Incidence and Neuropsychiatric Sequelae of Traumatic Brain Injury: Implications for the Military

Deborah L. Warden, M.D
National Director
Defense and Veterans Brain Injury Center

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Talk Overview

- TBI Overview – pathophysiology
- Mental Health Aspects of TBI
- Epidemiology
- Blast Injury
- Possible Areas of Research

Measurements of TBI Severity

- Length of loss of consciousness (LOC)
- Length of post-traumatic amnesia (PTA)
  - Post-injury period of confusion with deficits in retaining new information and processing new memories; PTA ends when continuous (or near-continuous) memory resumes
- Glasgow Coma Scale (GCS)

Neuropathology of Closed TBI

Primary Injury:

- Contusions/Hemorrhages
- Diffuse Axonal Injury (DAI)

Secondary Injury (Intracranial):

- Blood Flow and Metabolic Changes
- Traumatic Hematomas
- Cerebral Edema
- Hydrocephalus
- Increased Intracranial Pressure

Neuropathology of Closed TBI

Secondary Injury (Systemic), e.g.,:

- Hypoxemia
- Hypotension
- Hyponatremia
- Infection

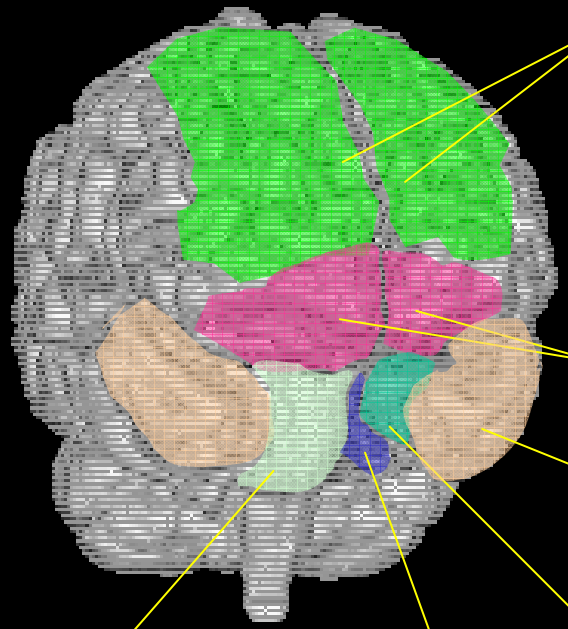
Diffuse Axonal Injury

- Axonal Stretching or Tearing
- Physiological Reaction (e.g., Povlishock, et al. 1992):
  - Impairment of axoplasmic transport, focal swelling of the axon, progression to axonal separation
  - Potential “window of opportunity” before axon becomes discontinuous

Morbidity of TBI

Cognitive, somatic, neuropsychiatric sequelae

Regional Cortical Vulnerability to TBI Predicts Neuropsychiatric Sequelae



Dorsolateral prefrontal cortex (executive function, including sustained and complex attention, memory retrieval, abstraction, judgement, insight, problem solving)

Orbitofrontal cortex (emotional and social responding)

Anterior temporal cortex (memory retrieval, face recognition, language)

Amygdala (emotional learning and conditioning, including fear/anxiety)

Hippocampus (only partially visible in this view - declarative memory)

Ventral brainstem (arousal, ascending activation of diencephalic, subcortical, and cortical structures)

D. Arcineagas, M.D.

Postconcussion Symptoms (PCS)

- Headache
- Dizziness
- Irritability
- Decreased Concentration
- Memory Problems
- Fatigue
- Visual Disturbances
- Sensitivity to Noise
- Judgement Problems
- Anxiety
- Depression

Post Concussive Sx inMild TBI

- Natural history is recovery within weeks to months (Levin 1987), although a small percentage will continue to have persistent symptoms (Alexander, Neurology 1995)
- High school athletes with 3 or more prior concussions were up to 9 times more likely to develop symptoms than athletes without prior injury (Collins, et al, Neurosurgery 2004)
- Patients with MTBI may be more sensitive to symptoms/dysfunction than their families; patients with moderate-severe TBI are less sensitive to dysfunction than their families (Drake, et al, unpublished data)

Average Number of Post TBI Symptoms by Severity of Injury: Ft. Bragg

(For those reporting on 20 or more of the 22 symptoms)

Severity of Prior TBI	Average Number of Symptoms
No TBI (n=687)	2.00
Altered Mental State Only (n=281)	3.41
1-20 mins LOC (n=296)	4.24
21-59 mins LOC (n=40)	5.58
1 hr or more LOC (n=30)	5.90

