

# Primary Blast Injury of Brain

Presentation to the  
ICD-10-CM Coordination and Maintenance Committee  
March 10, 2021

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# Disclaimer

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# Primary Blast Injury of Brain

- ICD-10-CM Diagnostic Codes exist for primary blast injury to eight organs susceptible to blast overpressure:
  - colon      ○ bronchus
  - rectum    ○ small intestine
  - ear        ○ fallopian tube
  - lung       ○ thoracic trachea
- A Diagnostic Code does not exist for primary blast injury of the brain.
- *Primary blast injury to the brain is a unique clinical entity.*
  - Qualitatively different in its origin and consequences.
  - Emerging clinical and experimental evidence supports the reality of this diagnosis absent impact acceleration.
  - Experimentally, the injury can occur in the absence of head motion.
- This injury can affect Service Members during training and combat operations.

# DoD Traumatic Brain Injury Worldwide – Total First-Time TBI Diagnoses Since 2000

SEVERITY	NUMBER	PERCENTAGE
Penetrating	5,482	1.3%
Severe	4,475	1.0%
Moderate	44,713	10.4%
Mild	354,991	82.4%
Not Classifiable	21,059	4.9%
<b>Total</b>	<b>430,720</b>	<b>100%</b>

Source: Defense Medical Surveillance System (DMSS), Theater Medical Data Store (TMDS) provided by the Armed Forces Health Surveillance Division (AFHSD).  
Prepared by the Traumatic Brain Injury Center of Excellence (TBICoE).  
2000-2020 Q3, as of Dec. 18, 2020.

# Pathologic Chain of Events

Blast wave energy transfer



Contusion

Shearing

Laceration

Axonal stretching



Secondary Brain Injury Mechanisms

(Complex biochemical/physiological processes)



