TBI & POST-CONCUSSION SYNDROME AFTERMATH

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OBJECTIVES

• To gain an understanding of the incidence and severity of TBI and PCS in the military

• To gain a general understanding of how the brain is injured and expectations for recovery

• To gain an understanding of mild TBI and Post-Concussion Syndrome (PCS) aftermath
  • To include a brief discussion of additional contributing factors

• Learn about treatment options for moderate to severe TBI, mild TBI and PCS
TRAUMATIC BRAIN INJURY (TBI)

• “TBI occurs when an external mechanical force causes brain dysfunction.” (Mayo Clinic)

• “Traumatic brain injury (TBI) is a nondegenerative, noncongenital insult to the brain from an external mechanical force, possibly leading to permanent or temporary impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered state of consciousness.”
# SEVERITY OF TBI

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaging</td>
<td>Normal</td>
<td>Normal / Abnormal</td>
<td>Normal / Abnormal</td>
</tr>
<tr>
<td>LOC</td>
<td>0-30 minutes</td>
<td>&gt; 30 minutes &lt; 24 hours</td>
<td>&gt; 24 hours</td>
</tr>
<tr>
<td>AOC</td>
<td>A moment up to 24 hours</td>
<td>&gt; 24 hours</td>
<td>Severity based on other criteria</td>
</tr>
<tr>
<td>PTA</td>
<td>0-1 day</td>
<td>&gt; 1 and &lt; 7 days</td>
<td>&gt; 7 days</td>
</tr>
<tr>
<td>GCS</td>
<td>13-15</td>
<td>9-12</td>
<td>3-8</td>
</tr>
</tbody>
</table>

Classification based on 2009 VA/DoD Clinical Practice Guidelines for Management of Concussion/Mild Traumatic Brain Injury

*LOC = loss of consciousness  
*AOC = alteration of consciousness / mental state  
*PTA = post-traumatic amnesia  
*GCS = Glasgow Coma Scale
MILD TBI (MTBI)

- mTBI and concussion are interchangeable terms

- Diagnostic Criteria for MTBI by the American Congress of Rehabilitation Medicine

A traumatically induced physiological disruption of brain function, as manifested by at least one of the following:

- Any loss of consciousness
- Any loss of memory before or after injury
- Any alteration of mental state
- Focal neurological deficit that may or may not be transient
- Severity of Injury does not exceed the following:
  - LOC ≤ 30 minutes
  - After 30 minutes, an initial GCS score of 13-15
  - PTA ≤ 24 hours
COMMON CONSEQUENCES OF TBI

- Moderate to Severe TBI:

**Physical**
- Decreased muscle movement
- Disruptions to sensory systems
- Problems swallowing
- Difficulty with speech
- Headaches
- Fatigue

**Behavioral - Emotional**
- Decreased initiation
- Disinhibition
- Impulsivity
- Irritability
- Anxiety
- Depression
- Disturbed sleep
- Decreased awareness

**Cognitive**
- Slowed processing speed
- Difficulty Concentrating
- Difficulty Remembering
- Difficulty multi-tasking
- Word-finding problems
- Inflexibility in thinking
- Perseverative
“GENERAL” RECOVERY FROM TBI

• Moderate to Severe TBI:
  • Most rapid recovery occurs in the first 3-6 months
    • Physical issues tend to resolve most quickly
    • Cognitive and Emotional/Behavioral typically longer
  • Recovery slows down some but still continues
    • Beyond 2 years!
  • Setbacks and plateaus are normal
  • May not achieve 100% recovery but can learn compensatory strategies
  • Establish a “new normal”
COMMON CONSEQUENCES OF MTBI

