

AEROMEDICAL EVACUATION-RELEVANT HYPOBARIA WORSENS AXONAL INJURY AND BLOOD BRAIN BARRIER BARRIER DISRUPTION INDUCED BY UNDERBODY BLAST-INDUCED HYPERACCELERATION

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Many warfighter victims of blasts are passengers within vehicles targeted by improvised explosive devices. Over half of those who survive these blasts suffer from TBI. Axonal injury and disruption of the blood brain barrier are commonly reported following exposure to blast. These victims are relatively shielded from blast overpressure but are subjected to very brief but exceedingly high acceleration, sometimes exceeding 1000 Gs. Survivors are typically aeromedically evacuated within a few days to a regional medical center, presenting the possibility that exposure to hypobarica could exacerbate their injuries.

HYPOTHESIS

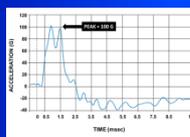
Exposure to flight cabin barometric pressure (=8000 ft altitude) for 6 hr worsens injury when initiated at 6 – 72 hr after underbody blast-induced mild TBI.

METHODS

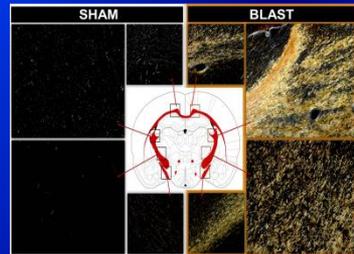
The device used to model blast consists of an aluminum water tank in which a platform is located that supports a thick aluminum plate located above the water. The two cylinders secured to the top of the plate serve to house the ketamine-anesthetized rats. An explosive charge (0.75 g PETN) is detonated under the center of the plate at distances that generate precise forces on the plate but not directly on the rats. Rats were then randomized into groups that were or were not exposed to 6 hr hypobarica (=8000 ft) at 6-72 hr post-blast.

Animals were perfusion fixed at either 7 days post-injury for brain histopathology or at 24 hr for electron microscopy. Axon injury was assessed by quantifying numbers of silver-stained axon fibers present in the internal capsule. Blood brain barrier (BBB) disruption was assessed by the cortical perivascular area immunostained for immunoglobulin G.

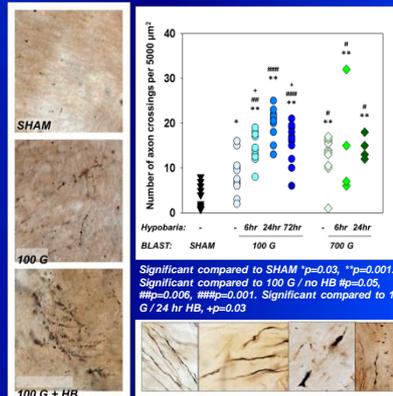
Blast Device Accelerometry Altitude Chamber



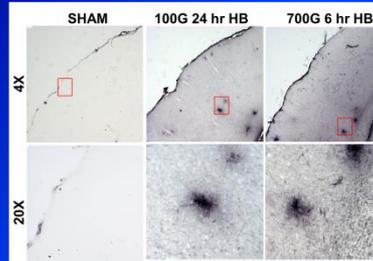
BLAST-INDUCED AXONOPATHY



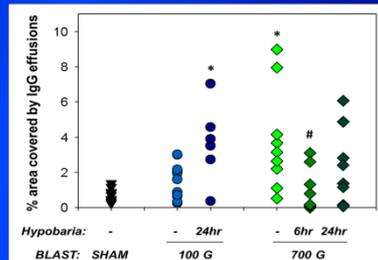
deOLMOS SILVER STAINING



BLAST-INDUCED BBB DISRUPTION



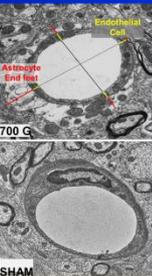
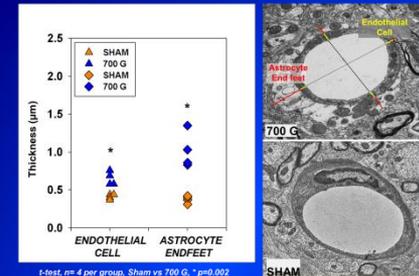
IgG IMMUNOSTAINING



CONCLUSIONS

- Underbody blast-induced loads of 100 – 700 G damage white matter axon fibers. Exposure to 6 hr hypobarica starting at 6, 24, or 72 hr post-injury worsens axon injury after 100 G but not 700 G blasts.
- Blast induced acceleration causes blood brain barrier disruption which is exacerbated by hypobarica.
- 700 G underbody blast causes swelling of vascular endothelial cells and astrocyte end-feet.
- When possible, blast TBI victims should wait approximately one week before flying under hypobaric conditions.

BLAST-INDUCED VASCULAR DAMAGE



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ELECTRON MICROSCOPY