Acute/Chronic Pathological Changes

Increased BBB permeability

Compromised cerebrovascular permeability

Compromised neuronal permeability

Diffuse axonal injury

Astrocyte and microglia activation

Apoptotic cell death

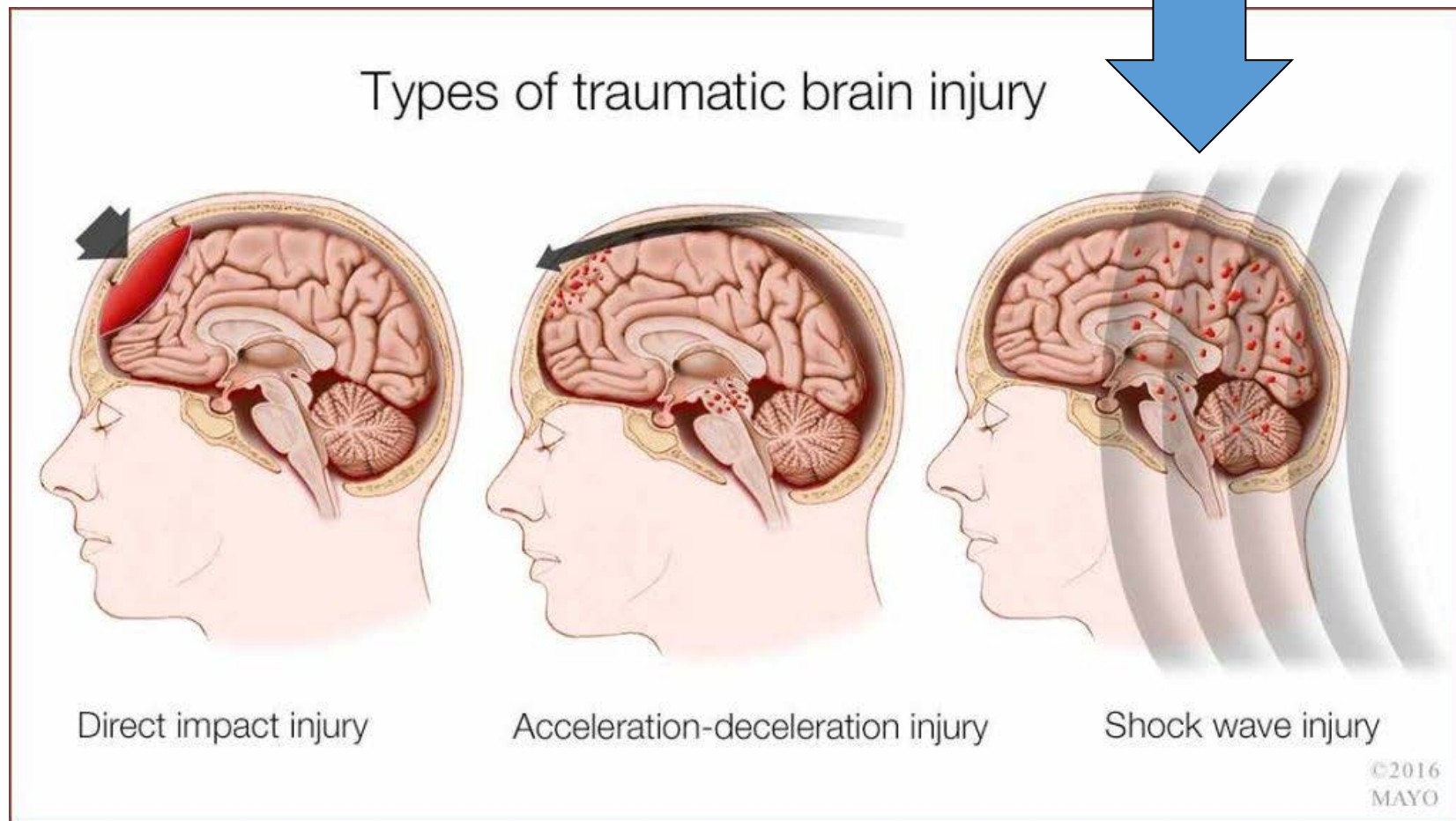
Purkinje cell degeneration

Increased vacuolization of cytoplasm

Myelin sheath damage

Neurofilament abnormalities

# Primary Blast Injury to the Brain: Exposure to a Shock Wave



Source: Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.