<table>
<thead>
<tr>
<th>Physical</th>
<th>Behavioral - Emotional</th>
<th>Cognitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>Drowsiness</td>
<td>Feeling “Slowed Down”</td>
</tr>
<tr>
<td>Nausea</td>
<td>Fatigue/Lethargy</td>
<td>Feeling “in a Fog” or “dazed”</td>
</tr>
<tr>
<td>Vomiting</td>
<td>Irritability</td>
<td>Difficulty Concentrating</td>
</tr>
<tr>
<td>Blurred or Double Vision</td>
<td>Anxiety</td>
<td>Difficulty Remembering</td>
</tr>
<tr>
<td>Seeing Stars or lights</td>
<td>Depression</td>
<td></td>
</tr>
<tr>
<td>Dizziness</td>
<td>Sleeping more than Usual</td>
<td></td>
</tr>
<tr>
<td>Sensitivity to light or noise</td>
<td>Difficulty Falling Asleep</td>
<td></td>
</tr>
</tbody>
</table>
TBI IN THE CIVILIAN POPULATION

- In the United States each year:
  - Leading cause of death and disability ages 1-44
  - 1.7 million sustain a TBI requiring medical attention
  - 53,000 deaths
  - 5.3 million Americans currently live with disabilities from TBI
  - 75% are classified as mTBI
CAUSES OF TBI (CIVILIAN)

**Traumatic Injuries**
Major Causes of Traumatic Brain Injuries

- **Falls**: 28%
- **Motor Vehicle Accident**: 20%
- **Struck by... (incl. Sports)**: 19%
- **Assault**: 11%
- **Suicide**: 1%
- **Other**: 21%

Source: National Center for Injury Prevention and Control, CDC
A NEW ERA IN COMBAT

Interceptor Body Armor Vest

Kevlar helmet after an IED attack in Iraq
A NEW ERA IN COMBAT

- Advances in in-theater medical care = reduced killed-wounded ratio (less than 1 in 10)

- Improved body armor and vehicle protection has reduced fatalities

- Proportion of head and neck wounds has doubled from the Vietnam War

- Repeated / extended deployment → increased risk of multiple TBIs

- Combat TBI differs from civilian TBI with respect to the extreme physical and psychological conditions of war
A FEW STATISTICS

- Cost of care for TBI in the military was $21 million in 2003 and $646 million in 2010

<table>
<thead>
<tr>
<th>Branch</th>
<th>TBIs 2000 - 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Army</td>
<td>168,309</td>
</tr>
<tr>
<td>Marines</td>
<td>41,628</td>
</tr>
<tr>
<td>Air Force</td>
<td>39,128</td>
</tr>
<tr>
<td>Navy</td>
<td>38,846</td>
</tr>
<tr>
<td>Total</td>
<td>287,911</td>
</tr>
</tbody>
</table>

Severity

- Mild TBI = 82%
- Mod TBI = 8.1%
- Sev or Pen = 2.5%
- Not Classified = 6.9%
DoD Numbers for Traumatic Brain Injury

Incidence by Severity

No. of cases

30,000

25,000

20,000

15,000

10,000

5,000

0

Calendar year

'00 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11

Mild
Moderate
Severe
Penetrating
Unclassified

Source: Armed Forces Health Surveillance Center

Updated 10 Feb 2012
TBI INCIDENCE IN THE MILITARY

DoD Numbers for Traumatic Brain Injury

Incidence by Armed Forces Branch

No. of cases

25,000

20,000

15,000

10,000

5,000

0

‘00 ‘01 ‘02 ‘03 ‘04 ‘05 ‘06 ‘07 ‘08 ‘09 ‘10 ‘11

Calendar year

Source: Armed Forces Health Surveillance Center

Updated 10 Feb 2012
CAUSES OF TBI (MILITARY)

- In the military, the leading causes of TBI both deployed and non-deployed are (in no particular order):
  - Blasts
  - Bullets
  - Fragments
  - Falls
  - Motor vehicle – crashes and rollovers
  - Sports
  - Assaults

- In the deployed setting, blasts are the leading cause of TBI
MECHANISMS OF INJURY