Neurocognitive Changes

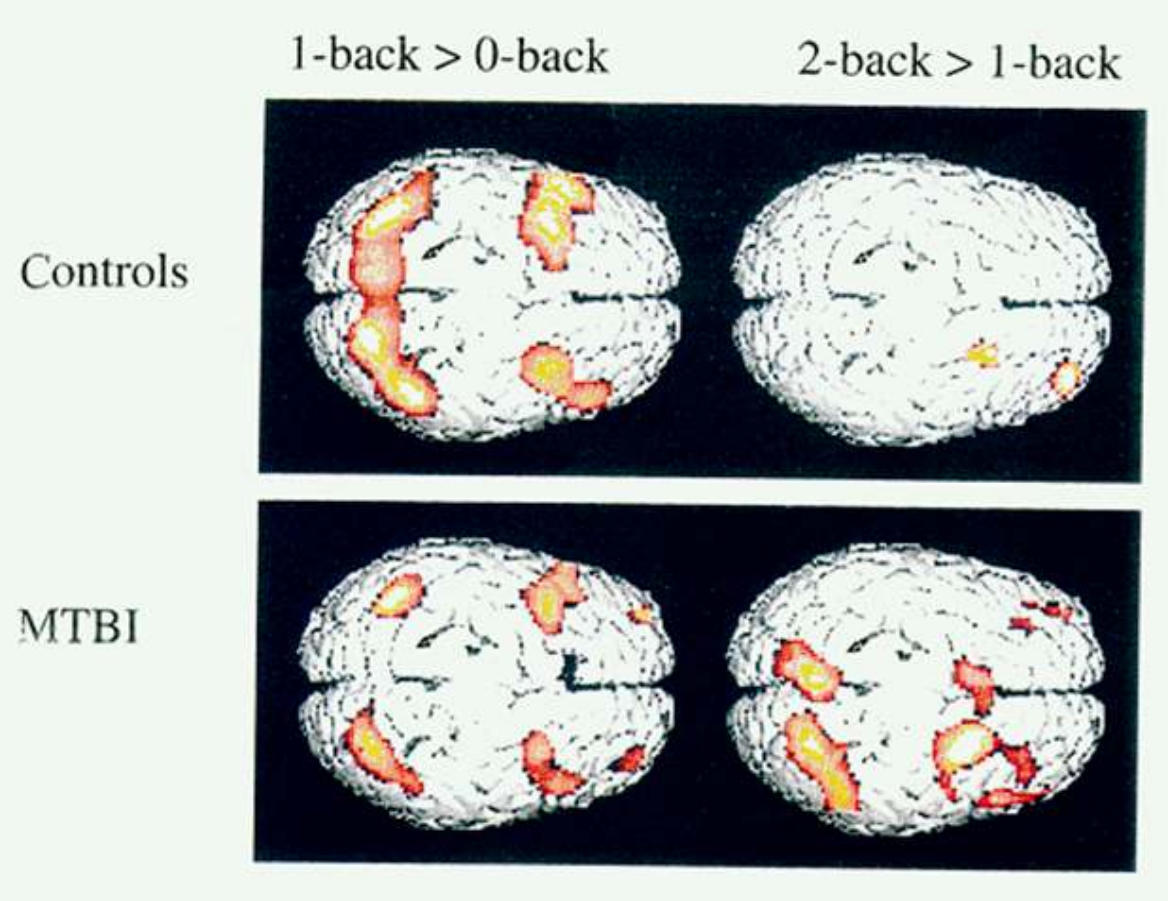
Attention/Concentration

Speed of Mental Processing

Learning/Information Retrieval

Executive Functions (e. g., Planning, Problem Solving, Self Monitoring) May see judgment problems, apathy, inappropriate behaviors

