Mild Traumatic Brain Injury:

The Military Experience and Applications for Management in the Community

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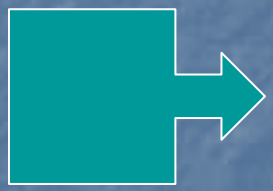
TBI "In the News"

- September 11th, 2001
- Iraq
- Afghanistan



Signature Injury

- NFL
- NHL
- Congresswoman Giffords
- Other media outlets

Goals and Objectives

- History
- Definition
- Epidemiology
- Pathophysiology

Overview

- Assessing cognitive changes
- Understanding behavioral changes
- Co-morbid factors that interfere with recovery

History of TBI Rehabilitation

- Pre-1900
  - Penetrating head injury = 70% mortality
- WWI-WWII (Germany and Austria)
  - Advent of "TBI rehabilitation"
  - Recognition of neuropsychological impairments
  - Teaching strategies of preserved skills to compensate for impairments
  - Employment and vocation as outcome measure.

History of TBI Rehabilitation

- Post WWII (United Kingdom, Russia, United States)
  - Research
    - Compensatory training (motor planning, visual perception, executive functioning)
    - Functional Prognosis (PTA)
    - Medical Complications (seizures)
  - Multidisciplinary approach
  - Standardized testing

History of TBI Rehabilitation

- Professional Development to meet veteran's needs.
  - SLP
  - PT
  - OT
  - Vocational
  - Mental Health
  - Physical Medicine and Rehabilitation (Physiatry)
- Dedicated rehabilitation centers
  - SCI
  - TBI
  - Stroke
  - Ortho (amputations)

THEN…

- …and NOW

http://blog.americanhistory.si.edu/osaycanyousee/2011/07/reflections-on-the-closing-of-a-hospital.html

http://www.caller.com/photos/2010/aug/14/85558/

http://www.usatoday.com/news/military/2011-07-27-walter-reed-closing_n.htm

File photo NMCD

http://www.frontpagenews.us/2009_04_01_archive.html

File photo NMCSD

http://ihm.nlm.nih.gov/luna/servlet/detail/NLMNLM~1~1~101442559~142364:Walter-Reed-Army-Medical-Center--Li?printerFriendly=1

http://www.army.mil/article/32595/

Traumatic brain injury (TBI)

- Nondegenerative, noncongenital insult to the brain
- External mechanical force
- Leading to permanent or temporary impairments of function
  - Cognitive
  - Physical
  - Psychosocial
- Associated diminished or altered state of consciousness.

Defining the problem

- Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine
- Traumatically induced physiologic disruption of brain function
  - LOC
  - Immediate Retrograde/post-traumatic amnesia
  - Alteration of mental state (stars, dazed, “bell rung”)
  - Focal neurologic deficits

Grading

- Mild
- Moderate
- Severe

Mild TBI

- Does not exceed
  - LOC<30min
  - PTA <24hr
  - GCS 13-15
  - No imaging findings
- mTBI=Concussion?
  - It depends on who you talk to…

Moderate

- LOC: 30min-24hrs
- PTA: 24hr-1 week
- GCS 9-12
- Neuroimaging evidence of intracranial trauma

Severe

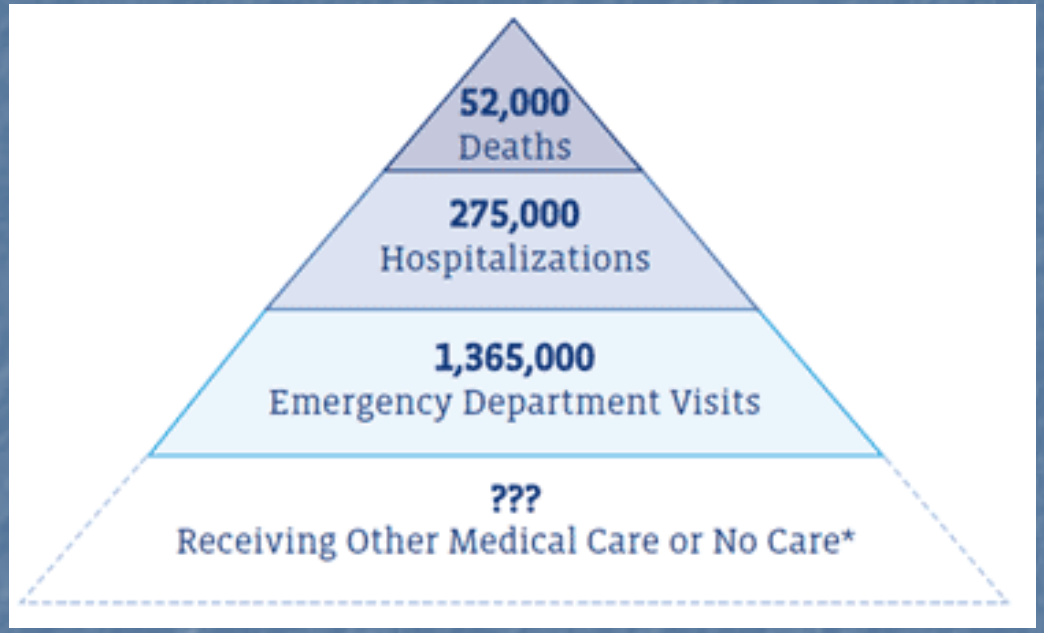
- LOC: >24hrs
- PTA: > 1 week
- GCS <8
- Neuroimaging evidence of intracranial trauma
- Penetrating/depressed/displaced scull fracture

Epidemiology: GWOT

- 12-35%, 1.6 million Service Members deployed in last 11 years.
- 80% Blast related (IED, RPG, EFP, etc.)