Coup – Contrecoup injury

Diffuse Axonal Injury

Figure 2–6. Diffuse axonal injury: twisting, tearing, and breaking of axons associated with primary impact damage in traumatic brain injury.
PATHO BIOLOGY IN MTBI AND PCS

“There is little doubt that abnormal neurophysiology is predominant cause of symptoms shortly after injury”

(Iverson, 2005)
STRUCTURAL IMAGING

~ 7-20% of consecutive patients presenting to the ER with MTBI show bleeding, bruising, swelling on Head CT (Iverson, 2005)

- “Complicated” MTBI

- Head CT abnormal in 5% of pts with GCS = 15, 30% of those with GCS = 13

- More similar to moderate TBI patients

- “Presence of structural abnormalities argue for causal association between injury and persistent cognitive symptoms”

(Mittenberg & Strauman, 2000)
DIFFUSE AXONAL DISRUPTION

- Most mTBI have no neuroimaging abnormalities

- Concussive injuries thought to be more metabolic in nature
  - Injured cells exposed to dramatic changes in intracellular/extracellular environments
  - Energy demand and supply mismatched
  - Cells become vulnerable to even minor changes in blood flow, pressure, etc.
  - This state lasts $\geq$ 2 weeks in animal models, perhaps longer in humans
  - Problems worst in first 72 hours, rapid improvement over first week
DIFFUSE AXONAL INJURY

- Upper brainstem 95%
- Corpus callosum 92%
- Choroid plexus of third ventricle 90%
- Hippocampus 88%
- Periventricular (3rd ventricle) 83%
- Cingulate gyrus 61%
- Thalamus 56%
BLAST-RELATED INJURY

• Pathophysiology
  
  • Both physical and psychological trauma
  
  • Physical
    • Supersonic blast wave compresses gas-filled spaces (e.g., lungs, GI tract, middle ear) which then rapidly re-expand → shearing and tearing forces damage tissue / perforate organs
    • Blood may be forced from the vasculature into the air spaces and surrounding tissue
    • Tympanic membrane rupture is the most common effect of this type of blast injury
    • Organs surrounded by fluid-filled cavities (e.g., brain and spinal cord) are also susceptible to the primary blast wave
  
  • Blast injuries to the brain include diffuse axonal injury, skull fracture, coup-contrecoup, subarachnoid and subdural hemorrhage
  
  • Primary blast waves can cause concussion even without any direct blow to the head
  
  • Barotrauma caused by acute gas embolism in which an embolism forms in the lungs and travels to the brain, leading to infarction
  
  • Psychological
    • PTSD, depression, anxiety
BLAST-RELATED INJURY

- **Primary** blast injury
  - Injury from the explosive materials

- **Secondary** blast injury
  - Injury from being hit by matter thrown by the explosion (i.e., projectiles)
  - Most common cause of death by blast injury
  - Head, neck, chest, abdomen, and extremities are particularly vulnerable
  - 10% will have eye injuries; can lead to blindness
BLAST-RELATED INJURY

- **Tertiary** blast injury
  - Injury from being thrown by the explosive blast and hitting against head against another object (e.g., wall or ground)
    - Closed head injuries
    - Fractures, dislocations, amputations

- **Quaternary** blast injury
  - Injury from burns, toxic fumes, and others not covered above
  - Also includes exacerbation of chronic medical condition

- **Quinary** blast injury
  - Injury from toxic material absorbed by the body from the blast that affects the immune system and perhaps the autonomic nervous system, leading to an immediate hyperinflammatory state
PCS DIAGNOSIS (ICD-10)

- History of head trauma with LOC preceding symptom onset by a maximum of 4 weeks

- Symptoms in 3 or more of the following categories:
  - Headache, dizziness, malaise, fatigue, noise intolerance
  - Irritability, depression, anxiety, emotional lability
  - Subjective concentration, memory or intellectual difficulties \( w/o \) neuropsychological evidence of marked impairment
  - Insomnia
  - Reduce alcohol tolerance
  - Preoccupation with Sx's, fear of brain damage with hypochondriacal concern and adoption of sick role
MTBI AND POST-CONCUSSIVE SYNDROME (PCS)