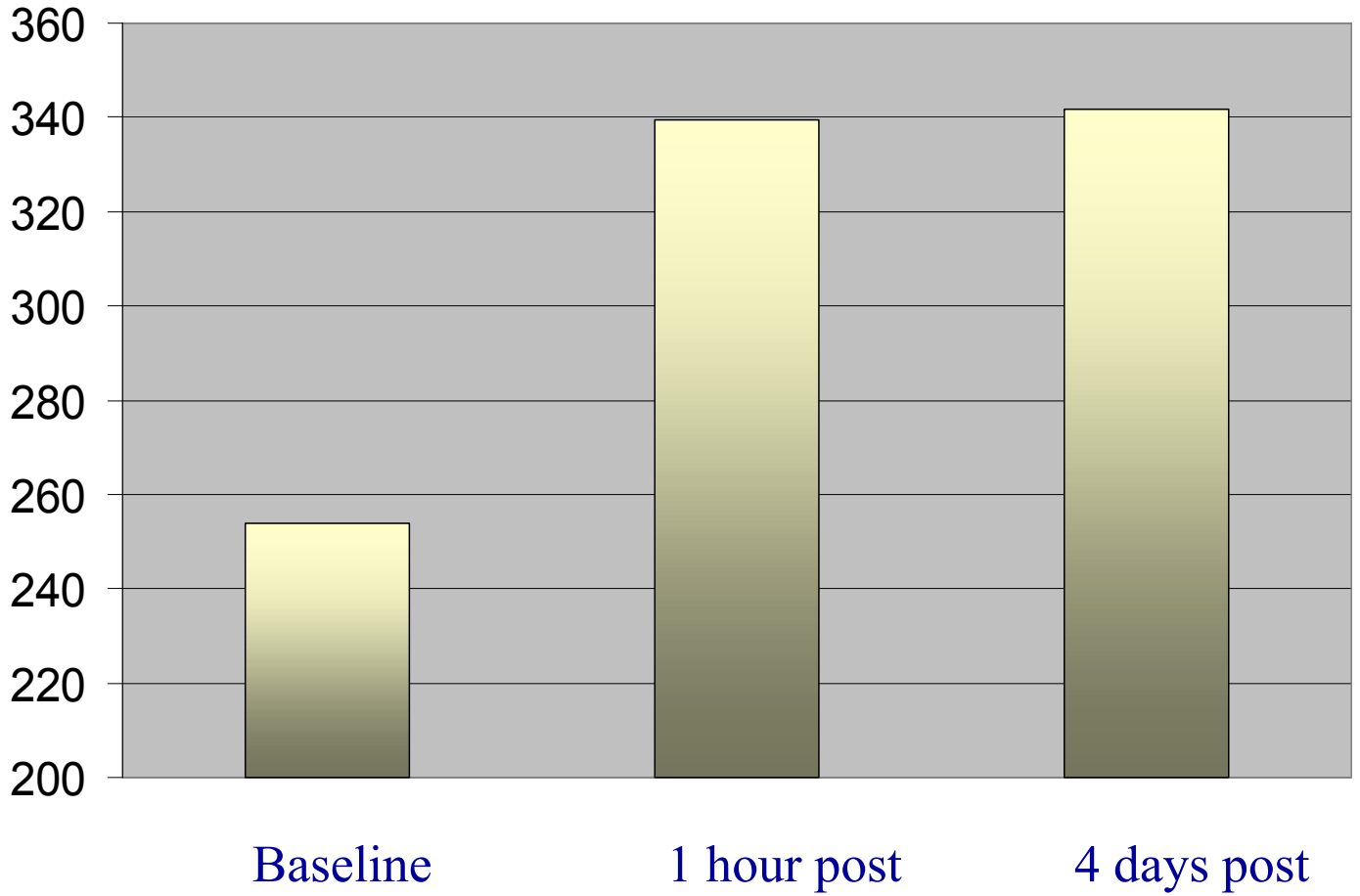
fMRI study of MTBI and Memory (McAllister, et al, 2000)