Epidemiology

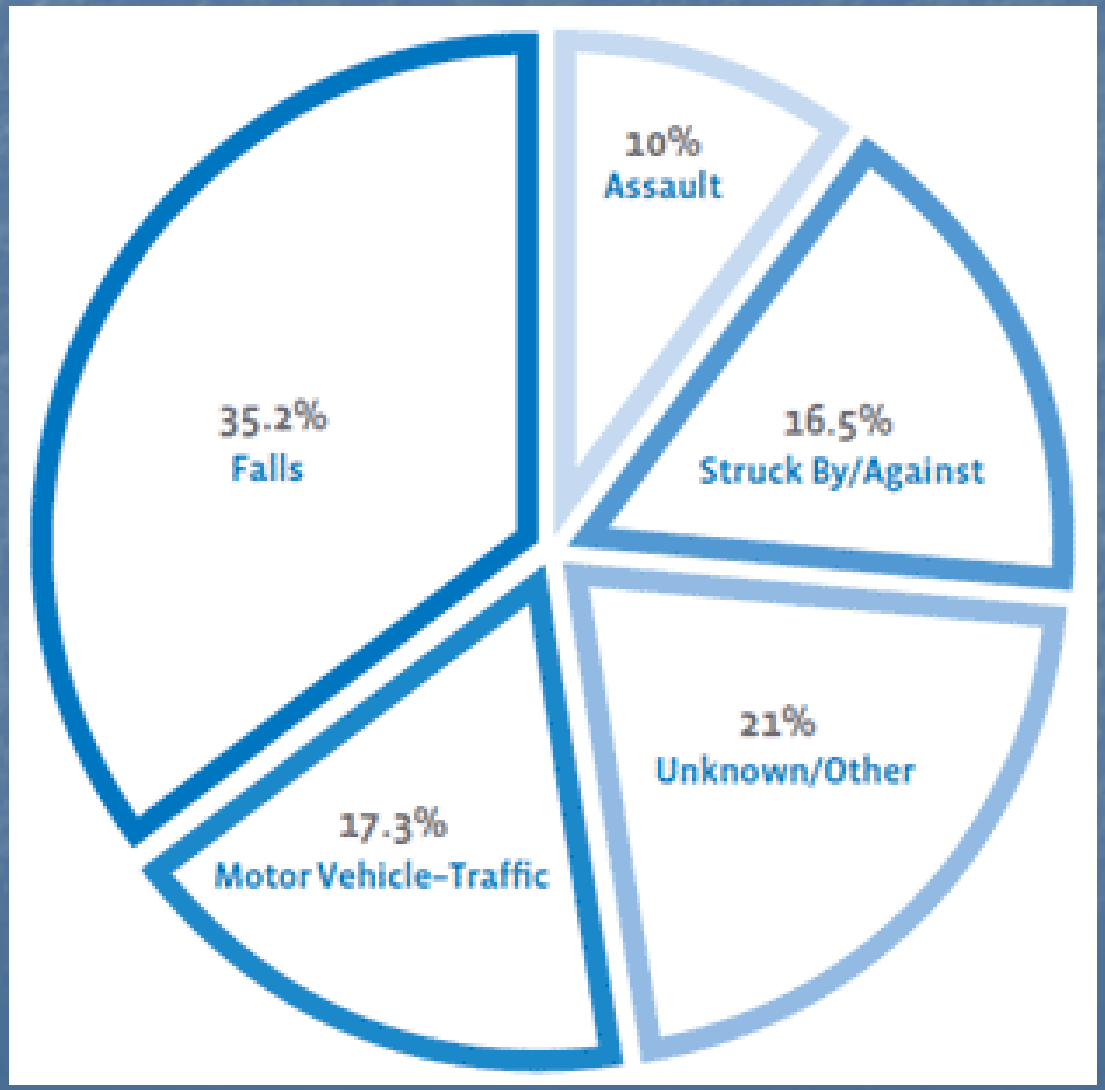
- CDC
  - 2002-2006
- Incidence 1.7 million per year (?underestimated?)



Epidemiology

- Pitfalls
  - Inconsistent definition
  - Inadequate reporting
  - Inadequate imaging

MOI


10%
Assault
16.5%
Struck By/Against
21%
Unknown/Other
17.3%
Motor Vehicle-Traffic
35.2%
Falls

Groups at Risk

- 59% male
- 0-4, 15-19, >65 yoa
- 18 % TBI ER visits 0-4 yoa
- 22% hospitalization >75 yoa
  - Highest rate of hospitalization and death

Risk Factors

- Alcohol
- Substance Abuse
- Crime
- Societal factors

Trends 1979-1992

- TBI deaths down 22%
  - GSW deaths (up 9%)
    - #1 cause of TBI deaths
  - Decreased MVA deaths (down 42%)
- 30% associated with all injury related death.

Importance

- 5.3 million Americans—2% of the U.S. population—currently live with disabilities resulting from brain injury.
- $76.5 billion total direct/indirect medical cost and lost productivity (2000)
  - LBP ~ $100 billion

Importance

- 75% of TBIs that occur each year are mild TBI.

Prevention and Education

- Airbags
- Safety belts
- Helmets
- Violence prevention programs
- Falls prevention programs
- Proper sports equipment
- Combat protective equipment

Goff, et. Al.

Weight Supported by Neck

1) Kevlar Helmet- 4.2 lbs (1.9 kg)
2) Night Vision Goggles- 1.5 lbs (.68 kg)
3) Tactical Kevlar Light- 4 oz (42.5 grams)

Total weight = 5.95 lbs (2.69 kg)

Weight Supported by Back/ Shoulders

4) Body Armor System- 35 lbs (15.9 kg)
5) Tactical Load Vest- 2 lbs (0.90 kg)
6) 12 Magazines of ammunition- 15 lbs (6.8 kg)
7) 4 Fragmentation grenades- 6 lbs (2.7 kg)
8) 2 Flash Bang grenades- 2 lbs (0.90 kg)
9) 2 First Aid Kits- 2.2 lbs (1 kg)
10) Multi-purpose tool- 1 lb (0.45 kg)
11) Seatbelt Cutter- 6 oz (170 grams)
12) Back-pack Hydration style with 3 liters- 8 lbs (3.6 kg)

Total Weight = 71.53 lbs (32.5 kg)

Weapon Systems

13) Rifle- 6.9 lbs (3.1 kg)
14) Scope- 7 oz (198.5 grams)
15) Night Vision/ Laser Emitter- 7.5 oz (212.6 grams)
16) Tactical Mount Light- 1 lb (0.45 kg)
17) Foregrip/Bipod- 1 lb (0.45 kg)
18) Pistol- 3.1 lbs (1.4 kg)
19) 2 Magazines of ammunition- 2 lbs (0.90 kg)
20) Holster- 1.4 lbs (.63 kg)

Total Weight = 16.40 lbs (7.43 kg)

ACU Uniform

21) Combat Shirt- 10 oz (283.5 grams)
22) Trousers- 1.2 lbs (0.54 kg)
23) Rigger Belt- 6 oz (170 grams)
24) Combat Boots- 4.4 lbs (2 kg)
25) Knee Pads- 1.2 lbs (0.54)
26) Gloves- 5 oz (141 grams)
27) Ballistic Eyewear- 1 oz (28.3 grams)

Total Weight = 8.15 lbs (3.7 kg)

http://en.wikipedia.org/wiki/MRAP

http://defensetech.org/2007/08/30/amazing-mrap-survival-photos/

Pathophysiology

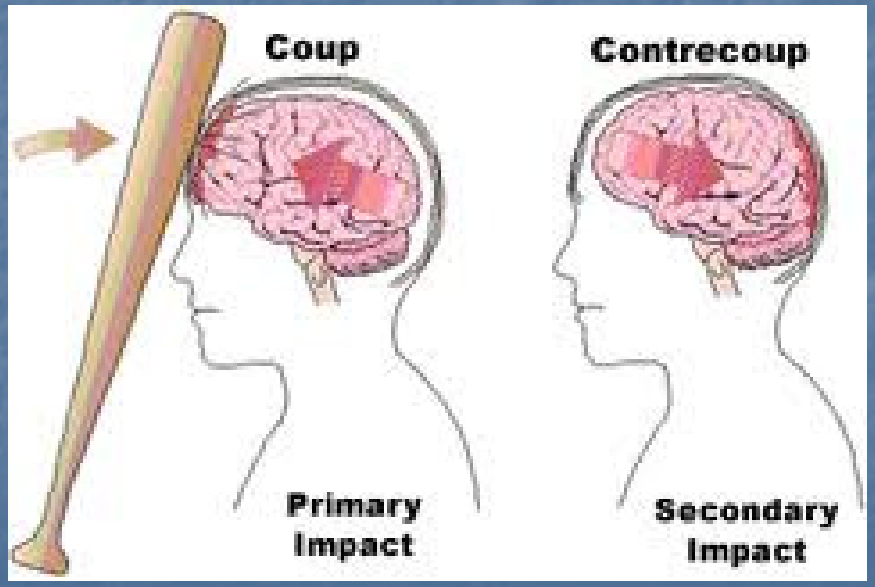
- Self limiting
- Short lived
- Spontaneous resolution
- Transient disturbances
- Observation
- Underreported and underestimated