• Diagnosed concussion

• PCS is a “hot topic” and heavily debated

• Diagnostic criteria can vary
  • Symptoms appearing within one week
  • Symptoms of at least 3 months’ duration

• Symptoms typically resolve within 3-6 months
  • Roughly 10-20% have continued symptoms

• Persistent Post-Concussive Syndrome (PPCS)
  • Symptoms lasting longer than 3 or 6 months

• “Permanent” PCS???
PERSISTENT PCS (PPCS)

• “Miserable Minority”

• Prevalence estimates vary:
  • ≤ 5% by 6-12 months (Iverson, 2005)
  • 7-15% have any symptoms one year postinjury (Hall et al., 2005)
  • 10-20% of MTBI pts who have persistent symptoms at 6-12 months and beyond (Millis and Putnam, 1996)

• Incidence of PPCS: ~ 27/100,000
  • Equal to annual incidence of Parkinson’s Disease, Multiple Sclerosis, Guillain-Barre, motor neuron disease, myasthenia gravis combined (Satz, et al., 1999)
PCS CONSIDERATIONS

• PCS is not related to TBI severity

• PCS symptoms: non-specific (chronic pain, depression, PTSD & to a varying extent in the normal population)

• Increased stressors associated with increased symptoms

• Premorbid psychological factors
  • Certain persons may be more vulnerable to developing PCS

• Psychological maintenance of symptoms
  • Pathobiological injury begins the process, but emotional factors may maintain PCS
A “MUDDY” PICTURE

• mTBI in the military is often not a clean injury

• Symptom overlap between PCS, PTSD, depression, substance abuse and chronic pain, make accurate diagnosis very difficult

• Researchers suggest that mTBI may make persons more susceptible to PTSD, and PTSD symptoms may serve to exacerbate mTBI symptoms

• “Polytrauma triad” = TBI, PTSD, pain
<table>
<thead>
<tr>
<th>Symptoms</th>
<th>mTBI</th>
<th>PTSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiencing Trauma</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Re-experiencing symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrusive memories</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nightmares</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Flashbacks</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Distress at reminders</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Avoidance symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoid reminders</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Social detachments</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Inability/partial recall of trauma</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Diminished interest in activities</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Sense of foreshortened future</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Arousal symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insomnia</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Irritability or anger outbursts</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Concentration problems</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Hypervigilance</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Exaggerated startle response</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
POST-CONCUSSIVE SYMPTOMS AND PTSD

- Research suggests that those who report experiencing “high stress” tend to report more post-concussive symptoms than those with “low stress”
PSYCHOLOGICAL DISTRESS AND PCS

- Anxiety about significance of symptoms maintains selective attention
  - Expectations are reinforced
  - Become convinced “I have brain damage”
  - Cognitive distortions

- Elevated anxiety persists, because patient does not perceive he is improving over time

- Prior coping strategies may no longer be available

- Avoidant coping = strong negative effect on recovery

“I’ll never get better....”

“life is over”
SPIRAL OF DETERIORATION

Pre-injury Personality

Interpersonal and Social Withdrawal

Co-Morbidities Emerge:
Depression
PTSD
Anxiety

Catastrophic Reaction

Transient or Permanent Cognitive Impairments

Awareness of Impairments (and Functional Limitations)

Modified from Trexler & Fordyce, 2000
POST-TRAUMATIC HEADACHE (PTH)

- Most frequent symptoms after TBI
  - Ranges from 30-90%
  - 18-22% last more than 1 year

- More likely to occur after mTBI than moderate to severe TBI

- Often resemble migraine headaches

- PTSD and sleep disturbances can complicate treatment of PTH and need to be treated

