJURY: FROM WHOLE BODY RESPONSES TO BRAIN MICRODAMAGE

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The blast induced traumatic brain injury (bTBI) has become a signature wound of the war on terror[1]. The majority of combat related TBI cases are categorized as mild (mTBI) based on the event history and cognitive symptoms such as: concentration problems, blurred vision, irritability, headaches, sleep disorders and depression[2]. In spite of immense clinical and preclinical research on TBI current understanding of injury mechanisms is limited, diagnostics and treatment remain controversial and little is known about the short- and long-term outcomes of mTBI. Compared to impact-related brain injury, the mechanisms involved in blast induced mTBI are much less understood. Mathematical models of human body, head and brain responses to a blast wave may provide a capability to study brain injury mechanisms, perhaps accelerating the development of neuroprotective strategies and aiding in the development of improved protective armor[1].

Mathematical models of brain injury have been developed for decades, initially to study head/brain scale biomechanics during accidental impacts and vehicle crashes and recently focusing on multiscale modeling[1,3]. Models of blast TBI are not well established yet because the injury mechanisms are not well understood and the computational methods needed to simulate these fast and multiphysics events are inadequate. We plan to present a potential multiscale, multiphysics simulation framework for modeling blast induced brain injury. A multiscale model of bTBI may involve a range of length scales such as blast scene, human body anatomy/geometry and brain microstructures. The salient characteristics of such a model may include:

Blast Physics - Computational Fluid Dynamics tools to simulate gas dynamics with shock waves and their interaction with solid objects and human bodies. Computed pressure loads on a human body as inputs for modeling human body biodynamics and biomechanics.

Anatomy, Geometry and Mesh of a human body, including head and brain for biomechanical modeling.

Human Body Biodynamics model to analyze blast load induced body/head movement, body translocation in air and impact on the ground[4]. It provides additional loading input for the body biomechanics model.

Body/Brain Macro-Biomechanics model using the blast and impact loads to simulate mechanical stress/strain fields in body tissues and organs, particularly in the brain. This model could be used as a direct input for the macroscopic brain injury biomechanics models.

Macro-scale to Micro-scale link to connect brain tissue biomechanics with injury to microstructures such as axons, dendrites, synapses and blood brain barrier. In the past, these micro-scale injury models have been used to analyze secondary (neurobiology) injury events[1,3].

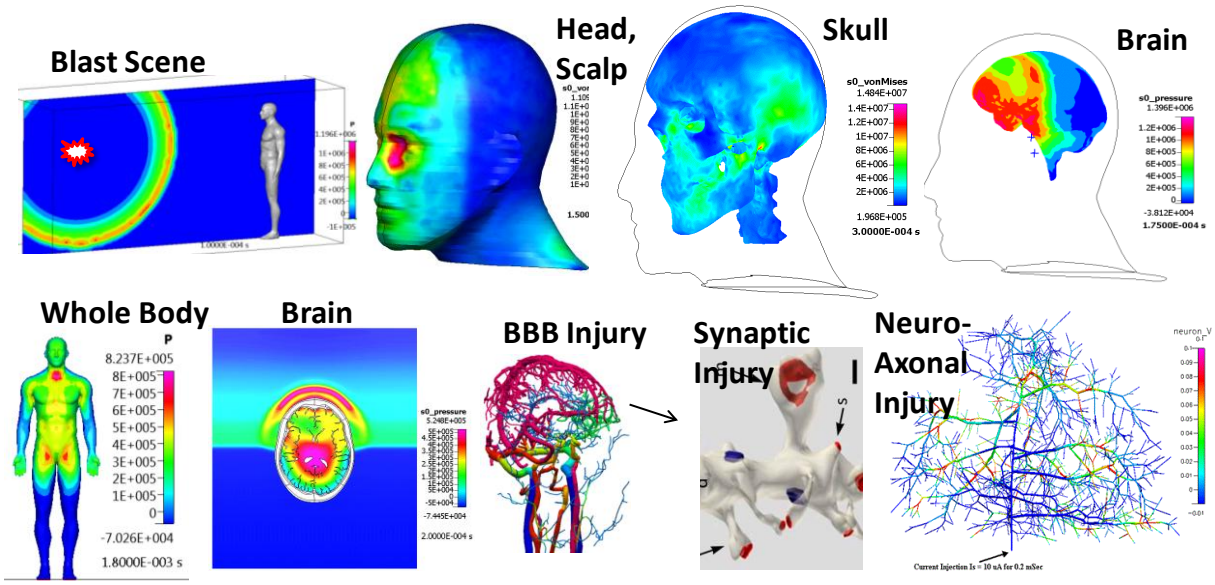

Figure 1. Multiscale Simulations of Blast Wave Human Body Interaction and Macro/Micro-Biomechanics of TBI

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