Pathophysiology

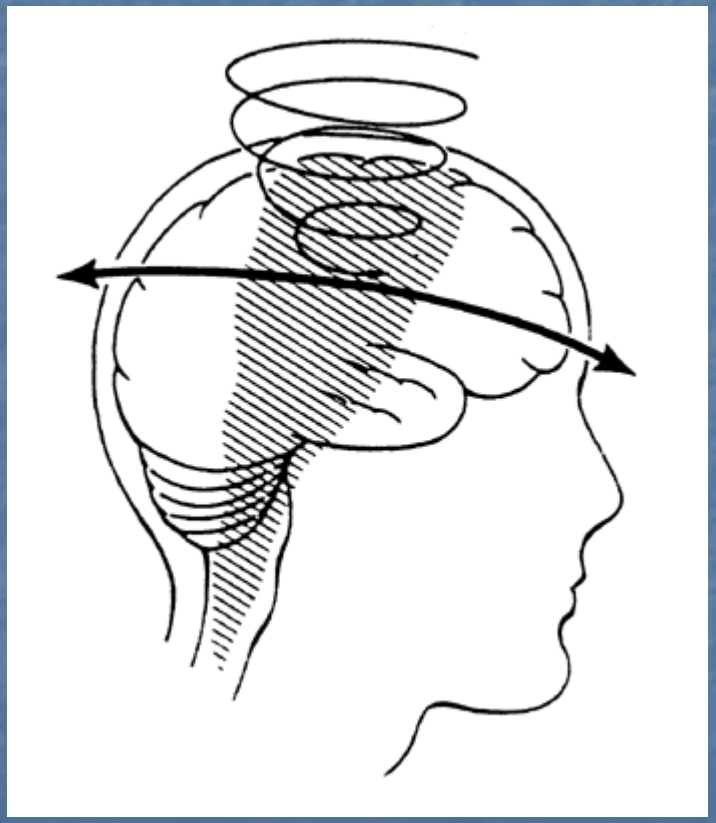
- "mild"=absence of cranial lesion
  - "mild"=describes mechanism of injury
- "mild" =/= 100% normal outcome or predict prognosis
- Typical resolution in 1-12wks
  - 15% remain symptomatic

Pathophysiology

- Diffuse Axonal Injury
  - Spectrum of severity



http://www.braininjury.com/injured.shtml



http://www.uihealthcare.com/topics/medicaldepartments/neurosurgery/braininjury/03whattypesbraininjuries.html

Pathophysiology

- Neurochemical/Neurometabolic events
  - Release of excitatory amino acids (EAA)
    - Glutamate
    - Activation of NMDA receptors
    - Influx of calcium
    - Impairment of mitochondrial activity

Pathophysiology

- Neurochemical/Neurometabolic events
  - Imbalance of ATP consumption/production
  - Compromises synaptic plasticity
    - Focal neurologic and other cognitive/behavioral deficits
- N-acetylasperate (NAA)
  - Brain specific metabolite
  - Low levels suggest neuronal injury
    - Stroke, MS, dementia

Pathophysiology

- Neurochemical/Neurometabolic events
  - N-acetylasperate (NAA)
    - Brain specific metabolite (neuronal mitochondria)
      - High energy cost
    - Low levels suggest neuronal injury
      - Stroke, MS, dementia
      - Hypoxic/ischemic/toxic
    - Proton magnetic resonance spectroscopy (1H-MRS)

Pathophysiology

- Neurochemical/Neurometabolic events
  - N-acetylasperate (NAA)
    - Animal models
      - Correlated with severity
      - Mild TBI vs. sham head injury
    - Brain vulnerability vs. Second Impact Syndrome
      - SIS is FATAL and rare (cerebral edema)
      - Changes in ATP/NAA in repeated mTBI models
    - Resolution over time?
      - ~30days

Pathophysiology

- Genetic expression
  - Increased ASPA gene expression
  - Decreased NAA production (depressed mitochondrial function)

Pathophysiology

- Clinical/Research applications
  - Monitor NAA levels
  - Determine window of clearance
  - Treatment targeting mitochondrial function

Modern State of TBI Surveillance

- DVBIC (DVHIP) – 1992 (GW)
- TBI Act of 1996
  - CDC
- DVBIC 2008 (GWOT)
  - "Signature Injury"

The DoD Approach

- Office of Neurotrauma, Navy Medicine West SoCal
  - Naval Medical Center San Diego
  - Naval Hospital Camp Pendleton
  - Naval Hospital Twentynine Palms

The NMCSD TEAM

- DVBIC
  - Multicenter network
  - Collaboration between DoD and VA entities
  - DCoE PH/TBI
- Comprehensive Combat and Complex Casualty Care (C-5) Program
  - Case Management and Primary Care model with a rehabilitation focus.
  - Management of all overseas/deployed service member who medically evacuated or transported to NMCSD.
  - Polytrauma Rehabilitation

The Approach

- VA-DoD CPG
  - Primary Care Model
- SATEPS
  - Screening
  - Assessment
  - Treatment
  - Education
  - Patient Follow-up
  - Surveillance

VA/DoD CPG

- Adult injury
- Apply to all medical providers
- Does not address acute management or mod/sev TBI.

VA/DoD CPG

- Establish accurate diagnosis
- Evidence based management and treatment
- Early intervention
- Multidisciplinary approach

VA/DoD CPG

- Adult injury
- Apply to all medical providers
- Does not address acute management or mod/sev TBI.

VA/DoD CPG

- Patient screening
- Patient education
- Early intervention
- Symptom management
  - Somatic
  - psychiatric
- RTD ASAP
  - Psycho-social support for refractory sypmtoms
  - Secondary gain?
- Continuity and Follow up.

Core Components

- Screening:
  - DVBIC TBI Screening Tool, TBI Severity Score
- Assessment:
  - Medical Exam
- Treatment:
  - 20 week care plan, VA DoD CPG, Interdisciplinary Team

