Prediction of Intracranial Responses from Blast Induced Neurotrauma using a Validated Finite Element Model of Human Head

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ABSTRACT

An estimated 19.5% of all U.S. troops deployed to Iraq/Afghanistan have symptoms related to blast-induced Neurotrauma (BINT). Up to now causal mechanisms of BINT are unknown. Previously an anatomically detailed human head finite element model (WSUHIM) was successfully utilized to predict brain injuries from blunt impact. This study focused on validating the WSUHIM against measured intracranial pressure (ICP) from blast experiments and quantifying various brain response variables from Bowen's blast lung thresholds. The FE model of WSU shock tube was developed and coupled with the WSUHIM to simulate the cadaveric head subjected blast wave generated from shock tube at three different blast intensities (0.074-0.104MPa). The ICPs measured at four brain locations were used to validate the WSUHIM. Four levels of overpressure (0.21-0.61MPa) and pulse duration (1-4ms) on Bowen's iso lung injury thresholds were applied to WSUHIM to quantify the resulting ICP, tissue strain and strain rate. The effects of head orientations as well as the surrounds on the brain response were also compared. MMALE was used to simulate blast. The model predicted ICP was correlated to the measured ICP in cadaver heads in terms of trend at frontal, parietal, occipital and ventricular regions. For all Bowen's cases, the blast overpressure propagated through brain at various magnitudes with peak brain pressure of 0.7-1.8MPa in the cortex. The peak brain strain was 2-11% and product of strain and strain rate was 6-21s-1 at various regions. Sideways blast produced highest coup responses in the cortex while forward blast induced high strain and strain rate in brainstem. The presence of the wall resulted in increases (50%) of pressure and strain in the contralateral site. The model results revealed that the pressure wave was directly coupled to the brain. Bowen's iso-damage curves produced dissimilar levels of pressure/strain brain responses which has never been reported.