USMA Concussion Study

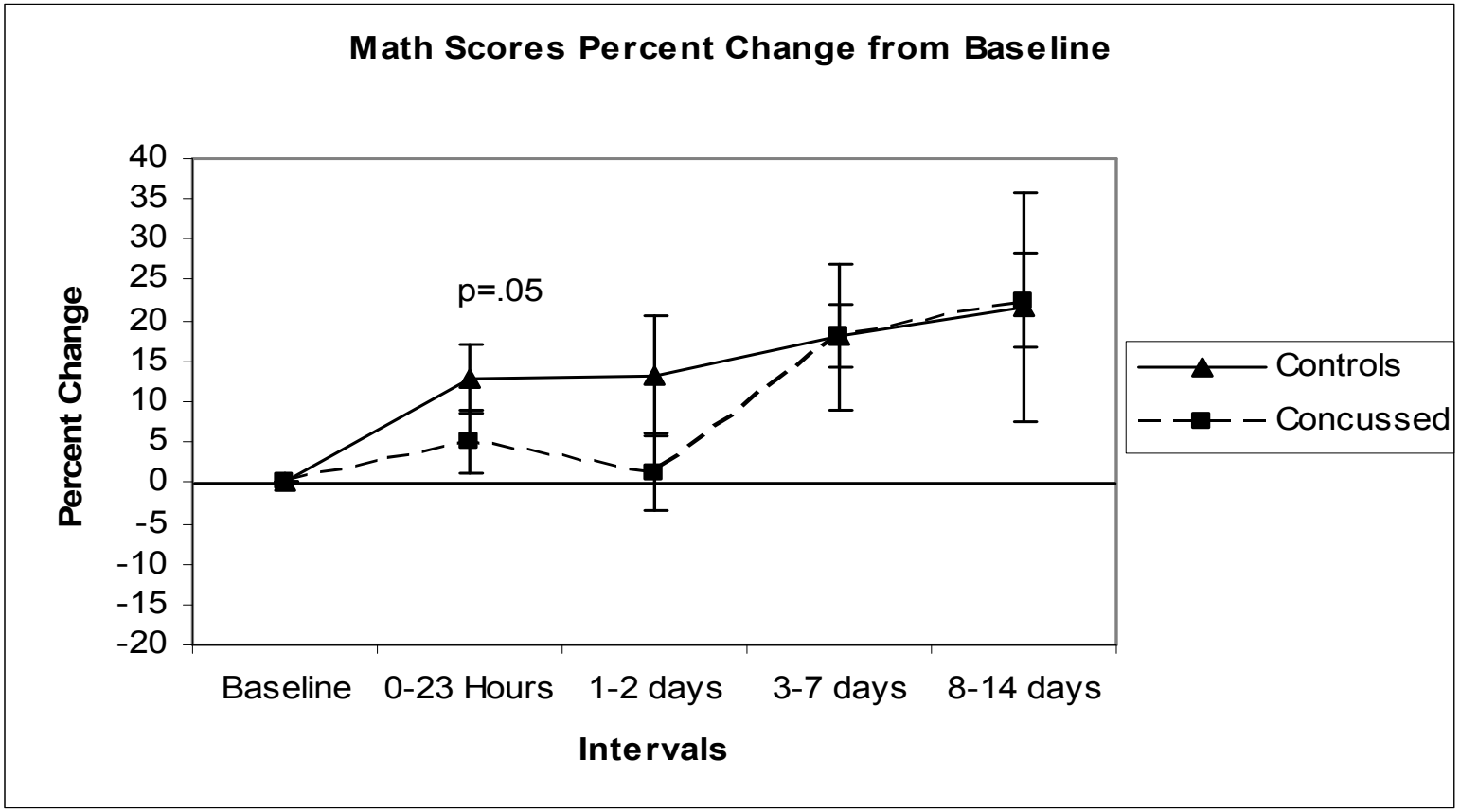
Simple Reaction Time

$p < 0.05$



Warden D, Bleiberg J, Cameron K, et al, *Neurology*, 2001

Concussion:Time to Recovery



Bleiberg J., et al. Neurosurgery, 2004.

Psychological/Psychiatric and Psychosocial Changes after TBI

Personality:

- Increased/Decreased Activation
- Episodic Dyscontrol;Irritability

Psychiatric:

- Mood Disturbance
- Psychosis

Psychosocial:

- Work Status
- Relationships with others

Depression and TBI

- Approximately 33% of hospitalized TBI patients develop Major Depression in 1st year (Jorge et al 2004)
- 25-60% of TBI patients develop a depressive episode within 8 years of injury (Kreutzer, 2001; Hibbard, et al, 1998; Jorge and Robinson, 2002).
- Depression is associated with comorbid anxiety, aggressive behavior, poorer social and functional outcome (Jorge and Robinson, 2002; Jorge et al 2004) and left frontal brain injury; Jorge et al 2004).

PCS and Acute Stress/ Post Traumatic Stress Disorder (PTSD)

- Overlap of symptoms
- Consideration that some patients with “battle fatigue”/”shellshock” may have had repeat concussions
- Issue of PTSD in individuals with LOC
- Consecutive series of military subjects with moderate-severe TBI, six of 47 (13%) met all criteria of PTSD except for the intrusive/reexperiencing phenomena (Warden, et al. 1997).

PTSD in TBI

- Studies suggest that PTSD following TBI does occur, but may be modified by the brain injury.
- Intrusive memories are less common than in non-TBI individuals; when present, highly predictive of PTSD; development of PTSD is more likely in less severely injured individuals with TBI.
- The rate of PTSD appears to increase over time, though few studies offer longitudinal follow-up.
- Range of traumatic memories: events immediately before loss of consciousness, events experienced after regaining consciousness, information/photos etc. learned upon regaining consciousness, and traumas reactivated from earlier life events.

Warden & Labatte, PTSD and other Anxiety Disorders, Textbook of Traumatic Brain Injury, APPI, 2004

TBI Treatment

Pharmacotherapy:

Symptomatic Treatment: Headache, Sleep, Irritability

Antidepressants (e.g., SSRI's); PTSD

Stimulants

Anticonvulsants/Mood Stabilizers

Note: Limited Class I evidence to date; DVBIC RCT's in progress for SSRI's

TBI Treatment

Psycho-educational:

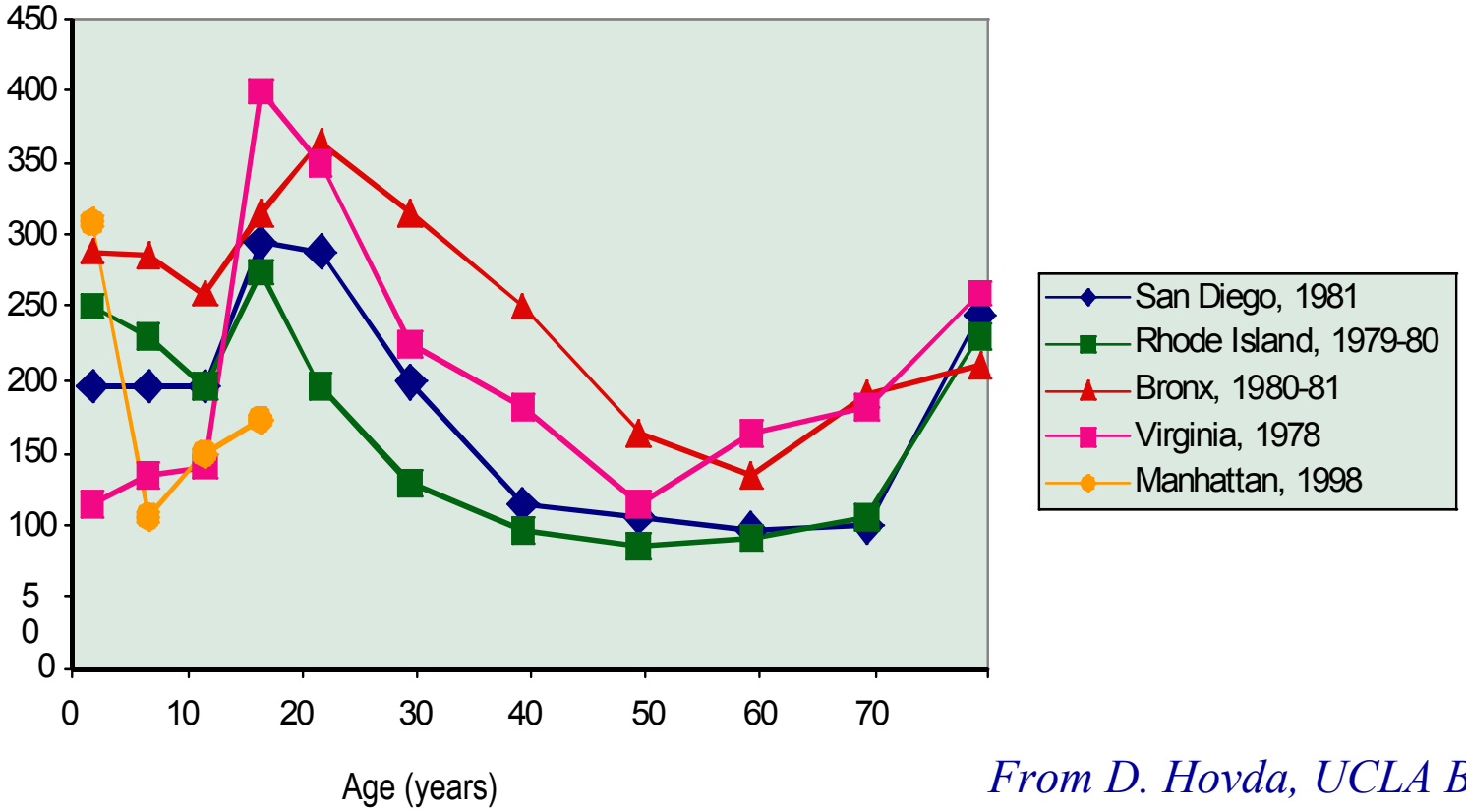
- TBI Symtomatology *
- Expected Course of Recovery *
  - With acute intervention, results show reduced morbidity

Rehabilitation:

- More intensive TBI rehabilitation when needed for more severe injuries (either in specialized centers or with TBI specialists in DVA or military centers; Salazar, et al., 2000)

Note: (*Ponsford, et al., 2002; Mittenberg, et al., 1996; Bell, et al., *J Head Trauma Rehabil*, 2004;)

Traumatic Brain Injury (TBI) Epidemiology: Incidence



From D. Hovda, UCLA BIRC Program (modified from Kraus JF, et. al. 1996 and Durkin MS, et. al. 1998)

Military Hospital Costs for TBI in 1992

Hospital Costs Associated with TBI Among Military Personnel, Dependents, and Retirees:

$42 million in FY 1992

Source:

Ommaya AK, Ommaya AK, Dannenberg AL, Salazar AM. Causation, incidence, and costs of traumatic brain injury in the U.S. Military Medical System. *J Trauma*. 1996; 40(2): 211-217.

Total Cost Associated with TBI in the Civilian Population in 1985

Costs for treatment and other care:	$4.5 billion
Costs resulting from lost work and disability for TBI survivors:	$20.6 billion
Costs such as lost income resulting from TBI fatalities:	$12.7 billion