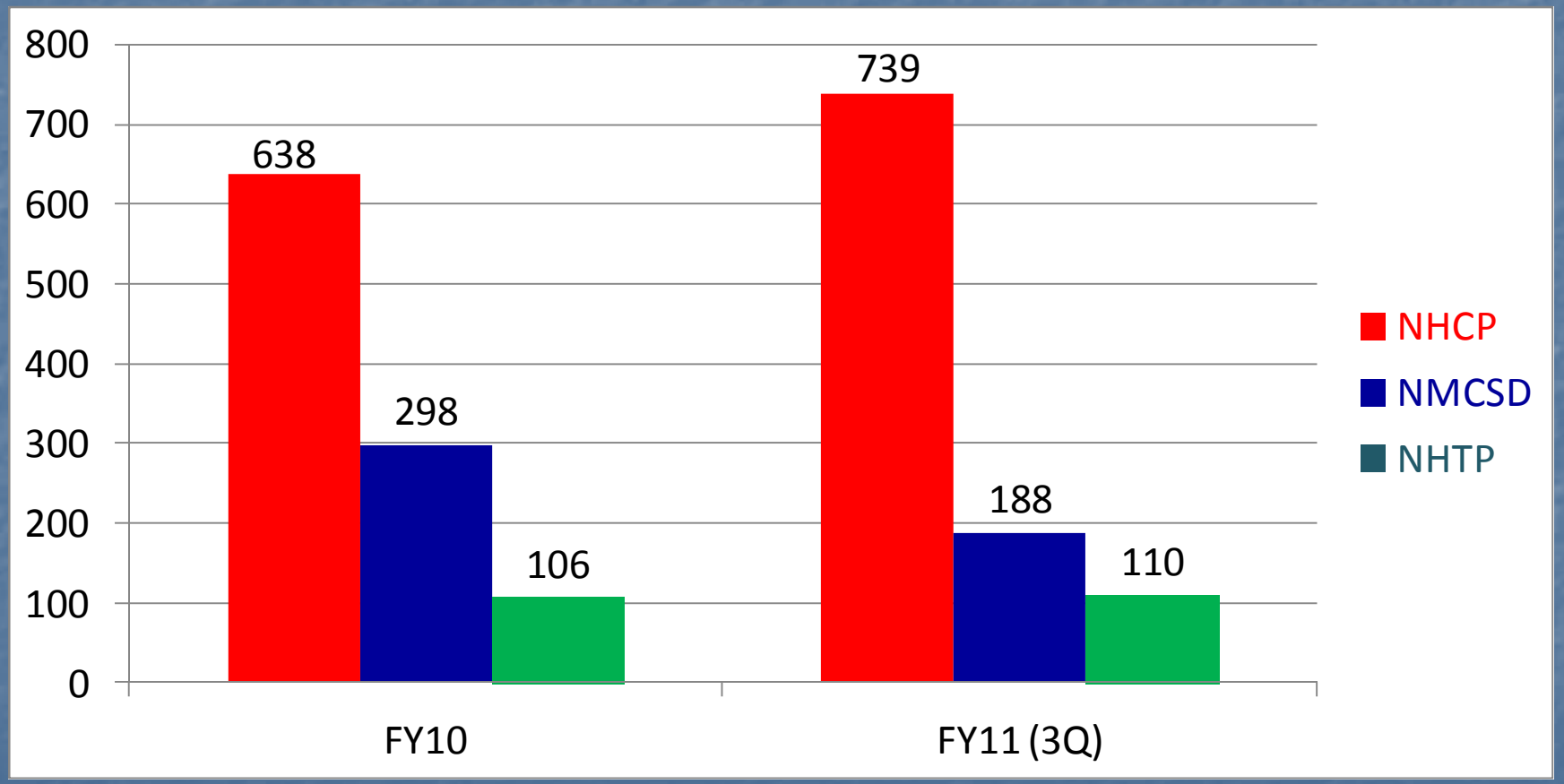
Core Components

- Education:
  - Face to face with provider, DVBIC
- Patient Follow-up:
  - Interdisciplinary Team
- Surveillance:
  - Demographics, Tracking, Metrics

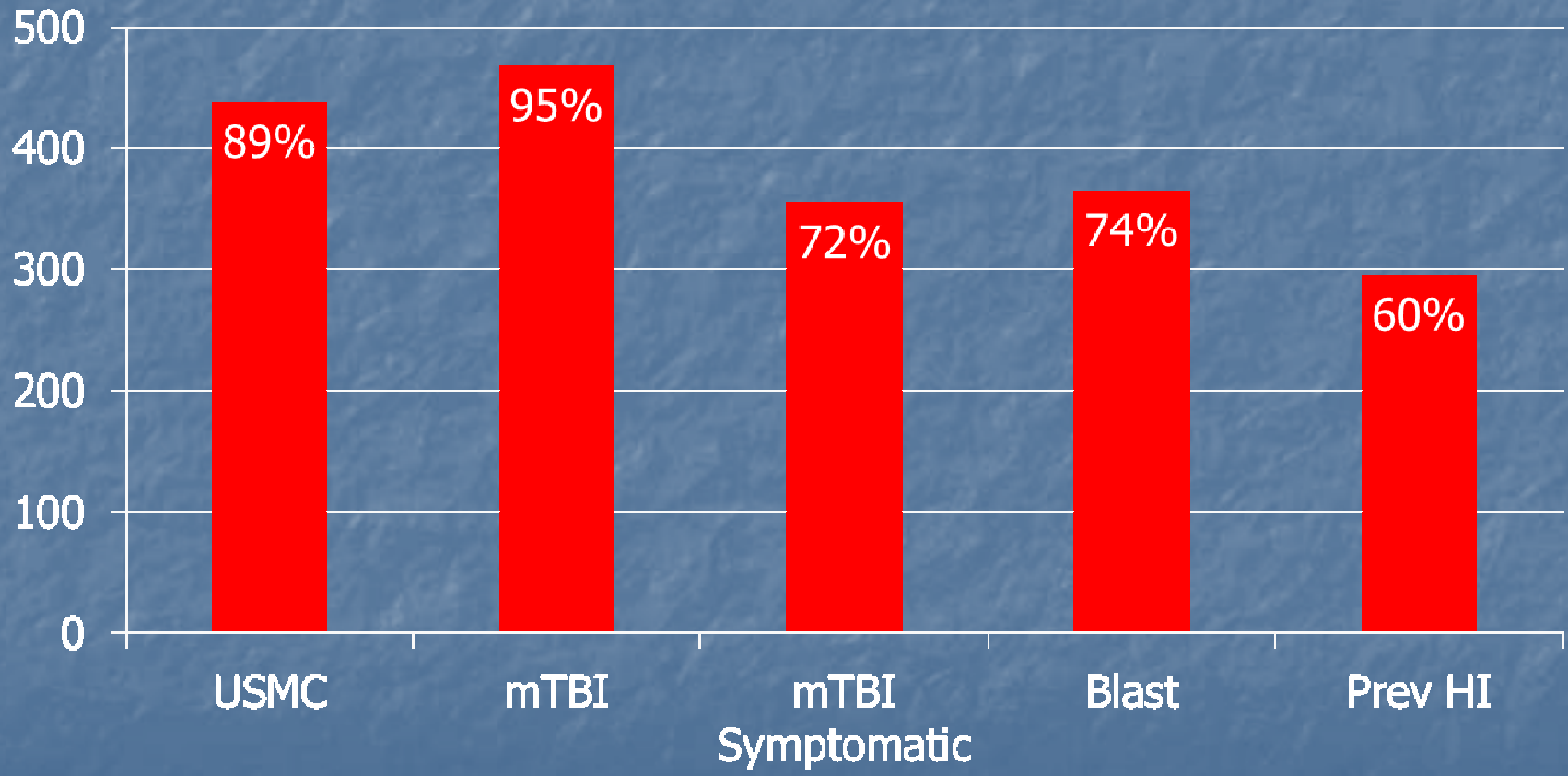
Military Demographics

- Navy Medicine West

TBI Patients Identified
n=2079

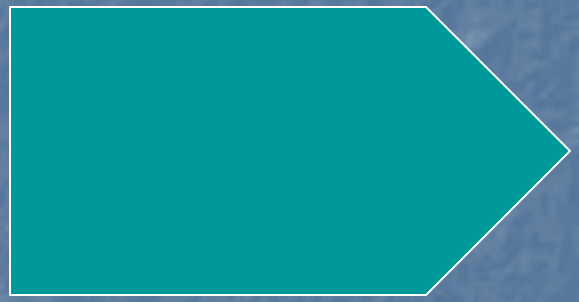


TBI Demographics
n=492



TBI in the Community

- MVA
- Falls
- Violence
- Sports
  - Amateur Athlete
    - Baby Boomers
    - Gen-Xers
    - Millennials



Alcohol

Screening

- Neurosurgery/Neurology/PM&R
- SLP
- OT
- VT
- Optometry
- Dental
- Mental Health
- ENT/Audiology
- Neuropsych (>3-4 months)

