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# Blast Injury Prevention Standards Recommendation (BIPSR) Process: Skull Fracture Blast Injury Type

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## Introduction

A Military Health System (MHS) Blast Injury Prevention Standard is a “biomedically-valid description of the physiologically- or biomechanically-based injury and performance response of a human to blast insults.” Standards range from simple dose-response curves and injury thresholds that address single components of blast insults, such as peak force, to complex algorithms and computational models that address multiple components of blast insults. Designed to address this, the MHS BIPSR Process is the DoD’s first unbiased, inclusive, stakeholder-driven process designed to identify and assess the suitability and applicability of existing candidate standards and to recommend standards that meet DoD Stakeholder needs with a suitable level of validity, rigor, precision, and confidence (Figure 1). Fourteen BIPSR Process Blast Injury Types were identified by DoD Stakeholders (Figure 2).

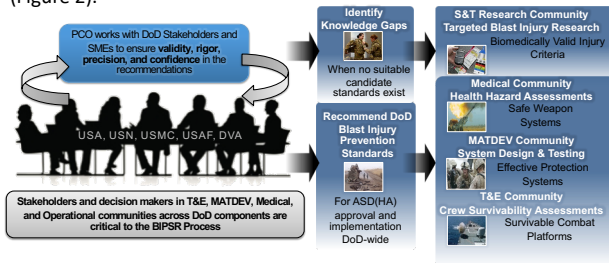


Figure 1: BIPSR Process Impact.

The MHS BIPSR Process has two major objectives. The first is to identify existing biomedically-valid candidate standards for immediate use by the DoD. The second is to inform the research community of gaps where no suitable candidate standards exist.

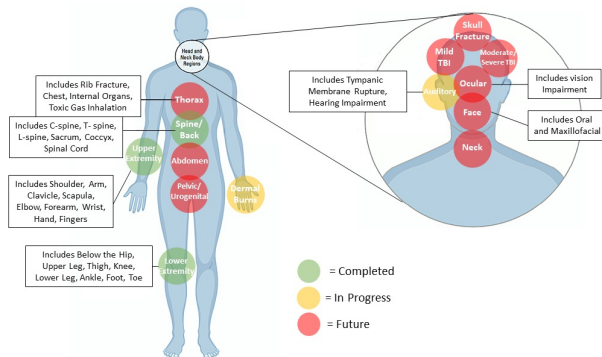


Figure 2: BIPSR Process Blast Injury Types identified by Stakeholders and their current status.

# BIPSR Process Skull Fracture Blast Injury Candidate Standards and mechanics of skull fracture



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## Preliminary Results

A preliminary literature review identified more than 1,065 closed-skull base fractures and 490 open-skull base fractures occurred during Operation Iraqi Freedom and Operation Enduring Freedom. Warfighters with penetrating brain injury (skull fracture with traumatic brain injury) were 69.8% more likely to have received that injury due to blast. Skull fracture injury due to blast occurs primarily due to penetrating fragments (secondary blast injury) and blunt trauma caused by head and body translation from initial blast wave (tertiary blast injury). A multidisciplinary approach to reconstruction, typically including an ophthalmologist, orthopedist, plastic, cardiovascular, and general surgeon, is required for an optimal recovery outcome.

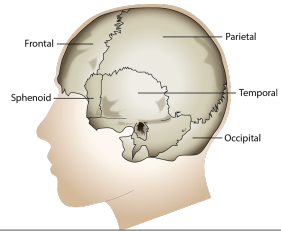


Figure 3: Skull bones included in the BIPSR Process Skull Fracture Blast Injury Type.

The force required to fracture the skull depends on the injury location and loading rate. Typically frontal and occipital bones require higher forces to initiate fracture, while parietal and temporal bones require lower forces to initiate fracture. Forces to fracture can vary between individuals due to skull thickness, history of previous trauma, and bone mineralization. When skull bones experience dynamic loading, the force tolerance before fracture increases approximately by a factor of two compared to quasistatic loading.

This preliminary literature review identified four potential BIPSR Process Skull Fracture Blast Injury Type Candidate Standards.

Injury Criteria	Skull Fracture Type	Model Input	Model Output
Wayne State Tolerance Curve	Linear	Acceleration & Time	Severity (unitless)
Gadd Severity Index	Linear	Acceleration & Time	GSI (unitless)
Head Injury Criteria	Linear	Acceleration & Time	HIC (unitless)
Skull Fracture Correlate	Linear	Velocity & Time	g-force / acceleration

## Next Steps

Next steps in the BIPSR Process include pulsing the community for additional Candidate Standards. This includes interviewing Subject Matter Experts (SMEs) identified in the literature search for additional Candidate Standards and information pertinent to the Skull Fracture Blast Injury Type. The BIPSR Process Skull Fracture Focused Stakeholder Committee, with members from DoD medical, T&E, operational, and MATDEV communities will be convened to define the problem statement, propose scenarios to be assessed, review standards currently in use, and identify knowledge gaps. These Focused Stakeholders drive the BIPSR Process. Focused Stakeholders will also issue a Request for Information (RFI) to identify potential injury prediction/simulation standards and ensure a broad canvassing of the community.

## Disclosure

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