Shock loading-induced Traumatic Brain Injuries in animal models - experimental and computational studies

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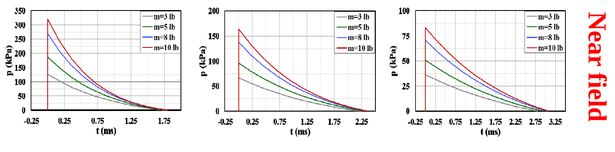
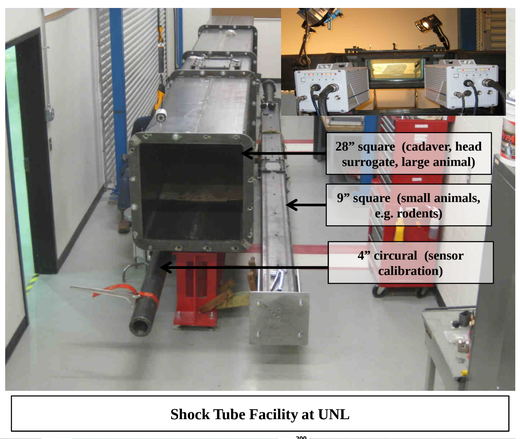
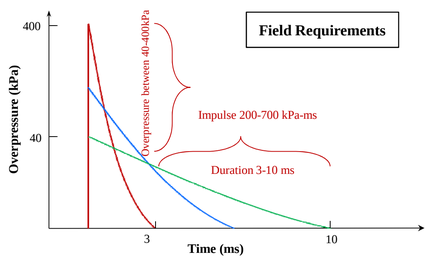
Introduction

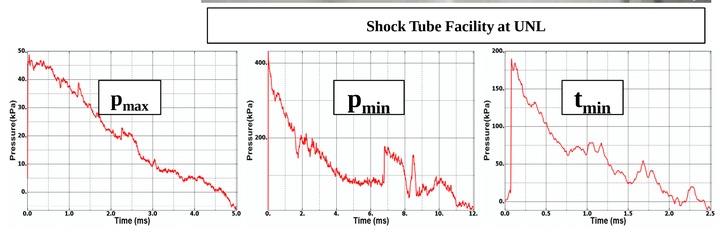
Blast induced neurotrauma (BINT) has been identified as the signature wound of the conflicts in Iraq and Afghanistan. This trend is expected to continue as the US engages in asymmetric warfare as the new world order develops in the coming years. At the center for Blast Trauma Mechanics at the University of Nebraska Lincoln we try to understand blast induced neurotrauma (BINT) of varying severities at various length and time scales. The state-of-the-art blast wave generator at the University of Nebraska-Lincoln (UNL) is used to simulate field scenarios and to subject cadavers, animals, dummy head models to well defined blast loading conditions. Post blast analysis involves evaluation of stress and deformation fields, immunohistochemistry, biomarkers, blood brain barrier. In addition, validated numerical models are employed to understand and elucidate experimental results.





