PRESSURE THRESHOLDS: WHAT YOUR MEDIC NEEDS TO KNOW

Numerous studies point out the dangers of overpressure in very real terms

The United States Department of Defense has reported more than 250,000 Service members have suffered from a traumatic brain injury (TBI) between the years 2000 and 2012.[1] For this reason, it's not surprising that TBI has become synonymous with the term "signature injury of modern war."

The main culprit of injury in blast TBI is peak overpressure caused by shockwaves from an explosion. The shockwave is undetectable to the human-eye, but can create lasting damage to the brain and body. Soldiers and Tactical Officers are often exposed to harmful levels of peak overpressure both in training and in the field. To counteract this threat, measuring an individual's exposure level is key.

Overpressure from an explosive event is measured in pounds per square inch (psi), and like any form of measurement, understanding what this metric means is key. So what are the thresholds for bodily exposure to overpressure?

When talking about minimum safe distance, it's common to hear law enforcement agencies and military operators cite 4 psi as a "safe" baseline threshold. This is consistent with the assumptions underlying the safe standoff curves currently used by most military and law enforcement breachers. However, research indicates this may be an oversimplification, as multiple low level exposures can still be damaging. In addition to the damaging effects of a single event, recent and ongoing studies of repeated blast exposures have revealed that there is a cumulative effect associated with chronic low-level blast (LLB) exposures. These findings indicate that—like concussive TBI injuries common in contact sports— even small, cumulative exposures can be damaging.

Furthermore, factors other than frequency of exposure can contribute to injury severity. Variability of factors such as blast duration, reflections, bodily condition, and dehydration[2] can greatly affect degree of injury. For all these reasons, measuring exposure level provides critical information to the health care provider aiding in triage and treatment of this complex injury.

This leads us to the original question: *what are the thresholds for bodily exposure to blast overpressure?* Simply put, a single exposure of 0 – 4 psi is typically safe, though it's critical to seek medical attention if you're not feeling well with symptoms such as headaches or nausea. This is because it only takes 3 blast exposures at 3 psi to cause gastrointestinal and pulmonary injury.[3] 5 psi is enough to rupture an eardrum, and as exposure levels climb further towards a peak overpressure of 16, the likelihood of injury grows.[4]

Two recent studies have shed new light on the neurological impacts of blast overpressure exposure: the Quantico Breacher Injury Study (QBIS) and the Preventing Violent Explosive Neurological Trauma (PREVENT) study. The QBIS study found that a single blast overpressure exposure of 13 psi showed no changes in neurobehavioral testing or imaging of the brain.

However, the PREVENT study using non-human primates identified neurological changes post-mortem as low as 12 psi in the absence of any symptoms.[5] Additionally, the PREVENT study using swine found biomarkers for brain injury and inflammation for blast overpressure exposures above 24 psi.[6] As the peak overpressure increases, the effects are more devastating: 30-40 psi is the threshold for lung injury and at 100 psi there is possibility of death.[7]

As mentioned earlier, it is not uncommon for a Soldier or Tactical Officer to be subjected to multiple blast events while performing his or her job. Multiple studies, including one recently published in the *Journal of Neurotrauma*,[8] suggest that LLB causes a measurable degree of brain agitation known to cause cognitive impairment and depression. In order to protect our heroes, we need to be able to detect, record, and monitor repeated exposures.

This is where the Blast Gauge® System comes in. Weighing less than an ounce, the Blast Gauge is a powerful, easy-to-use overpressure sensor that automatically records an

operator's exposure to an explosive event. With the push of a button, the gauge emits a discreet visual cue with green, yellow and red status LEDs providing instant feedback on overpressure exposure.

The system's ability to capture and record detailed signatures from events provides invaluable information that can be downloaded via a micro-USB connection and used by medical personnel to aid in the triage and treatment of TBI. In-depth reports can be used to track cumulative exposure and create a permanent health record for correlation to long-term effects. Exposure can be measured and recorded in both training and combat scenarios such as from improvised explosive devices (IEDs), shoulder fired weapons, and artillery live fire training.

PSI level	Possible injury
3 (3+ blasts)	Gastro-intestinal and pulmonary injury
5	Eardrum Rupture (threshold)
12	Neurological changes, no symptoms
24	Mild Neurological Damage
30-40	Moderate Neurological Damage, Possible Blast Lung (threshold)
75	Lung Damage in 50% of patients
100	Possibility of death

The life-preserving aspects of the Blast Gauge System are recognized by military and law enforcement communities across the world. Militaries, Bomb Squads, SWAT Teams, and other Tactical Officers are often exposed to overpressure from explosive breaching, flashbangs and IEDs, thus the need for adopting an advanced sensor that can measure exposure levels.

You may be wondering what more can be done to protect your operators from this threat. Knowledge of overpressure exposure is essential and can be achieved by wearing advanced overpressure sensors in both training and operations. Without them, you have no way of knowing the magnitude of blasts and could be guessing at the extent of possible injury.

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2. Defense Center of Excellence for Psychological Health & Traumatic Brain Injury. *Traumatic Brain Injury and Effects of Altitude: An Analysis of Literature*. September 14, 2010.
3. Dr. Daniel L Johnson, et al., *Blast Overpressure Studies with Animal and Man*. USAMRDC. Nov. 15, 1993.
4. Stewart, Charles. *Blast Injuries: Preparing for the Inevitable*. Emergency Medical Practice. Vol. 8 No. 4. April 2006.
5. Lu, Jia, et al., "Effect of Blast Exposure on the Brain Structure and Cognition in Macaca fascicularis." *Journal of Neurotrauma*. May, 2012.
6. Ahmed, Farid. *Time dependent changes of protein biomarker levels in the cerebral spinal fluid after blast traumatic brain injury*. Electrophoresis. 2012.
7. Dr. Daniel L. Johnson. *Nonauditory Damage Risk Assessment for Simulated Muzzle Blast from a 120mm M121 Mortar System*. USAMRMC. Oct. 1997.
8. Charmaine Tate and colleagues. *Serum Brain Biomarker Level, Neurocognitive Performance, and Self-Reported Symptom Changes in Soldiers Repeatedly Exposed to Low-Level Blast: A Breacher Pilot Study*. Vol. 30 No. 19. October 2013.

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BlackBox Biometrics specializes in developing innovative technology that measures the unseen impact of concussive injuries, aiding in triage and treatment. Find out more at blastgauge.com.

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