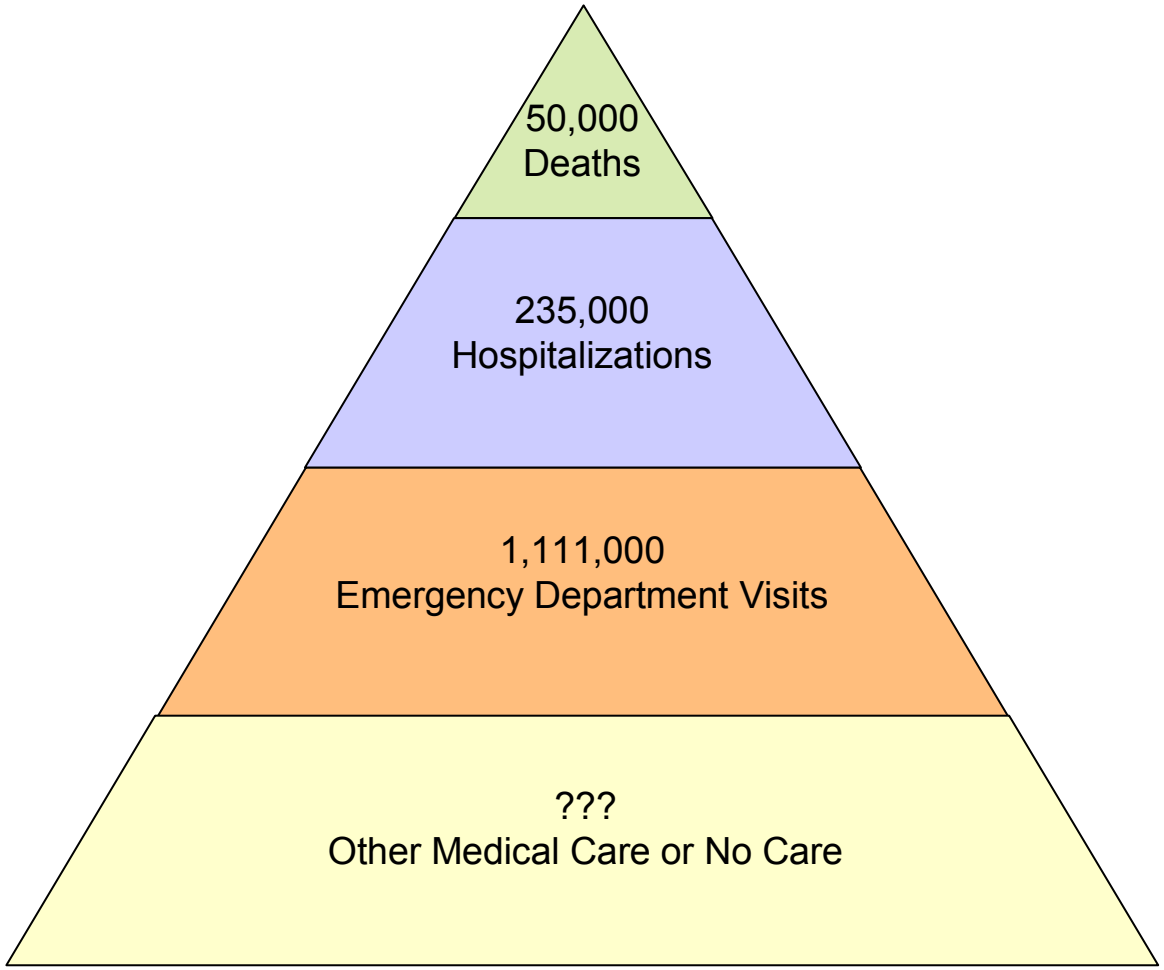
Sources:

Max W, MacKenzie EJ. Head injuries: Costs and consequences. *J Head Trauma Rehabil.* 1991; 6(2): 76-91.

Diagnoses Considered to be TBI

ICD-9 CM Codes	Code Description
800.00-800.99	Fracture of vault of skull
801.00-801.99	Fracture of base of skull
803.00-803.99	Other and unqualified skull factures
804.00-804.99	Multiple fractures involving skull or face with other bones
850.0-850.9	Concussion
851.00-851.99	Cerebral laceration and contusion
852.00-852.59	Subarachnoid, subdural, and extradural hemorrhage following injury
853.00-853.19	Other and unspecified intracranial hemorrhage following injury
854.00-854.19	Intracranial injury of other and unspecified nature
854.00-854.19	Intracranial injury of other and unspecified nature
959.01	Head injury, unspecified

Annual Incidence in Civilian Population



Source: Langlois, et al., CDC: Traumatic Brain Injury in the United States, October 2004

Selected Demographics of Hospitalized TBI Patients

15 to 24 age group is among those at the highest risk for TBI in the military(2) and civilian populations[1]

The TBI risk for civilian males is about 1.7 times greater than for civilian females[1]. The TBI risk for military males is about 1.4 times greater than for military females (2).

The TBI risk for military females is approximately the same as that of civilian males[2]

Sources:

1. Langlois, et al., CDC. Traumatic Brain Injury in the United States: Emergency department visits, hospitalizations, and deaths. October 2004.
2. Ommaya AK, Ommaya AK, Dannenberg AL, Salazar AM. Causation, incidence, and costs of traumatic brain injury in the U.S. Military Medical System. *J Trauma*. 1996; 40(2): 211-217.

Estimates of Untreated TBI Cases

Sosin, Sniezek, and Thurman conservatively estimated from the 1991 National Health Interview Survey that 25% of TBI cases were medically untreated.*

* Brain injury was defined as self-reported head injury with loss of consciousness that also resulted in a period of restricted activity.

Missed TBI Diagnoses*

51% of 47 patients seen in a British trauma center with a TBI did not have a TBI diagnosis recorded

Most TBI patients lacking a coded TBI diagnosis had other injuries coded

*TBI defined as any injury to the head *and* some gap in memory for events.

Moss NEG, Wade DT. Admission after head injury: How many occur and how many are recorded?. *Injury*. 1996; 27(3): 159-161.