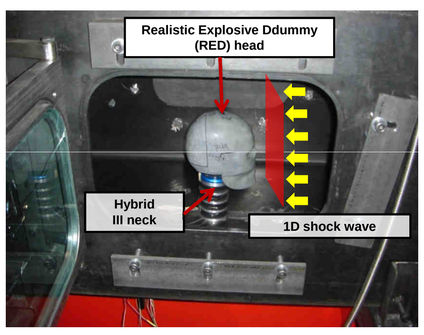
Shock Tube Facility at UNL

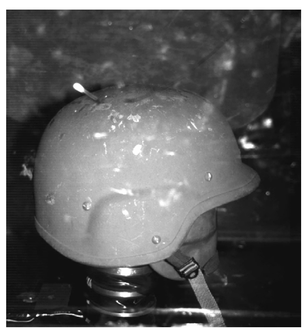


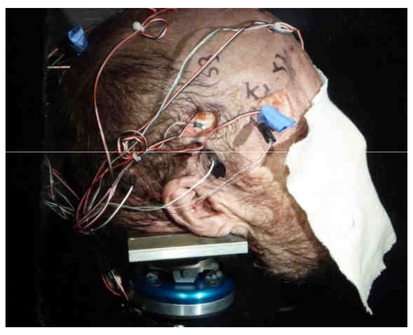


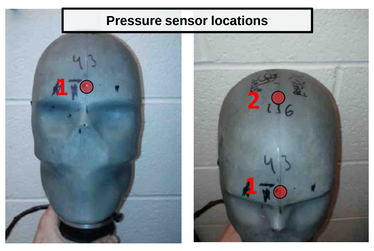
Shock Tube Capabilities

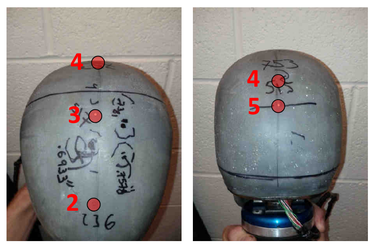
Primary blast studies with surrogate head models: RED and PMHS

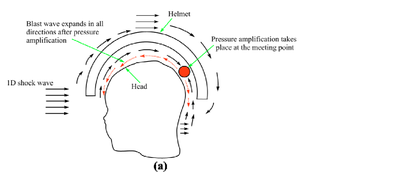




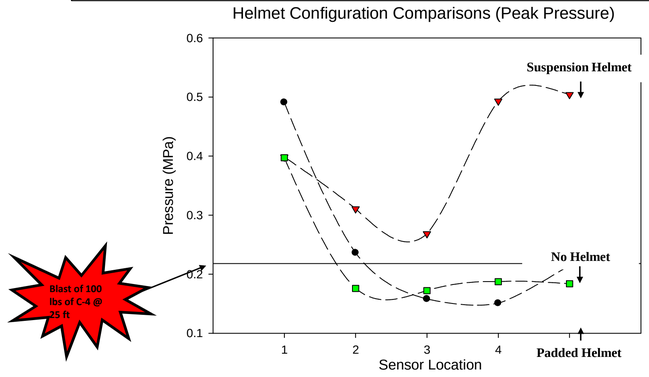


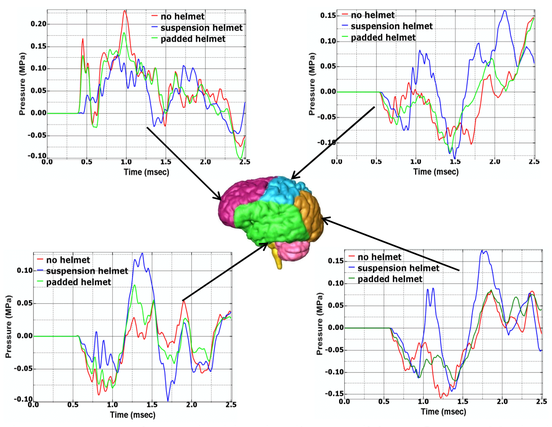






Evaluation of Personal Protective Equipment





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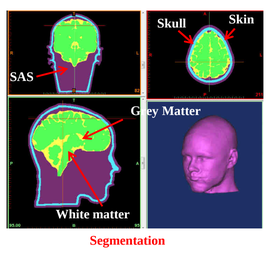
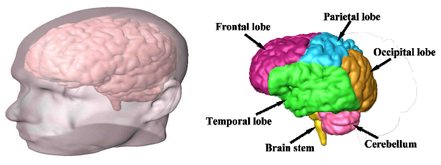
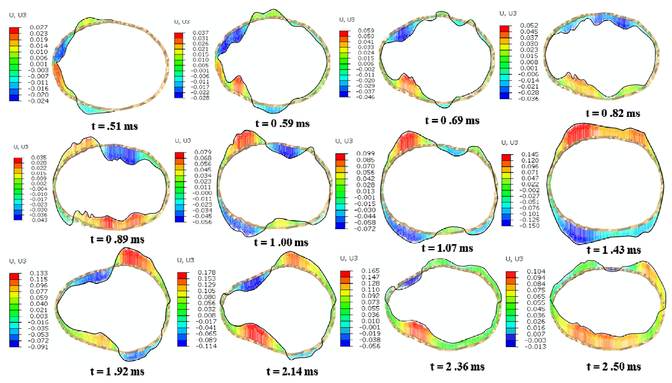
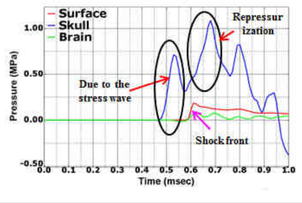
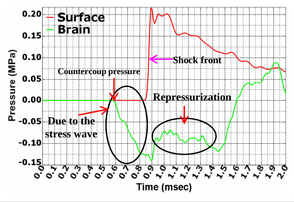
Head-blast wave interactions modeling - mechanics of BINT



