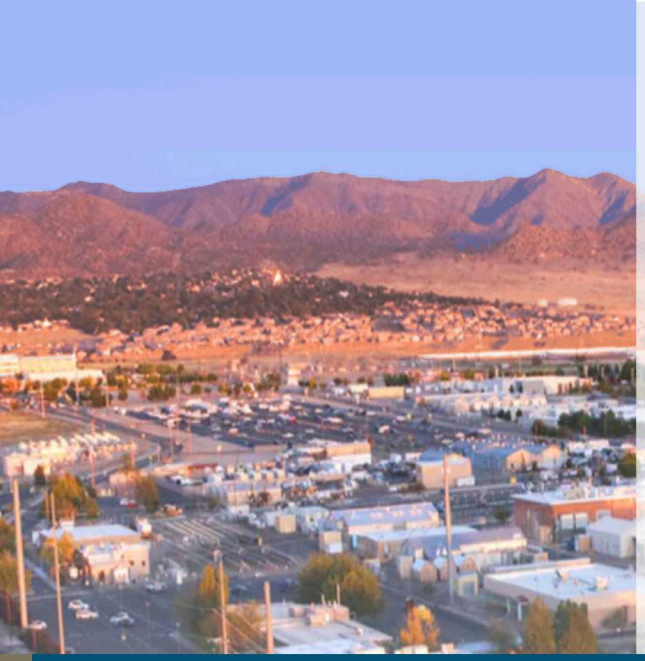

SAND2020-5239PE

Naval Force Health Protection Program Review 2020

C2B2 Project

Chad B. Hovey, Adam C. Sokolow, Douglas A. Dederman

Sandia Injury Biomechanics Laboratory (SIBL)

Web Conference, July 6-10, 2020

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C2B2: A Phenomenological Model for Cavitation

Chad B. Hovey, Sandia National Laboratories

Abstract:

A phenomenological model of cavitation is presented, based on observations that both high relative negative pressure and high relative negative time derivatives of pressure are required for cavitation onset.

We simulated two cavitation experiments to generate cavitation scaling parameters for relative pressure drop and relative pressure drop rate. The parameters were then used in a computational model to predict both the location of cavitation and the probability of cavitation.

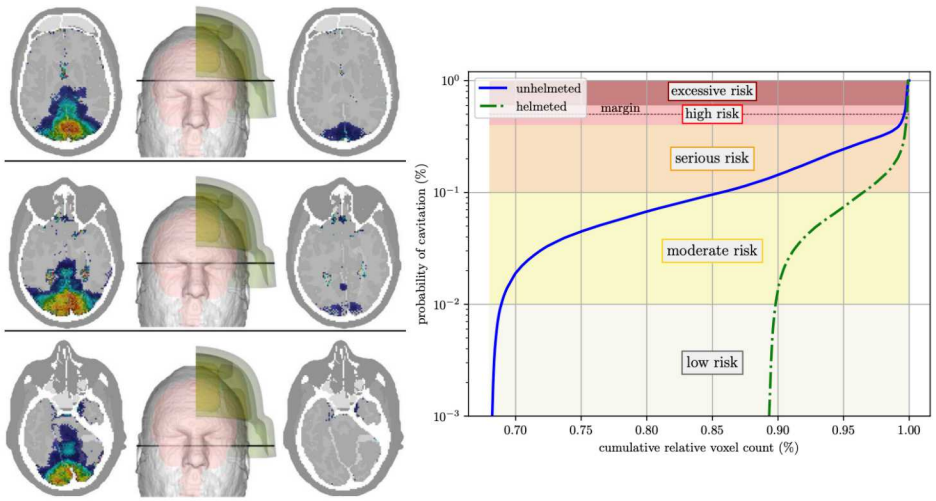
Our results show the model, while simple, is effective at reproducing results from laboratory experiments of cavitation. We used our verified model as a predictive tool for cavitation expectation in the human brain, secondary to blast exposure. The results suggest that the magnitudes of blast overpressure observed in field data is sufficient to cause intracranial cavitation.

PANTHER: Development of a Predictive Multiscale Traumatic Brain Injury Model

Chad B. Hovey, Sandia National Laboratories

Description: The Sandia Injury Biomechanics Laboratory (SIBL) contributes to the understanding of the potential of injury from intracranial cavitation in the human head, secondary to blast exposure.

Technical Approach: We created a high-fidelity geometric model of the human head and neck, consisting of 5.7M hexahedral finite elements at a nominal resolution of 1-mm^3. We created high-fidelity material models for the human tissues and helmet constituents. We calibrated our model based on results from an experimental drop test and an experimental blast. We then applied our calibrated cavitation model to a numerical blast exposure of our human digital twin. We compared unhelmeted and helmeted cavitation outcomes.



- **PERFORMERS:** Sandia Injury Biomechanics Laboratory (SIBL)

FY21-FY22 Plans:

- We plan to investigate parameterization of the model, to quantify injury risk based on overpressure and standoff variables.

FY23 Plans: (As applicable)

- As of this writing, the C2B2 team does not have funding beyond FY21. Were follow on funding received, our laboratory would begin work on **deployment** of the framework, creating a user community within military and university research communities.

FY20-21 Accomplishments:

- Demonstration of shortcomings of existing approaches, showing mesh dependency, and motivation for an alternative approach.
- Development of a phenomenological model for cavitation based on high relative negative pressure and high relative negative time derivatives.
- Verification of the phenomenological model based on drop test and blast experiments.
- Application of model to human digital twin to quantify brain exposure to cavitation by volume and anatomical region.

Impact Statement: Through its ability to see into the virtual brain, the framework can predict tissue-level response in-silico, as a complement to in-vitro and in-vivo approaches.

Naval Need: The SIBL high-fidelity digital twin framework can be used to evaluate and improve personal protective equipment (PPE) designs.