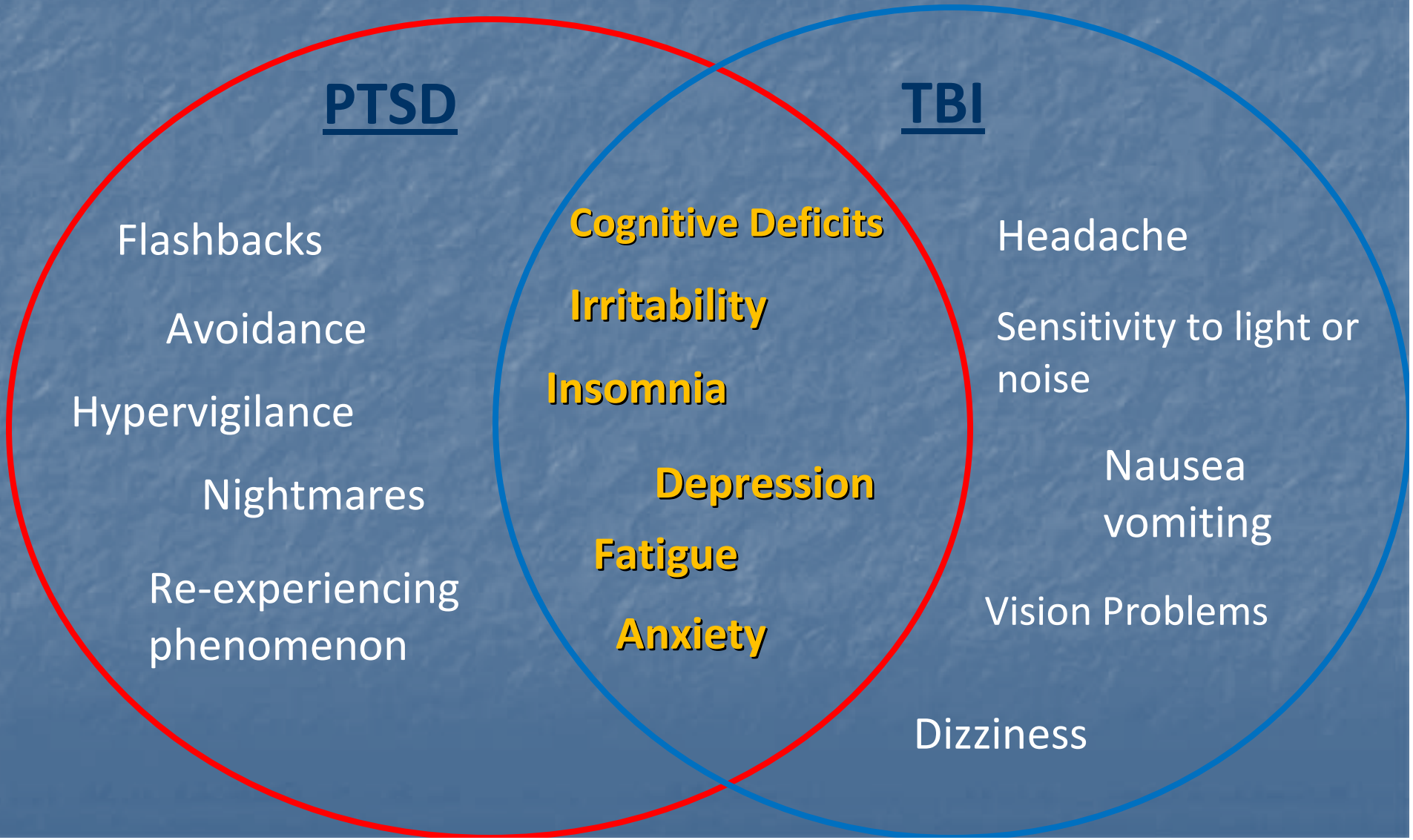
Common Symptoms

- Post Concussive Syndrome (11-64%):
- Headache
- Dizziness,
- Insomnia
- Anergia
- Irritability,
- Anxiety
- Dysphoria
- Apathy

Management

- Also commonly seen in:
  - chronic pain
  - anxiety/depression
- Service Member without body or brain injury
  - headaches 8%
  - sleep disturbance 24%,
  - fatigue 25%,
  - memory difficulty 7%
  - irritability 24%

Symptoms of PTSD & TBI



Treatment

- NO MAGIC CURE FOR CONCUSSION…except time
  - Manage the symptoms
  - Develop compensatory strategies

Treatment

- TBI education (TEAM)
  - Empower patient and hold them accountable for recovery
  - Support improvements in function
  - Rehabilitation plan
  - Return to work/school plan.
  - Resist conveying that all difficulties are psychiatrically driven
  - Offer reasonable explanation for cognitive complaints
  - Be weary of secondary gain (36% MEB non-credible cognitive findings)

Conclusion

- MUST HAVE COORDINATED EFFORTS:
  - Improve symptoms
  - Maximize function
  - Return to work
  - Improve quality of life
- Multi-disciplinary efforts

References

- http://www.cdc.gov/traumaticbraininjury/statistics.html
- Faul M, Xu L, Wald MM, Coronado VG. Traumatic brain injury in the United States: emergency department visits, hospitalizations, and deaths. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2010.
- Centers for Disease Control and Prevention (CDC), National Center for Injury Prevention and Control. Report to Congress on mild traumatic brain injury in the United States: steps to prevent a serious public health problem. Atlanta (GA): Centers for Disease Control and Prevention; 2003.
- AMERICAN COLLEGE OF SPORTS MEDICINE. Concussion (mild traumaticbrain injury) and the team physician: a consensus statement. Med. Sci. SportsExerc. 43:2412-2422, 2011.
- AMERICAN COLLEGE OF SPORTS MEDICINE. Sideline preparedness for the team physician: a consensus statement. Med. Sci. Sports Exerc. 33:846–849, 2001.
- AMERICAN COLLEGE OF SPORTS MEDICINE. The team physician and return-to-play issues: a consensus statement. Med. Sci. Sports Exerc. 34:1212–1214, 2002.
- Laker, Scott R. Epidemiology of Concussion and Mild Traumatic Brain Injury. PM&R Journal. 3:S354-358, 2011.
- Rigg, J.L., Mooney, S.R. Concussions and the Military: Issues Specific to Sevice Members. PM&R Journal. 3:S380-386, 2011.
- Chang, V.H., Lombard, L.A., Greher, M.R. Mild Traumatic Brain Injury in the Occupational Setting. PM&R Journal. 3:S387-395, 2011.
- Signoretti, S., Lazzarino, G., Tavazzi, B., Vagnozzi, R. The Pathophysiology of Concussion. PM&R Journal. 3:S359-368, 2011.
- Department of Defense [DOD] Task Force on Mental Health, 2007, p. ES-I
- Crow W., Willis D. "Estimating Cost of Care for Patients with Acute Low Back Pain: A Retrospective Review of Patient Records." J Am Osteopath Assoc. 2009:109:229-233.
- Braddom (2006). Physical Medicine and Rehabilitation. WB Saunders .
- Cicerone e al. Evidence-Based Cognitive Rehabilitation: Updated Review of the Literature From 1998 Through 2002. Arch Phys Med Rehabil Vol 86, August 2005
- Crooks et al. Physical Medicine and Rehabilitation clinics of North America. Traumatic Brain Injury: A review of practice management and recent advances. 18(2007) 681-710.
- Cuccurullo (2004). Physical Medicine and Rehabilitation Board Review. Demos Publishing.
- Boake C, Diller L (2005). "History of rehabilitation for traumatic brain injury". In High WM, Sander AM, Struchen MA, Hart KA. *Rehabilitation for Traumatic Brain Injury*. Oxford [Oxfordshire]: Oxford University Press
- www.Dvbic.org

