ADVANCEMENTS IN THE UNDERSTANDING OF BLAST-INDUCED NEUROTRUAMA

T.W. Sawyer[1], S. A. Parks[2], D. V. Ritzel[3]

[1]DRDC Suffield, PO Box 4000, Medicine Hat, AB, Canada T1A 8K6; [2]ORA Inc., 71 Commerce Pkwy, Suite 107, Fredericksburg, VA, USA 22406; [3]Dyn-FX Consulting Ltd, 19 Laird Ave North, Amherstburg, ON, Canada N9V 2T5

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Blast-induced neurotrauma is considered the ‘signature wound’ of NATO and Coalition Forces from the Afghan and Iraqi conflicts due to the unprecedented scale of attacks using Improvised Explosive Devices. As with ‘blast lung’, mild Traumatic Brain Injury (mTBI) from blast is sometimes regarded as invisible wounding, since it can be inflicted without any overt external signs of injury and may not present immediate critical symptoms in the field. Very little is known of the causes or nature of the damage at the cellular scale, hence diagnosis and development of protective counter-measures remain forefront concerns. Engaging this problem requires a multi-disciplinary effort including blast physicists and biomedical experts.

The blast injury research program at Defence R&D Canada has undertaken a unique approach to resolving blast-induced neurotrauma through the use of brain-cell aggregates in high-fidelity blast simulation experiments. The aggregates are live, 3D masses of fully functional and differentiated brain cells, unlike traditional 2D cell cultures grown on a substrate, and allow study of the effects of blast-induced 3D stress fields imparted by the external blast loading on the skull.

The first phase of the program developed advanced blast simulation capabilities for the biomedical laboratory and investigated the injury biomechanics, that is, how external blast loading imparts brain stresses by action on the cranium. The second phase of the program currently underway applies the novel brain-cell aggregate technology in conjunction with animal testing to resolve the cellular disruption and cognitive/functional deficits caused by those imparted stress conditions. In particular, a biofidelic headform is under development which will be calibrated against the response of human skulls and incorporate the brain-aggregate clusters. As such, the brain-cell aggregates act as ‘reporter cells’ to identify adverse stress conditions from particular blast load conditions. With such a capability it will it be possible to provide a relative assessment of the efficacy of proposed protective countermeasures such as improved helmet designs. Ultimately, the headform will be calibrated against the biomechanical response of human skulls and allow quantifying safe thresholds for head exposure to blast as well as impact or acceleration brain trauma.