BHSAI Works to Establish an Evidence-Based Injury Threshold for Blast-Wave Exposure

Exposure to blast-pressure waves from explosive devices poses a serious threat to Warfighter health and well-being, potentially leading to brain injury and cognitive deficits. Even a mild traumatic brain injury (mTBI) can affect an individual's physical functioning and mental health. Despite advances in our understanding of the detrimental effects of blast exposure on brain health, we still lack criteria that allow us to screen Service Members for brain injury after a blast exposure and establish procedures to ensure safe operational and training environments. To address this knowledge gap, Dr. Jaques Reifman, Director of the Biotechnology High Performance Computing Software Applications Institute (BHSAI) here at TATRC, leads an inter-disciplinary, multi-organizational effort to use experimentation, computations, and clinical data to establish, for the first time, evidence-based injury criteria for mTBI caused by blast exposure.

Dr. Reifman and the team at the Henry M. Jackson Foundation (HJF) in support of BHSAI, previously developed a unique, validated computational human-head model that predicts the human-brain response to a blast exposure. Although this computational model can accurately predict intracranial pressure (within 7%), the team could not link a Service Member's blast exposure to a brain injury diagnosis due to the lack of curated data directly associating a specific blast exposure, including the exact characteristics of the pressure wave loading the head, with the resulting clinical outcome. However, data now exist linking a well-documented blast-exposure event (the ballistic missile attack of the Al Asad Airbase in Iraq in January 2020) to the subsequent clinical diagnoses of mTBI reported by 109 Service members. In addition, in 2021, Dr. Jason Roth and his team at U.S. Army Engineer Research and Development Center (ERDC) completed a preliminary field study at Ft. Johnson, LA, to reconstruct the Al Asad Airbase attack and found that they were able to determine the pressure fields experienced by Service Members inside of their protective bunkers during the attack. Furthermore, the Joint Trauma Analysis and Prevention of Injury in Combat (JTAPIC) office at Ft. Detrick will provide clinical outcome data. Therefore, in response to the Congressionally Directed Medical Research Program's Joint Warfighter Medical Research Program, Dr. Reifman proposed a collaboration between BHSAI, HJF, ERDC, and JTAPIC to enable the development of quantitative, evidence-based guidelines for establishing injury criteria for blast exposure in humans, and his was the only project selected for funding (out of 26) in Operational Medicine and Readiness.

This Joint Warfighter project will identify blast-insult thresholds that induce mTBI in humans and develop dose-response curves linking blast exposure to brain injury using an experimental/computational approach. First, BHSAI will collaborate with ERDC to perform field studies at Ft. Johnson, LA, to reproduce the blast-pressure waves experienced by our Service Members sheltered at multiple locations inside protective bunkers during the 2020 Al Asad Airbase attack. Next, using the data from these studies, the BHSAI team will develop and validate computational models that allow them to simulate and expand the field studies in order to characterize the load to the head of bunker occupants at multiple locations inside the bunker for a range of blast-pressure exposures (see **Figure 1**). Then, using their previously developed human-head model, they will predict the mechanical responses of the human brain (e.g., pressure, stress, and strain) in response to the range of blast-pressure waves. Finally, in collaboration with JTAPIC, the BHSAI team will use de-identified medical records and diagnostic data for Service Members stationed at the Al Asad Airbase during the attack to link *actual* blast-pressure exposures to *documented* brain injuries, enabling the determination of an evidence-based lower-limit pressure threshold linked to brain injury and the development of dose-response curves that relate blast-wave exposure to the likelihood of brain injury.

During the course of the study, the BHSAI team will also assess commercial wearable pressure sensors for their ability to accurately monitor blast exposures. The identification of accurate wearable pressure sensors represents an important step in establishing the ability to monitor Service-Member exposure.