# Blast Physics

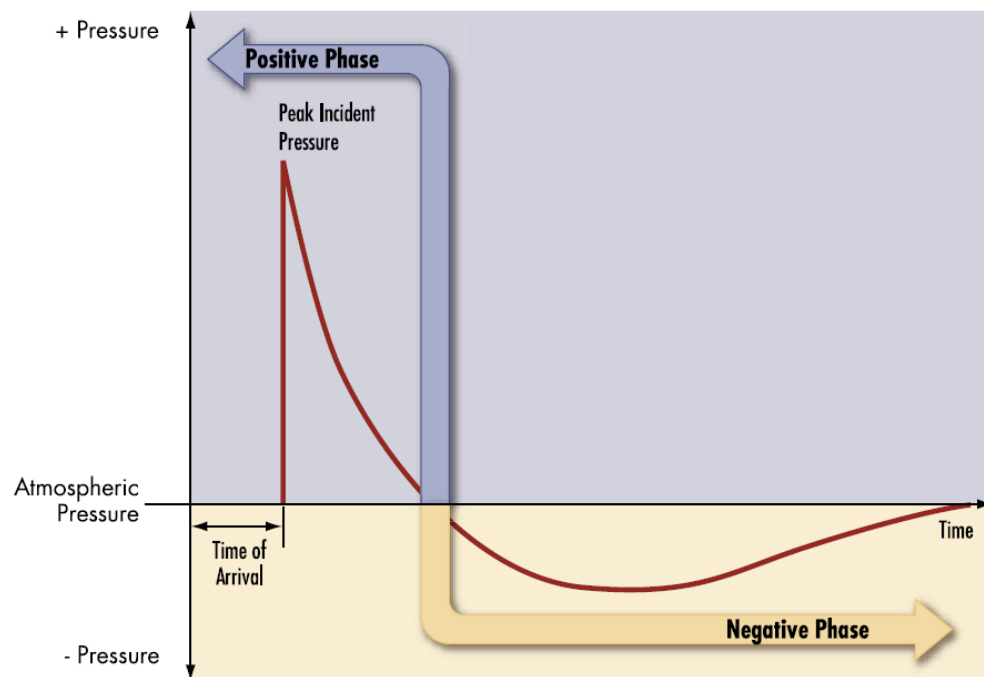
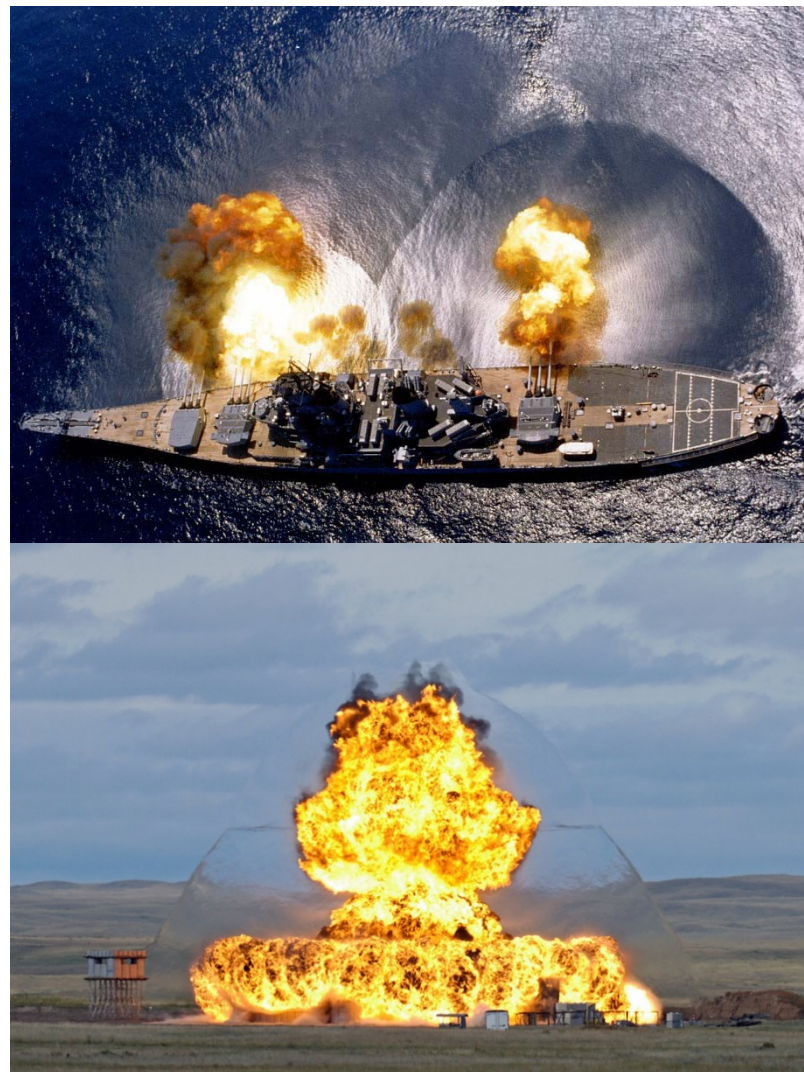


Figure 4-1 Typical pressure-time history

Source: FEMA 426, Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings (2003).

Source: Phan J. Alan Elliott - Public Domain.



Source: Defence Research and Development Canada (by permission statement)



# Blast-Brain Interaction

Two main mechanisms occur in parallel:

1. Transcranial

Direct interaction with the head through direct passage of the blast wave through the skull.