Combat TBI

Blast Induced Injury

Blast Injuries

Multifactorial injury mechanism:

- Primary: Direct exposure to overpressurization wave – velocity >/= 300m/sec (speed of sound in air)
- Impact from blast energized debris – penetrating and nonpenetrating
- Displacement of the person by the blast and impact
- Burns/Inhalation of gases
- Combination with MVA in war theater

G. Cooper, et al 1983

Blast Injuries

- Primary blast injury: interaction of the overpressurization wave and the body
- Air-filled organs vulnerable: ear, lung, and GI tract
- The brain is also vulnerable: direct injury, e.g. cerebral contusion; indirect injury, e.g. cerebral infarction secondary to air emboli (Elsayed, 1997;Mayorga, 1997). Data on non-fatal blast closed brain injury are limited.
- Blast injury induced brain injury & resultant cognitive dysfunction are described in rats exposed to both whole body overpressurization waves, and also to more focal blasts to the torso while the head was protected (Cernak et al., 2001).

Blast Injury Induced Brain Injury

- Research to date: focused on injuries to extremities, torso, and penetrating head injuries (shrapnel/flying debris).

- Penetrating injuries typically identified and cared for immediately.

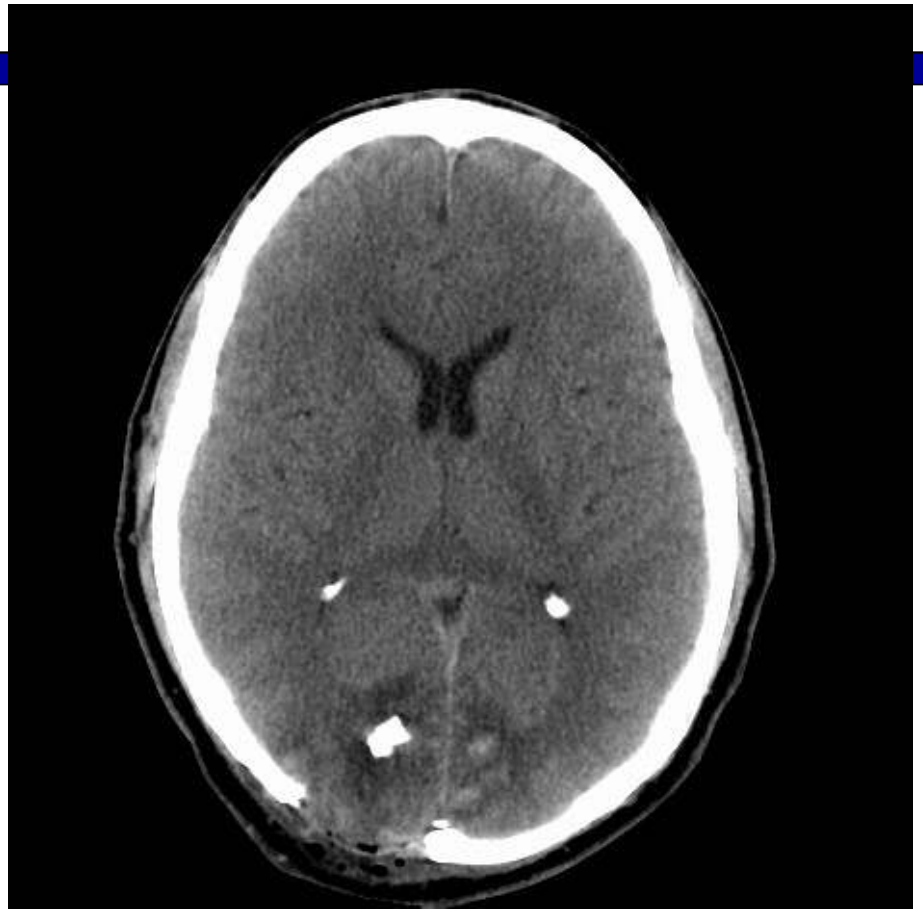
- Closed head injury, especially more mild injuries/concussions, may not be as readily identified, particularly if occurring with other injuries requiring immediate attention such as amputation.

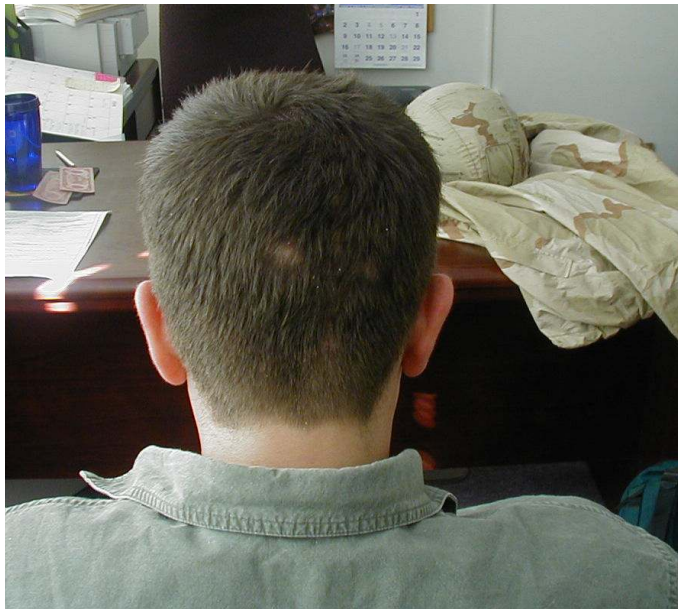
Cernak, I., et. al. 1999. J Trauma: Injury, Infection, and Critical Care. 47:1 96-104

