Finite Element Analysis of the Role of Helmet Pads in Mitigating Blast-induced Traumatic Brain Injury

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Abstract

Introduction
Much research has been reported on the mechanism of traumatic brain injury (TBI) due to blunt impact, commonly seen in vehicular collisions. Over the last ten years, the increasing use of improvised explosive devices (IEDs) in military settings has resulted in increasing cases of blast-induced traumatic brain injury (bTBI) in surviving soldiers and its mechanism remains poorly understood. The objectives of this paper are to investigate the role of blast overpressure on bTBI and study the effect of helmet pads on mitigating bTBI.

Methodology
We hypothesize that an increase in bTBI is correlated to the build-up of blast overpressure (BOP) in the gap between the helmet and the soldier’s head, and that the presence of a helmet pad in the gap will reduce the BOP buildup and consequently, the likelihood of bTBI. To study this, we have developed a three-dimensional finite element model of a human head-brain interfaced with an advanced combat helmet. The model was subjected to a frontal explosion of 788g of TNT equivalent weight placed at 2m front of the head to generate a non-lethal blast wave with peak overpressure of 200KPa on the face. Computational fluid dynamic simulations were performed to investigate the BOP distribution around the head.

Results
A helmet pad of varying material properties was modeled between the helmet and head, and parametric studies were performed to investigate their effect on BOP distribution around the head. The frontal blast exposure resulted in peak BOP at the back of the helmet gap. Numerical simulation showed that a single padding can reduce about 15% of BOP around the head.

Conclusions
Our preliminary findings confirmed the hypothesis that there is a correlation between BOP and bTBI, and the introduction of helmet pads leads to a lower likelihood of bTBI. As blast injuries from IEDs are multi-mechanistic in nature, blunt impact from fragments of IEDs is another potential cause of bTBI. Our computational model of the human head and helmet could be used to study this mechanism in the future. The validated model will be used to optimize our design of the new helmet padding system.