# Vehicle Improvement Studies

## Development of an Advanced Vehicle Hull Design

Explosive blast is a leading cause of traumatic brain injury (TBI) among Service members in modern conflicts. In particular, blast-induced TBI is often sustained as a result of an underbody explosion, as many TBI sufferers are occupants of vehicles targeted by improvised explosive devices buried under roadways. Recent improvements in military vehicle design have successfully protected occupants against blast over pressure after underbody blast (UBB), but fail to address the effects caused by UBB-induced hyperacceleration.

An interdisciplinary team of researchers at the University of Maryland Schools of Engineering and Medicine (Baltimore, Maryland) used their rodent model of UBB-induced TBI to elucidate the pathophysiology of TBI caused specifically by UBB hyperacceleration. Using a small-scale model of UBB, the team demonstrated that blast-induced gravitational forces (G-forces) alone can cause TBI; biochemical, histologic, and magnetic resonance imaging-based measurements indicate that cerebrovascular damage, neuroinflammation, and loss of neuronal synapses contribute to UBB-induced TBI in a G-force dose-dependent manner. The researchers are now testing the hypothesis that altering the vehicle frame design to reduce the energy transferred from the blast to the animal will mitigate blast-induced neuropathology and behavioral deficits. One very effective approach is the incorporation of light, thin-walled aluminum cylinders coated with polyurea within the vehicle frame. The elastomeric polyurea absorbs UBB forces, resulting in a 90 percent reduction of the G-force experienced by the animal. At normally lethal G-forces, this elastomere-based vehicle design eliminates mortality and dramatically reduces TBI, as demonstrated by a reduction in apoptotic cell death and markers of inflammation, as well as protection against synapse loss and deficits in behavioral performance (Figure 1).

This research has provided the first direct insight into the pathophysiology of TBI caused by hyperacceleration from UBB, utilizing the first animal model of TBI resulting from under-vehicle blast. Future work will focus on further refinement of vehicle hull design, to aid in the development of the next generation of blast-resistant military vehicles.

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Advances in vehicle design to mitigate hyperacceleration after under-vehicle blast could significantly reduce the incidence and detrimental effects of brain injury experienced by Service members.

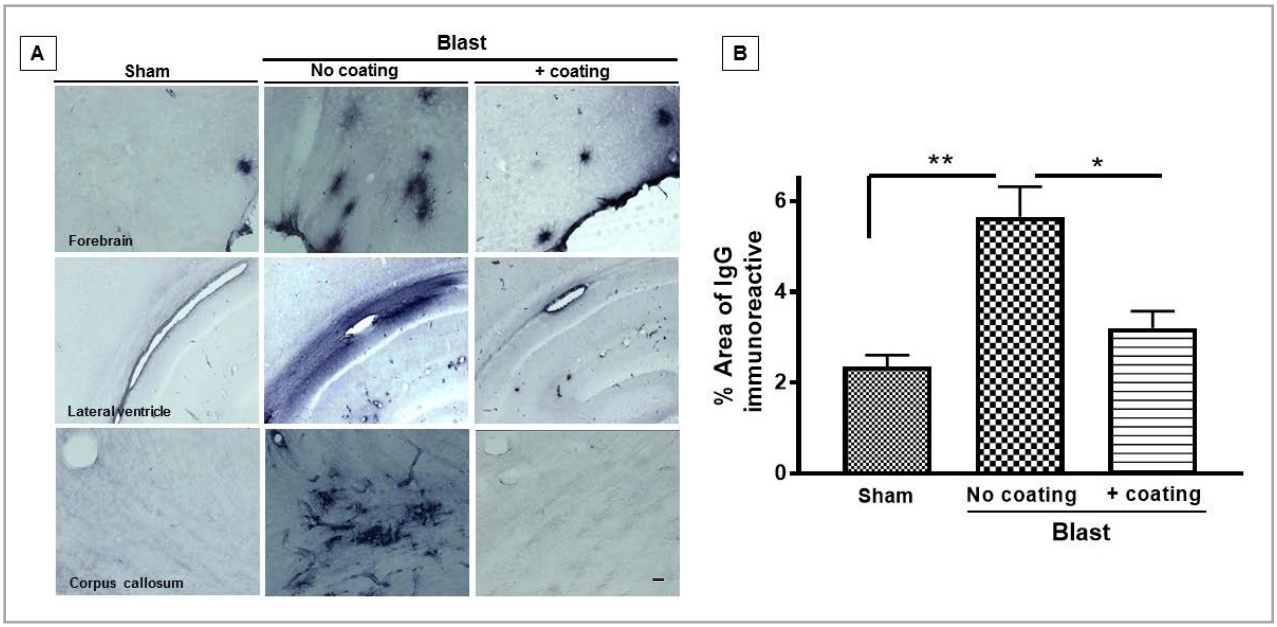


**FIGURE 1:** Increased perivascular immunoglobulin G (IgG) effusion in the brain post-blast and by incorporation of polyurea-coated cylinders. A. Representative microscopic images exhibiting IgG immunoreactivity in different brain regions at 24 hours post-blast or post-Sham blast. Scale bar is 50 µm. B. Quantification of the percentage of the cerebral cortex area that was immunopositive for IgG. There was a significant, 700% increase in rat cortical IgG immunostaining following blasts generating 2300G compared to sham animals (**$p < 0.01$, n=5) and a 100% increase compared to the area present following blasts with vehicles that incorporated polyurea-coated cylinders (*$p < 0.05$; n=6). (Figure used with permission from the authors)