- Treatment options – medications and behavioral strategies
SLEEP DISTURBANCE

- One of the most common PCS symptoms
  - Insomnia type

- Review of the literature in 2009 (Orff et al.)
  - Sleep disturbance is a result of multiple factors related to the injury
  - More common among mTBI than moderate to severe TBIs
  - Can complicate course of recovery and resolution of PCS symptoms
SLEEP DISTURBANCE

- 114 veterans with blast-related mTBI
- 77% reported sleep disturbance

Factors associated with report of sleep disturbance:
- LOC at time of injury
- Positive screening for PTSD
- Presence of other emotional distress (anxiety / depression)
- Pain (headache)
- Fatigue

- VA recommends and provides Cognitive-Behavioral Therapy for Insomnia

(Farrell-Carnahan et al., 2013)
SOCIAL FACTORS

• Having a relative with TBI changes everyone in family
  • Role loss, caregiving expectations, financial and other pressures

• Can lead to increased depression, anxiety, frustration, stress for family members

• Family stress influences patient behavior
TREATMENT
TREATMENT FOR MODERATE TO SEVERE TBI

- Acute hospitalization – often trauma center

- Inpatient rehabilitation
  - Psychiatry, PT, OT, ST, Neuropsychology, nursing

- Specialty nursing facility or L-TAC

- Residential programs
  - E.g., NeuroRestorative

- Outpatient rehabilitation
  - Specialized comprehensive brain injury programs

- Other community services
  - BIAI
  - VR
  - Resource Facilitation
TREATMENT FOR MTBI & PCS

• Military has adopted sports-related strategies to guide safe return to active duty

• Guidelines include:

  • Exposure to blast = 24 hr. rest period (unless required for a mission)

  • If diagnosed with mTBI = off duty until resolution of symptoms; minimum 24 hr. rest period

  • 2 documented mTBIs within 12-month period = off active duty for minimum of 7 days after resolution of symptoms

  • 3 documented mTBIs within 12-month period = comprehensive neurological examination, neuroimaging, if warranted, neuropsychological and functional assessment
TREATMENT FOR MTBI & PCS

• Premorbid psychological health is an important factor in symptom recovery of mTBI

Symptom Treatment Hierarchy

1 Primary
   • Depression, anxiety and irritability
   • Sleep disorder
   • Post-traumatic headache

2 Secondary
   • Balance
   • Dizziness and vertigo
   • Cognitive impairment
   • Fatigue
   • Tinnitus/noise intolerance

Ontario Neurotrauma Foundation
TREATMENT FOR MTBI & PCS

• The patient should be advised that a full recovery of symptoms is seen in the majority of cases
  • Provide education and support for first 3 months

• For patients with
  • co-morbidities or identified health risks and do not improve by one month, or
  • Persistent symptoms at 3 months post-injury, it is recommended that

The patient should be seen for a comprehensive evaluation at a specialized brain injury program
GUIDELINES: MANAGEMENT

- Education should be provided in printed material combined with verbal review and consist of:
  - Symptoms and expected outcomes
  - Normalizing symptoms
  - Reassurance about expected positive recovery
  - Gradual return to activities and life roles
  - Techniques to manage stress
- Patients with persisting cognitive symptoms should be referred for neuropsychological assessment to derive appropriate treatment recommendations
  - Cognitive rehabilitation
  - Stress Management or psychotherapy
  - Resource Facilitation for return to work
  - Family education and supports
Triage

Cognitive

No

Physical

Yes

MD Track

Vision

PT (balance, dizziness, fatigue)

Headache

Additional Diagnostic Studies

No

Emotional

Yes

Neuropsychological Triage: Education and Management

No

Symptoms not Resolving at 3 months

Rehabilitation

Stress Management and/or Psychotherapy

Cognitive Rehabilitation

Resource Facilitation

Neuropsychological Testing
GOOD NEWS FOR MOST...