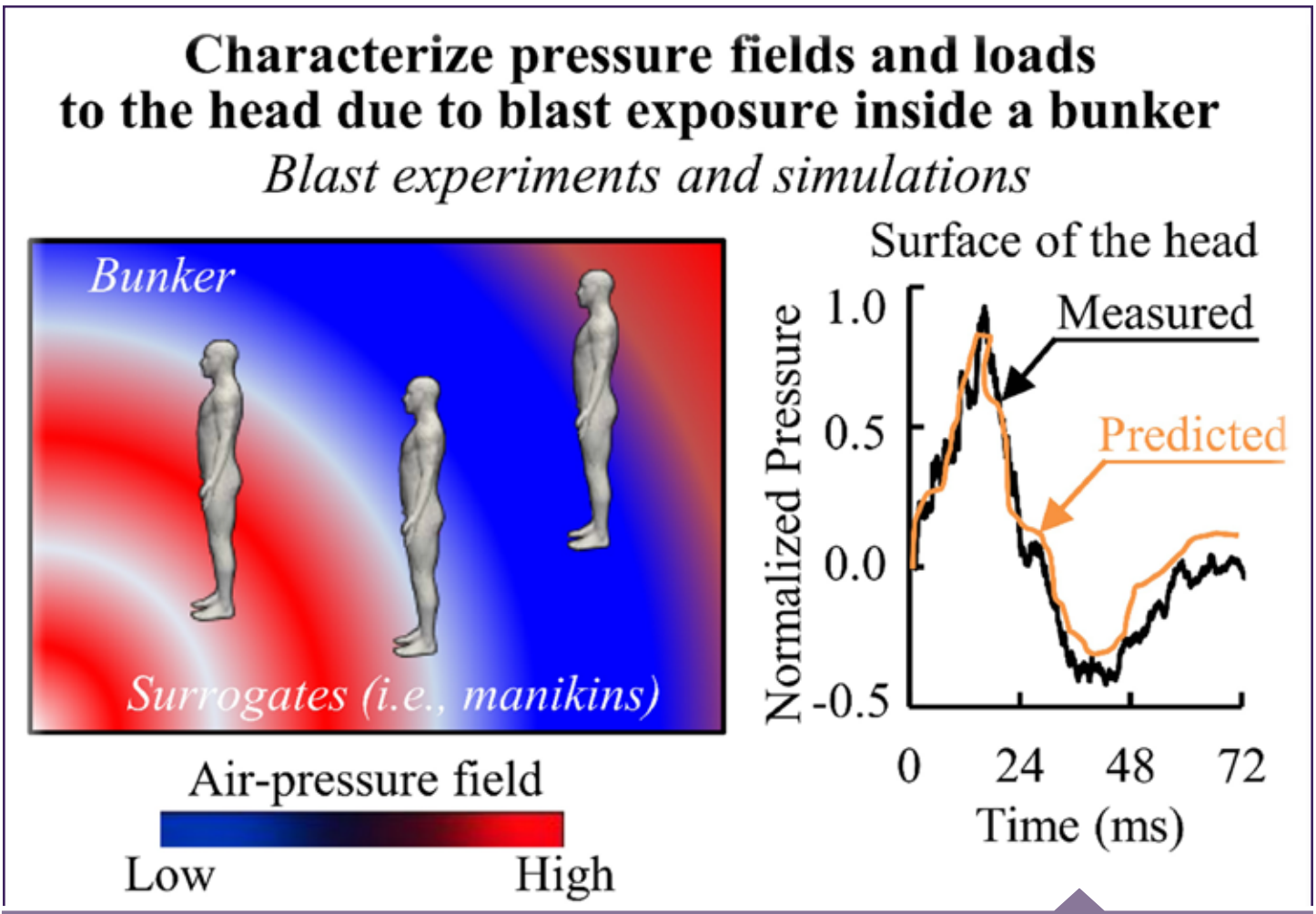

Figure 1. BHSAI's inter-disciplinary, multi-organizational effort will identify blast-insult thresholds that induce mild traumatic brain injury (mTBI) in humans and develop dose-response curves linking blast exposure to brain injury. First, the team will reproduce blast exposures equivalent to those experienced by our Service Members inside a bunker during the Al Asad Airbase attack in January 2020. Then, they will quantify the resulting blast-flow fields and load to the head, and use validated computations to extend blast insult predictions to other blast-exposure levels.

When combined with the developed guidelines for blast exposure and dose-response curves, this will allow for real-time assessment of whether a blast exposure is likely to result in mTBI.

In the short term, this research will provide evidence-based blast-exposure pressure thresholds for mTBI and critical knowledge to inform the establishment of Force Health Protection injury criteria. In addition, this knowledge will guide the evaluation and revision, as necessary, of training and operational doctrine that defines blast exposure limits to minimize mTBI risk. In the long term, Dr. Reifman anticipates that this work will lead to the ability to screen Warfighters for brain injury in the field immediately after a blast exposure, enabling the quick evacuation of Service Members at risk for mTBI who require immediate medical care and leading to early interventions and improved clinical outcomes.

"We are excited for the opportunity to make a tangible contribution to blast research, with the potential to help enhance Force Health Protection," stated Dr. Reifman with regard to the Joint Warfighter project. This effort offers the potential to mitigate the effects of blast exposure and enhance Warfighter Brain Health, a key directive of the U.S. Department of Defense Office of Health Affairs.

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