Cognitive Symptoms reported following concussion/mTBI

- Impaired memory
- Trouble concentrating
- Difficulty finding words
- Slowed overall processing
- Impaired organizational and problem solving skills

Neuropsychological Evaluation

Context of referral

- Self-referred
- Provider referred
- Medical Board

Pre-morbid Functioning

- Rank
- ASVAB scores
- Education

Credible vs. Non-credible Clinical Presentation

- Undocumented or questionable mild head injury
- Marked discrepancy between the individual's claimed injury and the objective test findings
  - Implausible test results when compared to the medical history

Credible vs. Non-credible Clinical Presentation

- Excessive inconsistencies in test data
  - Poor performance on obvious, but not less obvious tasks of same function
- Symptom validity tests
  - Valid vs. invalid test performances
  - Will see terms: "inconsistent," "invalid," "results cannot be interpreted"
  - Effort vs. malingering

Credible vs. Non-credible Clinical Presentation

- Evaluate symptom complaints within the context of historical data, behavioral observations, and current "real world" functioning
- Be wary of a delayed onset of symptoms
- Assess for secondary gain
  - Litigation
  - Medical board

Neuropsychological Test Performance in Soldiers w/ Blast-Related Mild TBI (Brenner, et al., 2010)

- Exploratory study to examine whether persistent mTBI-related symptoms or PTSD negatively impacted test performance
- Compared 27 SM's w/enduring mTBI symptoms to 18 SM's w/o symptoms
- Results:
  - Presence of mTBI symptoms did not impact test performance
  - No significant differences between soldiers with and w/o PTSD were identified

"Symptom validity test performance in U.S. veterans referred for evaluation of mild TBI"
Armistead-Jehle (2010)

Medical Symptom Validity Test (MSVT)

58% scored below the cut scores on subtests more sensitive to effort than neurological insult

Those with service connection failed at a higher rate

Maybe it is not secondary gain?

- "Good Old Days" Bias Following Mild Traumatic Brain Injury
  - Iverson, et al., (2010)
  - *The Clinical Neuropsychologist*

Research suggests that people who sustain an injury often underestimate past problems ("good old days")

"Good Old Days" Bias Following Mild Traumatic Brain Injury" Iverson, et al.(2010)

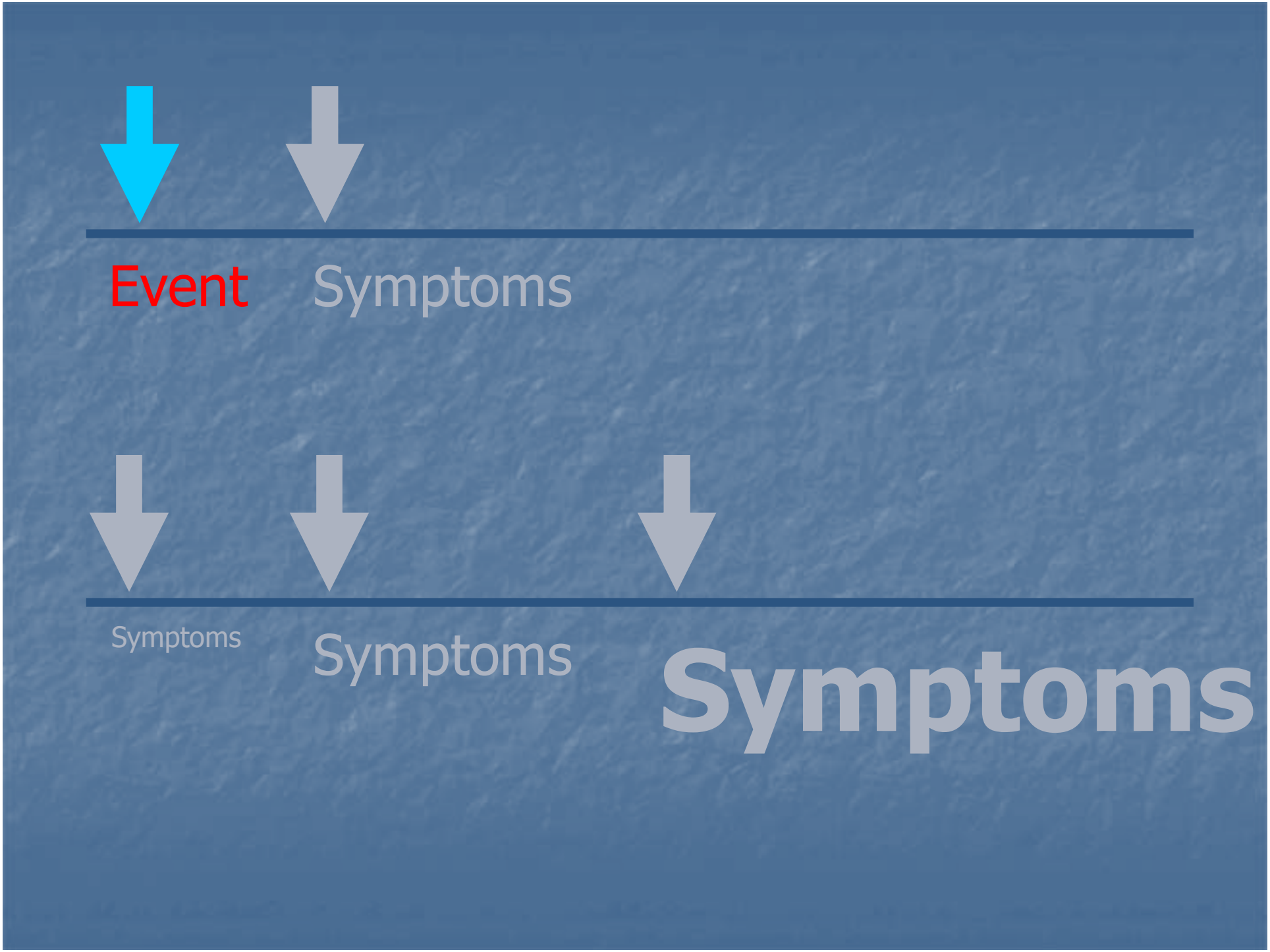
- Sample: 90 temporarily fully disabled individuals from a mTBI receiving Worker's Compensation
- Patients provided post-injury & pre-injury retrospective ratings on the British Columbia Post-concussion Symptom Inventory
- Compared ratings with 177 healthy controls

"Good Old Days" Bias Following Mild Traumatic Brain Injury" Iverson, et al.(2010)

- mTBI patients endorsed fewer pre-injury symptoms compared to the controls
- Those who failed effort testing, reported fewer symptoms pre-injury compared to those who passed effort testing
- Many mTBI patients reported their pre-injury functioning as better than the average person

Important Facts

- Look for documentation
- Be wary of delayed symptoms or worsening of symptoms
- Are the symptoms in line with the medical history?
- Cognitive/psychiatric evaluations should contain formal SVT's and embedded measures
- Avoid a "knee-jerk" assumption of secondary gain
- Consider the unknowns of blast-related TBI
- Never base conclusions on one test score
- Assess "real world" functioning