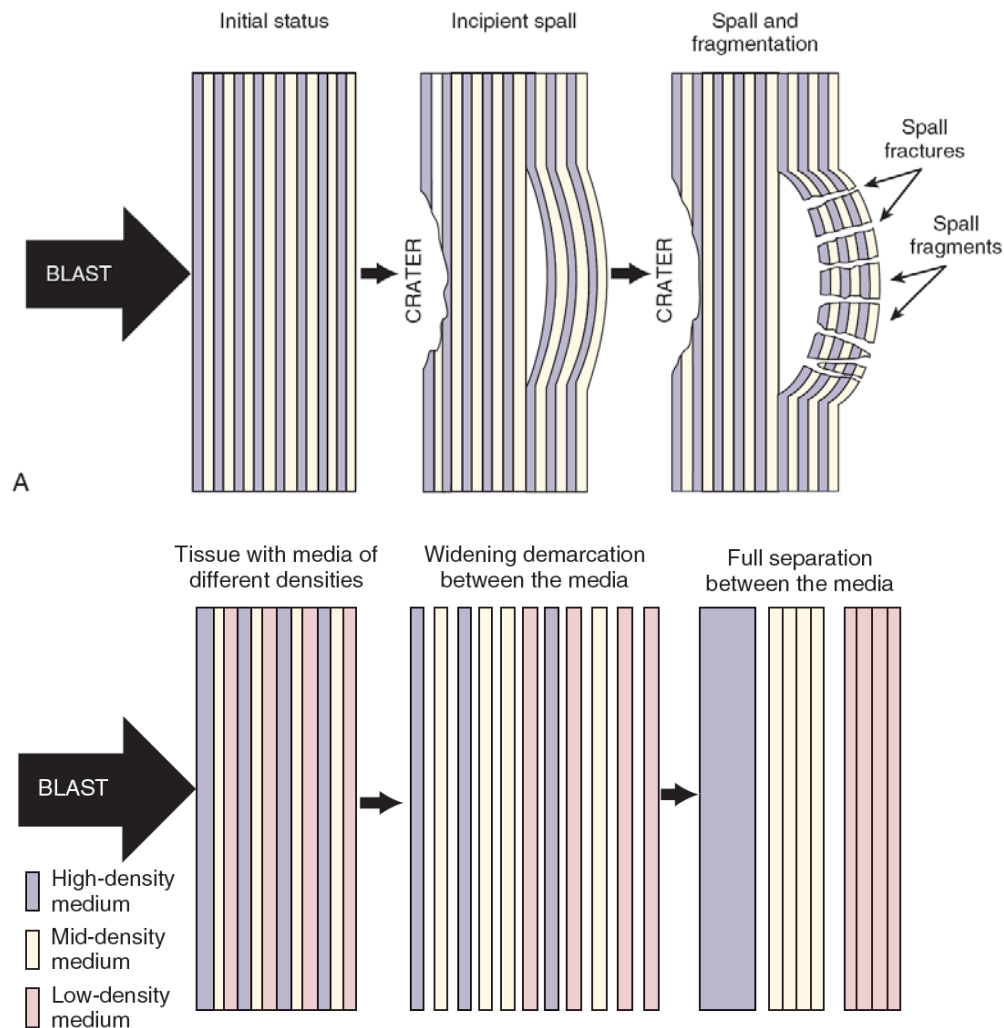
2. Transcorporal.

Kinetic energy transfer of the primary blast wave that *compresses the torso*, impacting blood vessels which send damaging energy pulses into the brain.



# Blast-Brain Interaction (Tissue Level)

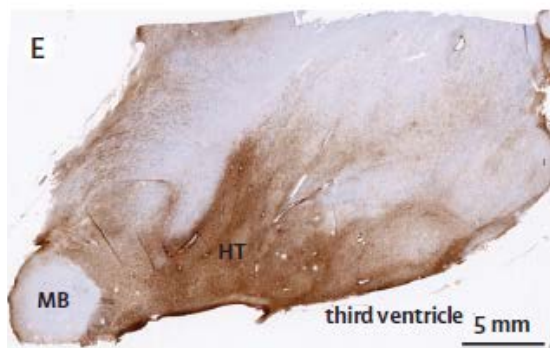
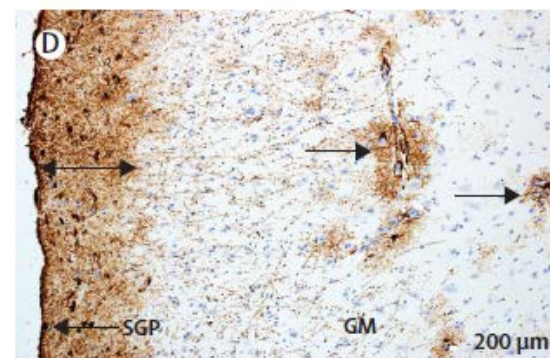
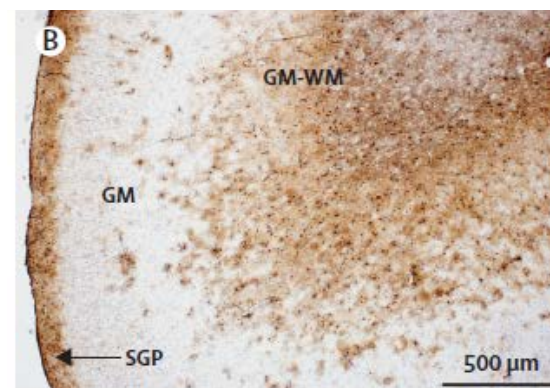
- Two general types of tissue response:
  - Caused by the impulse of the shock wave and is of longer duration.
  - Caused by the pressure variations of the shock wave and is in a form of oscillations or pressure deflections of shorter duration.
- Related tissue and organ damage:
  - Spallation
  - Inertial effects
  - Implosion (or “cavitation”)