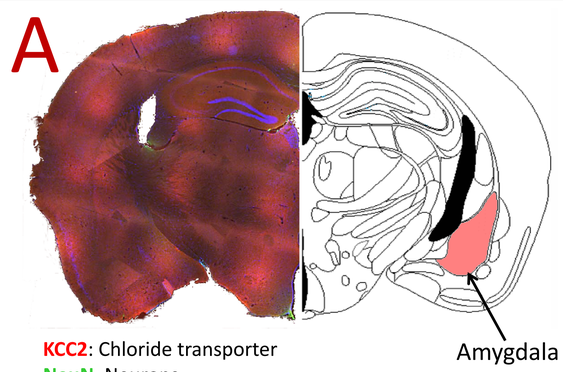


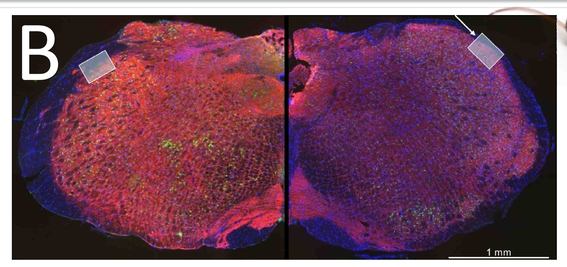


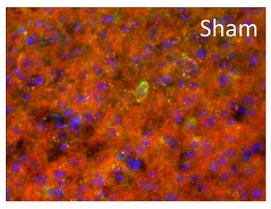


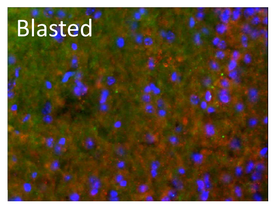


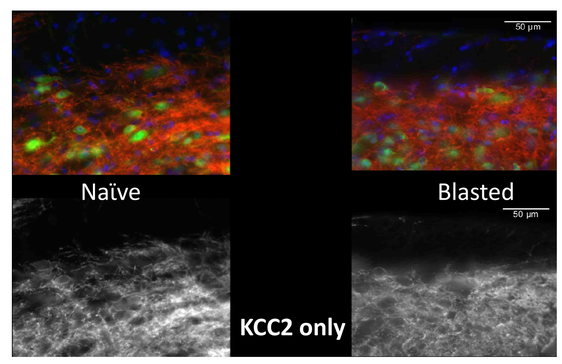
Long term brain pathology in C57BL/6J wild type mouse





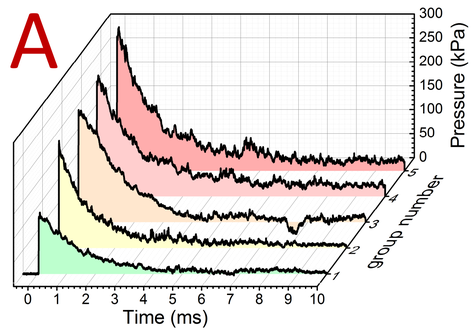






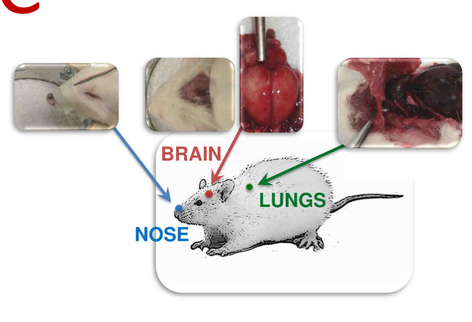
Long-term (60 days) changes in behavior and chloride regulation in the mouse brain exposed to airblast (peak overpressure 130 kPa): **A.** Downregulated KCC2 in amygdala (formation and storage of memories associated with emotional events). **B.** Brainstem staining. Sp5/Sp5c region transition: Head/neck/face pain generator. KCC2 is downregulated in blasted mice, resulting in disturbed chloride ion homeostasis and leads to pain.