• Outcomes are generally positive

  • International Coma Data Bank: 83% of persons with PTA< 2 weeks had good outcome

  • Cognitive deficits resolve in 1-3 months

  • Other PCS symptoms commonly resolve within 12 months at the latest
    • True for 85-95% of veterans with MTBI

• Majority of people recover from PCS in 3-6 months
TIPS ON MANAGING TBI & PCS SYMPTOMS

• Irritability and Anger
• Attention and Memory
• Slowed Processing Speed
• Sleep Disturbance
• Fatigue

• ***Mood swings, Anxiety, & Depression
IRRITABILITY AND ANGER

- Frustration
- Irritability
- Anger
- Rage
IRRITABILITY AND ANGER

• Prevention Strategies:
  • Learn your early warning signs
  • Know your triggers
  • Be prepared

• Loved ones can help too:
  • Give simple directions
  • Cue, don’t criticize
  • Use empathy
IRRITABILITY AND ANGER

- Management Strategies:
  - Take a time out
  - “Take ten”
  - Use reassuring self-talk
    - “What will this matter in the grand scheme of things?”
  - Release your energy in productive way
    - Exercise; work on a hobby
  - Call a friend

- Loved ones can help:
  - Inquire if something is wrong
    - “No” means “No”
  - Avoid raising your voice
  - Involve them in decision-making
ATTENTION AND MEMORY

**Attention**
- Focus on one task at a time
- Break tasks into smaller steps
- Work in a quiet area
- De-clutter your environment
- Use checklists
- Prioritize tasks for best part of the day

**Memory**
- Memory notebook; calendar; daily planner
- Post visual reminders in key places
- Structure a routine
- Use alarms in phone
- Keep items in the same place
- Repeat new information
SLOWED PROCESSING SPEED

• Compensatory strategies:
  • Allow more time to complete a task
  • Let others know you are thinking of a response so they do not continue to ask more questions
  • Politely ask the other person to briefly stop talking so that you can process what they said before they continue

• Loved ones can help by:
  • Presenting information in smaller chunks
  • Giving the person with TBI opportunities to repeat it back to ensure it is understood and to promote memory for the information.

**Anxiety may also need to be addressed**
SLEEP DISTURBANCE

• Sleep hygiene tips:
  • Make a sleep routine and stick to it!
  • Consistent bedtime and wake time
  • Use relaxation techniques
  • Cool, comfortable, and dark environment
  • Get up after 30 minutes if can’t fall asleep
  • Use earplugs or white noise machine

• Things to avoid:
  • Avoid daytime napping
  • Caffeine, alcohol, nicotine, & sugar 4-5 hours before bedtime
  • Don’t eat or drink too much
  • Avoid heavy exercise 2-3 hours before bedtime
  • Do stressful activities in another room
FATIGUE

- Know your warning signs:
  - Increased mistakes
  - Feeling “stuck” or blocked
  - Increased pain
  - Feeling anxious/irritable
  - Increased sensitivity to light and sound

- Management strategies:
  - Maintain a healthy diet & exercise
  - Take pain meds as prescribed
  - Ask for help / delegate tasks
  - Pace yourself; take frequent breaks
  - Prioritize tasks for your best time of day
  - Avoid sensory overload
  - Learn to say “No”
RESOURCES FOR MATERIALS ON TBI

• Lash Publishing

• Brain Injury Association of America

• Brainline.org

• Ontario Neurotrauma Foundation
  • mTBI and concussion guidelines

• DOD and VA TBI websites
  • DVBIC
FUTURE RESEARCH

• Still so much to learn!!

• DVBIC is involved in several on-going projects:
  • Validation of diagnostic tests (neuroimaging techniques)

• Questions to be answered???
  • Determine what prognostic factors are associated with long-term post-concussive symptoms and PTSD as there may be a delay in presentation
  • Identification of biomarkers
REFERENCES

- http://www.mayoclinic.org/diseases-conditions/trumatic-brain-injury/basics/definition/con-20029302