COMPUTATIONAL MODELING OF BRAIN RESPONSE TO BLAST PRESSURE WAVE

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INTRODUCTION

Traumatic brain injuries (TBI) as a result of blast impacts are not well understood. Finite element analyzes of a head subjected to a 1lb and 2 lb charge pressure wave has been performed. This study provides insight into possible causes of brain injuries and may be used to develop better personal protective equipment or new techniques to mitigate traumatic brain injuries.

METHODS

The three dimensional finite element mesh of the head with neck and shoulders is constructed from a MRI scan of a 50th percentile male Caucasian taken at a 1 mm resolution. The model is comprised of a representative brain, cerebral spinal fluid, the skull with cervical vertebrae and generalized tissue (Figure 1).

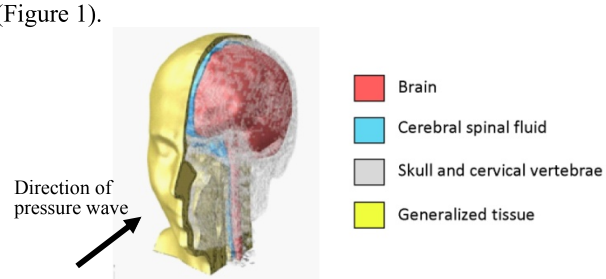

Figure 1: Finite element mesh of the head.

Material properties are based on open literature [1, 2]. The brain is comprised of viscoelastic material properties. The cerebral spinal fluid is modeled as a hyperelastic neo-hooke material with a low shear and a high bulk modulus. The remaining components, the skull with cervical vertebrae and the generalized tissue, are modeled using linear elastic material properties.

The model is constrained at the shoulders. The pressure profiles (Figure 2) for the 1 lb and 2 lb charges that are

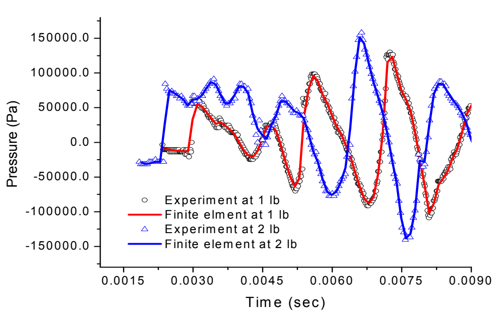

Figure 2: Pressure wave profiles.

applied to the model are based on experimental blast test data conducted on human surrogate models (GelMan) developed at the Naval Research Laboratory [3]. The experimental blast pressure profiles are smoothed to remove the signal noise and is necessary obtain numerical convergence in the models.

RESULTS AND DISCUSSION

Pressure contours at the midplane of the head (Figure 3) for both charges and pressure time histories in the lobes of the brain (Figure 4) for the 1 lb charge are presented.

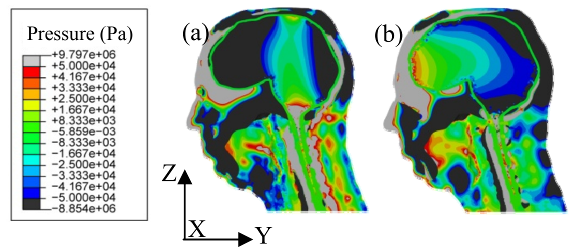

Figure 3: Pressure contours of the midplane in the head for the (a) 1 lb charge at 7.30 x 10^{-3} seconds and (b) 2 lb charge at 6.63 x 10^{-3} seconds.

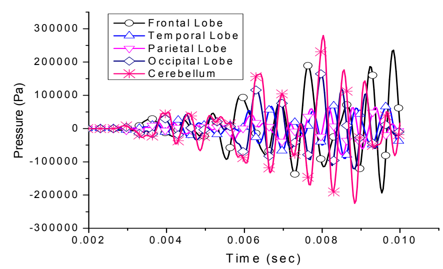

Figure 4: Pressure time histories in the brain lobes at the 1 lb charge, left hemisphere only.

For both charge levels, the cerebral spinal fluid isolates the pressures observed in the brain from the skull, cervical vertebrae and generalized tissue. The brain oscillates primarily between compression (positive pressure) and expansion (negative pressure) in the Y-direction. Also, the spinal cord acts as an anchor and inhibits the translation of the brain from the pressure load. As a result, there is also some smaller oscillation of pressure in the Z-direction. The time history curves does not appear to significantly differ from the asymmetry of the left and right hemispheres. These pressures are observed to be the greatest during the blast event at the frontal lobes of the brain and at the cerebellum.

REFERENCES

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3. Simmonds KE, et al., *NRL Review*, 156-158, 2004.