Event
Symptoms
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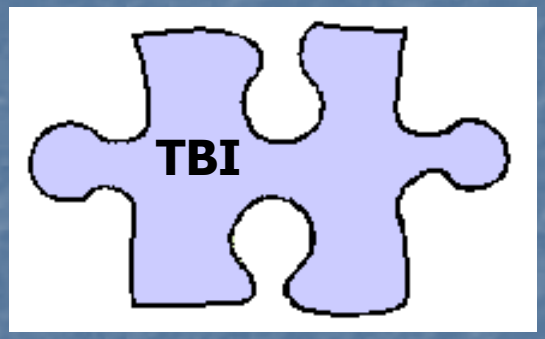
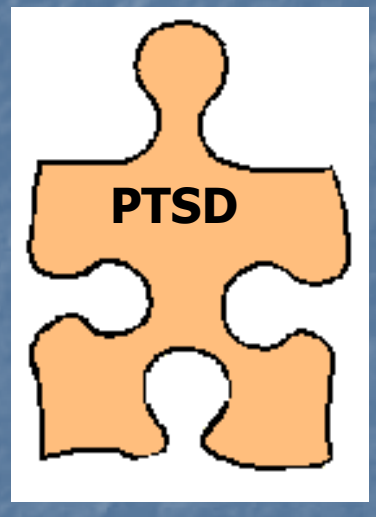
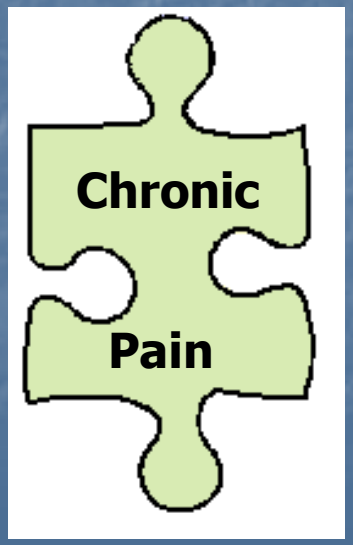
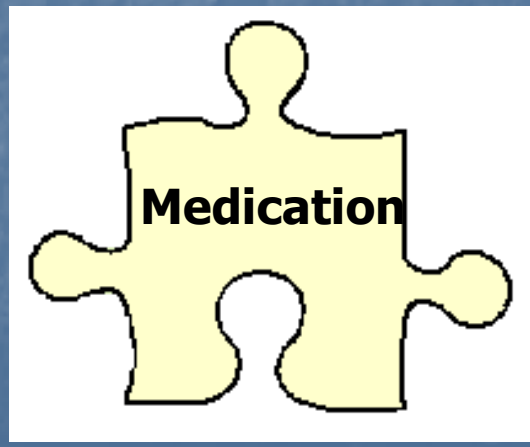
Co-morbid Complications









Veterans in State & Federal Prison 2004

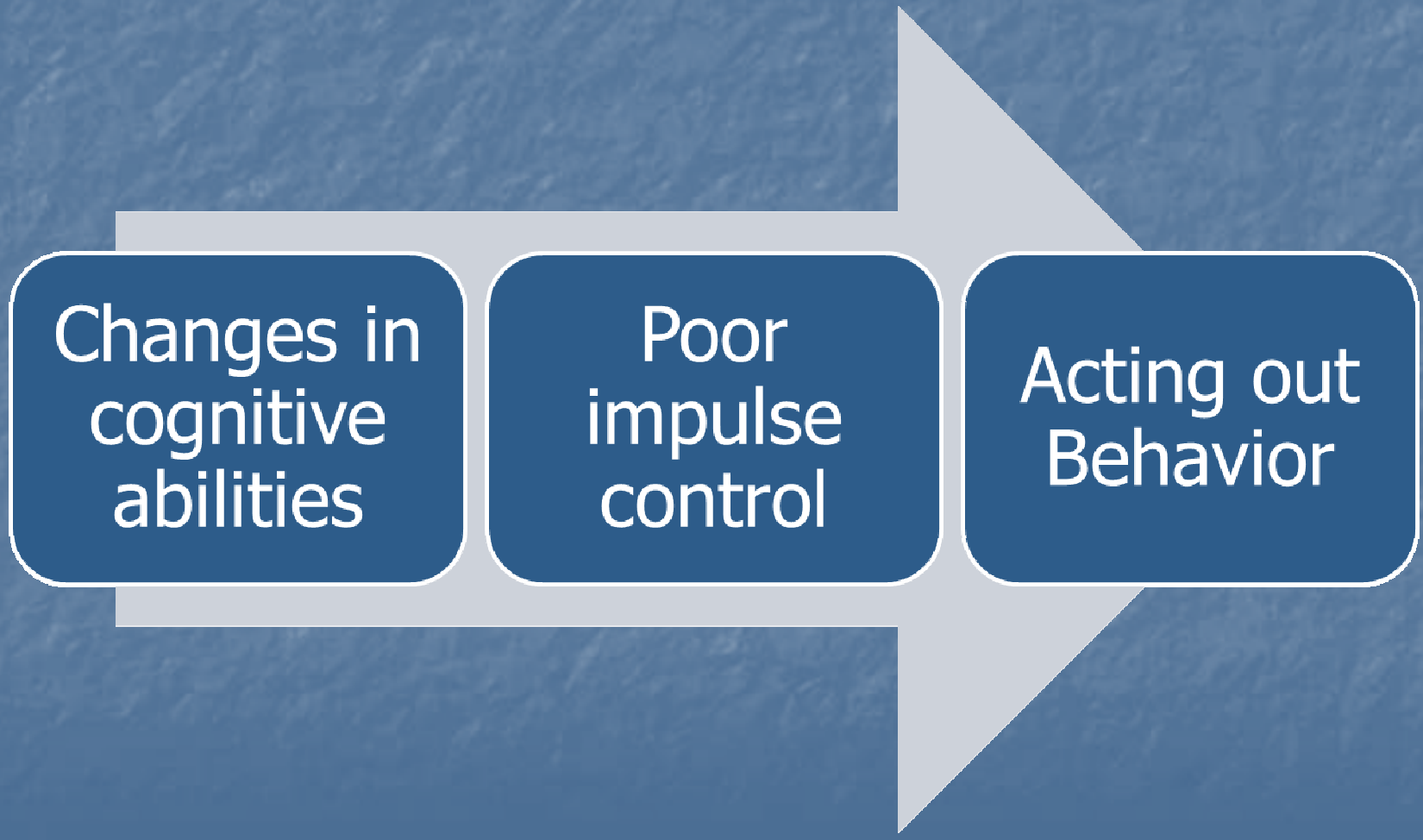
U.S. Department of Justice (May 2007)