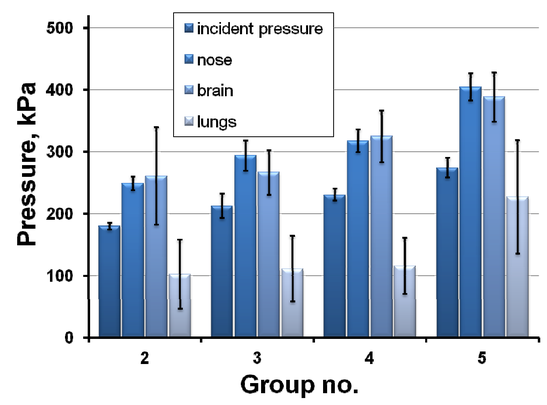
Blast injury scale in Sprague-Dawley rat model



B

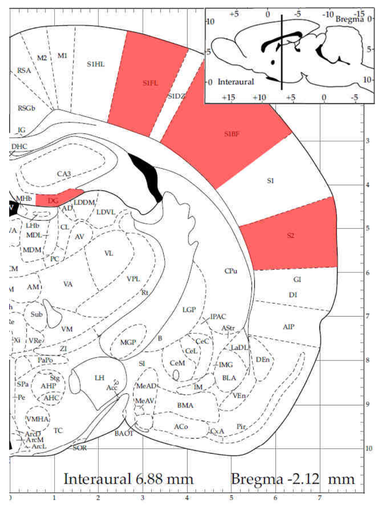
Group no.	Peak overpressure, kPa	Impulse, Pa·s	Survival, %	No. of animals tested
1	126 ± 1	204 ± 3	100	4
2	194 ± 10	335 ± 25	90	10
3	232 ± 10	393 ± 44	100	10
4	246 ± 12	437 ± 31	42	11
5	300 ± 10	515 ± 20	0	4

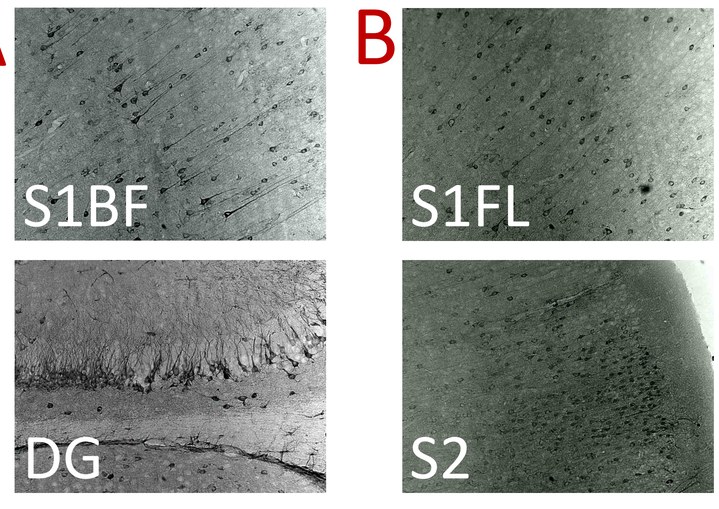




Overpressure profiles (**A**) and the survival of the 10 weeks old Sprague Dawley rats exposed to primary blast (**B**). **C.** The diagram of sensor location in the cadaver rat and average incident pressure on the nose, in the brain and lungs (**D**) of rats exposed to the blast with peak overpressure and impulse reported in the table **B**.

Blast induced membrane permeability of neural cells





Rats were exposed to blast with peak overpressure of: A. 190 kPa, and B. 230 kPa, and transcardially perfused 24 hours after the blast exposure (4% paraformaldehyde in cacodylate buffer). Brains were sliced (40 µm thickness) and stained against immunoglobulin G (IgG). Accumulation of IgG (MW = 150 kDa) inside the cells is caused by blast induced haemorrhage and indicative of severe plasma membrane damage. Damaged cells are apparent in the cortex (S1BF, S1 FL and S2) and hippocampus (DG).

Acknowledgement

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