Courtesy of the author, Ibolja Cernak, M.D. Ph.D.

# Post-Mortem Evidence of Blast-Brain Interactions

- Prominent astroglial scarring.
  - Subpial glial plate.
  - Penetrating cortical blood vessels.
  - Grey–white matter junctions.
  - Structures lining the ventricles.
- Distinct pattern of interface astroglial scarring.
  - Boundaries between brain parenchyma and fluids (cerebrospinal and blood).
  - Junctions between grey and white matter.
- Consistent with the general principles of blast biophysics.



Prepared by a US federal government employee as part of the employee's official duties; public domain.

# Pathophysiology of Primary Blast Brain Injury

Pressure wave passes through the body and head inducing complex response mechanisms:

- Secondary mechanisms initiated by primary tissue damage of the brain parenchyma.
- Changes triggered by the autonomic nervous system (vago-vagal reflex).
- Consequences of increased vascular load.
- Effects of locally synthesized and released mediators and modulators.

# **Blast Brain Injury: A Separate and Distinct Form of Brain Injury**

- Mechanism of injury.
- Early cerebral edema.
- Prolonged cerebral vasospasm.
- Cerebral vasospasm even in the absence of subarachnoid hemorrhage.
- Blood-brain barrier dysfunction.
- Unique pattern of diffuse axonal injury.
- Interface astroglial scarring.
- Systemic pathology that affects the brain.



# Blast Injury in Combat and Training



Photo By: Cpl. Victor A. Arriaga (VIRIN: 140731-M-FR159-352)



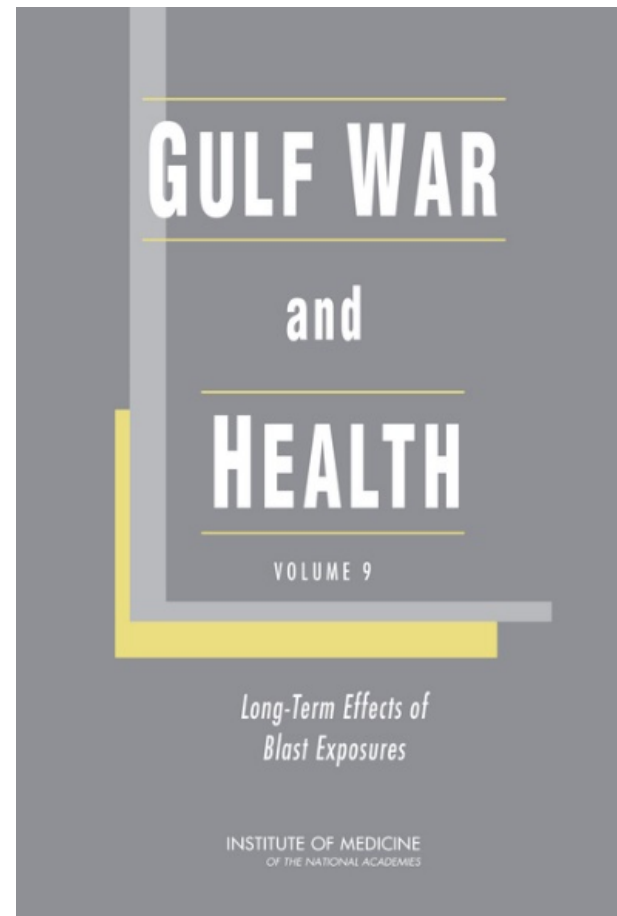
Army Photo By: Spc. Josselyn Fuentes (VIRIN: 180908-A-SD031-546X.JPG)