ARMY OIF – WOUNDED IN ACTION

19 Mar 03 – 31 May 04 N = 1288

Category	Occurrences	Percentage
IED	333	26%
Shrapnel	267	21%
GSW	235	18%
Blast	200	16%
Landmines	29	2%
MVA	26	2%
Burns	28	2%
Parachute	18	1%
Blunt Trauma	11	1%
Crushing Injury	11	1%
Acft Related	5	0.4%
Misc	125	10%
Total	**1288**	**100%**





ARMY OIF WIA BY SPECIALTY

19 Mar 03 – 31 May 04 N = 1288

Category	Occurrences	Percentage
General Surgery	522	41%
Orthopedic	467	36%
Ophthalmology	62	5%
Neurosurgery	55	4%
Ear-Nose-Throat	45	3%
Burns	37	3%
Internal Medicine	20	2%
Neurology	16	1%
Audiology	12	1%
Thoracic	12	1%
Oral Surgery	11	1%
Misc.	29	2%
Total	**1288**	**100%**

Combat TBI in OIF: The Walter Reed Army Medical Center (WRAMC) Experience

- The Defense and Veterans Brain Injury Center at WRAMC has evaluated 355 TBI patients from OIF/OEF as of end Aug 2004.
- Over half of all WIA injuries currently sustained are blast related injuries (OTSG).
- 59% of blast patients seen at WRAMC had at least mild Traumatic Brain Injury
- Preliminary data demonstrate that as many soldiers are treated at a CSH for head injury and returned forward as evacuated out of theater.

Implications of MTBI/Concussion

- Unit Readiness
  - 100 msec. – relatively large reaction time change
  - soldiers may be unable to will away symptoms
  - behavioral issues may ensue
- Individual Issues
  - feel “broken”
  - possible shell shock as repeat blast MTBI exposure
  - irritability/ issues with family and others

WAR ON TERROR

Military and Civilian Focus Merge

- Battlefield and Enemy are less defined
- Mass Casualty Preparedness at Home
  - Limited time and rapid depletion of resources
  - Triage dependent on salvagability vs. costs in time, resources and personnel

DVBIC Blast TBI Initiatives

- Establish archives of individuals treated in theater
  - QI projects: Records of many in-theater docs to DVBIC
- Determine the size of the problem in returning units
  - Capabilities within existing research protocols
  - Ability to screen for injury/symptoms
    - Post deployment questions
    - Telemedicine capabilities for assessment
- Follow-up of individuals seen at WRAMC
- Assess factors related to poor outcome/ good outcome – cumulative TBI

Take Home's on Military and Veteran TBI

- Need to screen all those at risk for TBI
- When these individuals are encountered
  - Good history for identification and documentation
  - Evaluation, including cognitive/behavioral and mood screens
  - Access to care and follow-up ensured by DoD and VA
  - www.dvbic.org

Summary

- TBI in the current combat environment: not uncommon, often in association with severe multi-trauma, PTSD, or underdiagnosed concussion
- Possible consequences:
  - Effects on unit readiness when service members prematurely returned to duty
  - Lack of care can lead to increased morbidity
- Effective treatment requires identification of cases

DVBIC Headquarters, WRAMC

- LTC R Armonda, MC
- Gayle Baker, MHS
- Stephanie Ball, BS
- Angela Bastolla, BS
- COL James Ecklund, MC
- Louis French, PsyD
- Kelly Gourdin, BS
- LTC Ed Hartmann
- Brian Ivins, MA
- Ronelle Inollado, RN
- LTC Geoff Ling, MC
- Warren Lux, MD
- Glen Parkinson, MSW
- Winston Punch, MA
- Alice Marie Stevens, MA
- Lorraine Goodrich, BA
- Laurie Ryan, PhD
- Karen Schwab, PhD
- Robert Sharpe, MPA
- Jose Valls, LPN
- Jehue Wilkinson, LPN
- Lauren Chandler, BA

DVHIP/DVBIC

- Walter Reed AMC -Lou French, Psy D
- Naval Medical Center, San Diego
  - CAPT John Grossmith, Angela Drake, PhD
- Wilford Hall AF Medical Center - LTC Michael Jaffe
- Tampa VAMC – Steve Scott, DO
- Minneapolis VAMC – Barbara Sigford, MD, PhD
- Palo Alto VAMC – Elaine Date, MD; Henry Lew, MD, PhD
- Richmond VAMC – William Walker, MD
- Virginia Neurocare, Inc. – George Zitnay, PhD