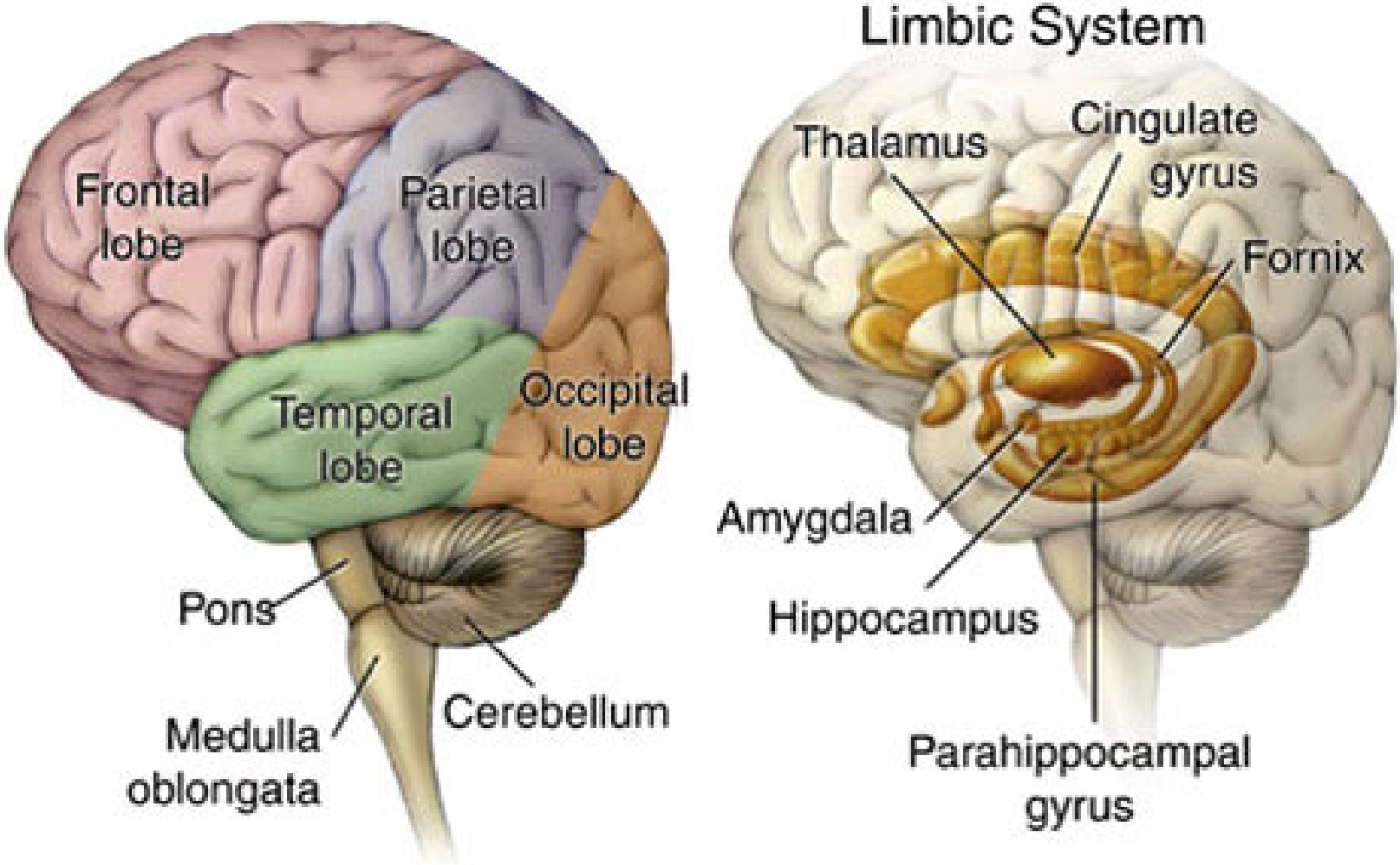
- In 2004: male veterans had lower incarceration rates than nonveterans; due in part to age differences
- 65% of male veterans in 2004 were at least 55 years old
- More than half of veterans in state prisons were serving for a violent offense
- More likely to have had recent mental health problems

Violence as a Consequence of TBI

- Not all brain-injured individuals are violent or aggressive
- Age of injury plays a role
- History of aggression
- Use of alcohol or drugs increases likelihood of aggressive acts
- Presence of a mental disorder increase likelihood of aggression

Behavioral Aspects of TBI





Source: American Health Assistance Foundation. Anatomy of the Brain Webpage.
http://www.ahaf.org/alzheimers/about/understanding/anatomy-of-the-brain.html

The Amygdala

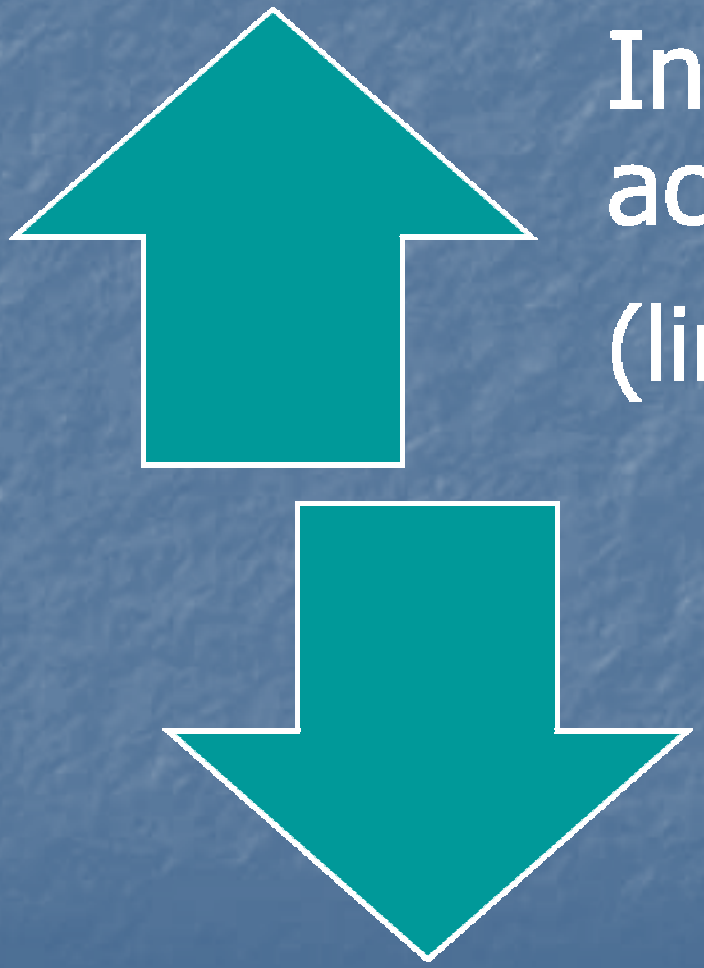
- Linked to the frontal lobe
- Primary role is in the acquisition and the physiological expression of conditioned fears
- It processes and stores memories of emotional events
  - Stores feelings and physiologic responses associated with the event (fear with increased HR)
- The stored memory can later be triggered

Phelps, 2004

The Amygdala

- Flight and fear responses ("freezing")
- Has a distinct difference from a *conscious* feeling of fear
- Defensive or aggressive reactions
- Has a sensory input system

Aggression and Violence Interaction: PTSD & TBI



Increased activation

(limbic system)

Decreased Inhibition

(frontal lobes)

Increased Violence Potential

References

- Armistead-Jehle, P. (2010). Symptom validity test performance in U.S. veterans referred for evaluation of mild TBI. *Applied Neuropsychology,*17: 52-59.

- Brenner, L.A., Homaifar, B. Y., Gutierrez, P.M., Harwood, J. E. F., Adler, L.E, Terrio, H., Staves, P.J., Reeves, D., Ivins, B.J., Helmick, K., & Warden, D. (2010). Neuropsychological test performance in soldiers with blast-related mild TBI. *Neuropsychology,* Vol. 24 No. 2, 160-167.

- Iverson, G. L., Lange, R. T., Brooks, B.L., & Rennison, L. A. (2010). "Good old days" bias following mild traumatic brain injury. *The Clinical Neuropsychologist,* 24: 17-37.

- Phelps, E.A., (2004). Human emotion and memory: interactions of the amygdala and hippocampal complex. *Current Opinion in Neurobiology, 14:198-202.*