Photo By: Maj. Carson Petry (VIRIN: 180717-A-EN512-001.JPG)

# 2014 Institute of Medicine Report: Long-Term Effects of Blast Exposure

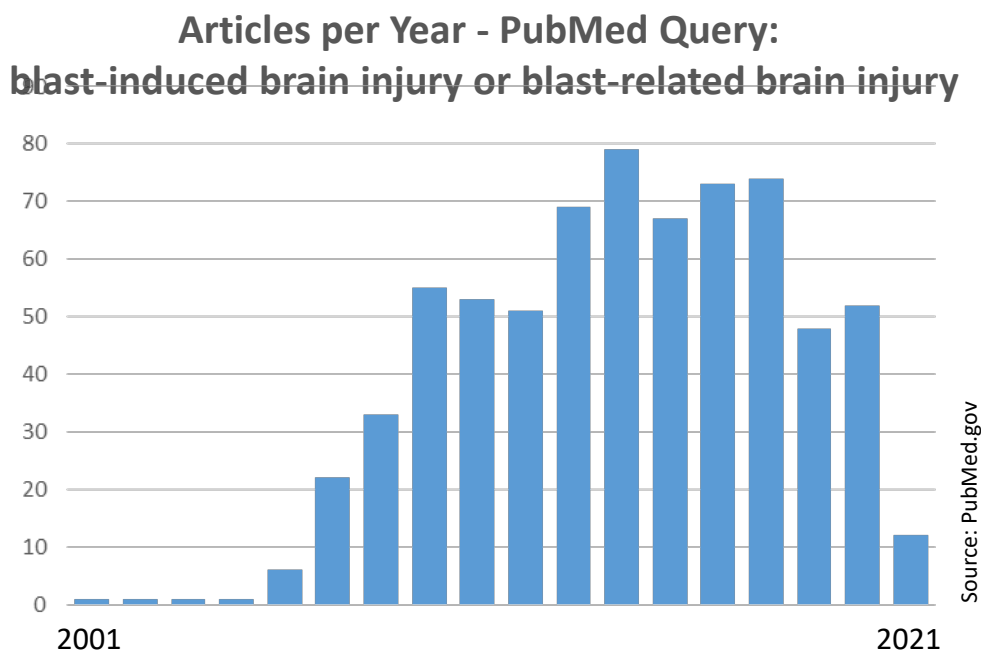
- Blast TBI is at least as severe as non-blast TBI.
- Distinctive clinical presentations that require different therapeutic strategies.
- Early malignant brain swelling.
- Distinctive neuroimaging patterns as measured by DTI (tractography).
- Diffuse bi-hemispheric pattern of disruption.
- May result in a higher frequency of global cerebral complaints involving cognitive, visual, auditory, and other sensory modalities.



With permission: The National Academies Press

# The Research Continues...

- 429 articles on blast-induced or blast-related **brain** injuries have been published since the 2014 IOM report.
- Combined VA and DOD research spending on military TBI in excess of \$2 billion in the past decade.





# Summary

- Important.
  - High burden of disease in military and veteran populations.
  - National security.
  - Costly.
  - Ongoing exposure in military training and some civilian occupations.
  - Public health issue.
- Unique clinical entity.
- Still much to learn and apply.
  - Prevention.
  - Screening and diagnosis.
  - Treatment, management, and rehabilitation.

# ICD-10 Diagnostic Code: Primary Blast Injury to Brain

- Needed.
- Appropriate.
- Will provide downstream benefits to patients, clinicians, and researchers.

Thank you.

*15 selected references available from proponents.*

# Questions/Comments

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