Mild Traumatic Brain Injury (Concussion)

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Objectives

• Define Mild Traumatic Brain Injury and associated terminology and identify resources
• Describe the cognitive, physical, behavioral and emotional sequelae of Mild Traumatic Brain Injury
• Identify intervention treatment models for successful management.

TBI Facts

• 1.5 million individuals sustain a TBI annually (Civilian incidence from the CDC, TBI Surveillance database)
• Males are 1.5 times more likely to sustain a TBI than females (this has changes significantly over the past 10-15 years).
• 235,000 people will be hospitalized with TBI
• 50,000 people will die as a result of a TBI
• 80,000 people annually experience the onset of Long Term Disability following TBI
• Currently 5.3 million Americans living with disability as the result of a TBI (Questionable with returning veterans)
• 1.1 million treated and released from ER

VA/ DOD Demographics

• 59% of blast injury patients seen at Walter Reed Army Hospital had TBI.
• 28% of all injuries had TBI.
• PTSD in combat veterans is 30%.
• Note: 54% of OIF and OEF veterans are Reserve and National Guard.
• Female service personnel = to male civilian rates
  – Warden JMJTR, Vol 21:3 Sept/Oct 06

For Clarification:

Is a Concussion the same thing as a MTBI?

• Per the Zurich Consensus Statement 2012, a concussion is a subcategory of Traumatic Brain Injury and it is noted that researchers in the United States prefer MTBI to concussion.
• Why?
  – MTBI makes the connection to “brain injury” clear
  – However MTBI implies mild symptoms and no complexity
  – Concussion leaves room for descriptions of severity within the classification
  – It leaves brain injury out of the label

For Clarification

What is Post Concussion Syndrome?

• A syndrome is the collection of signs and symptoms that are observed in, and characteristic of, a single condition.
  – Post Concussion Syndrome is a misnomer. Symptoms are not stereotypic
  – symptoms of MTBI may be latent.
Expert Sources Re MTBI/Concussion

- Consensus Statement on Concussion in Sport International Conference on Concussion in Sport; Zurich, November 2012 https://tinyurl.com/lavgx6e
- AANS; Position Statement http://tinyurl.com/5tse77q

Measurement of Severity

- Relates to amount of tissue damage
- Duration of loss of consciousness
- Initial score on Glasgow Coma Scale (GSC)
  - GCS defines the severity of traumatic brain injury within 48 hours of injury and goes from 3 (severe) to 15 (mild).
- Length of post-traumatic amnesia
- Other measures: Rancho Los Amigos Scale (RLA), DRS, MPAI

True or False

- Concussion isn’t serious unless someone “blacks out.”
  False; mTBI 0-20 minute loc (ACRM)

- Properly fitted helmets and mouth guards prevent concussions.
  False; whiplash can cause mTBI. Jane et al, 1985; Avonai Degeneration Induced by Experimental Non-Invasive Minor Head Injury; J. of Neurosurgery

- The best way to diagnose a concussion is with a CT scan or MRI.
  False; Zurich Consensus Statement, 2008 & 2012.

- You can get a concussion without hitting your head.
  True; established, Ommaya, 69; Yarnell, 69; Jane, 85.

- Boys are more likely than girls to get concussed.
  False; young women who play soccer, 68% more likely than boys and girls who play basketball have a 3:1 incidence. (Schwarz, 2011) (Halstead 2010)

- If concussion symptoms resolve within 24 hours it is safe to return to play.
  False; Zurich Consensus Statement, 2008 and 2012.

- Most doctors and pediatricians are well-trained in the management of concussions.
  False; McCarthy & O’Hara, 2010.
  CDC Tool Kit for Physicians; http://tinyurl.com/jut4dhts
  Concussion laws by state; http://tinyurl.com/kqjxwag

- State concussion laws protect all child athletes under the age of 18.
  False; intramurals and non school affiliated entities not covered.
TBI Prevention and Education

- CDC; On line concussion training, RTP guidelines, Management tools for health care professionals. http://tinyurl.com/3ut43ts
- Mom’s Team; News and information: Training links, Nutrition for young athletes http://www.momsteam.com/

VA Study of MTBI knowledge

Block, et al, 2014
- 100 vets & 50 friends/family members in a AL VA took voluntary questionnaire
- Both groups demonstrated accurate knowledge of some mTBI symptoms almost equally (i.e. vets did not score better than friends/family)
- Both groups endorsed significant number of severe symptoms not considered common for mTBI
- Most identified prior education/knowledge as coming from media (magazines, TV)... and only 22% of vets said they rec’d education while in military
Results point to a continuing need for education in the military about mild TBI

Measuring Severity of Injury

Mild Injury
- 0-20 minute loss of consciousness
- GCS = 13-15
- PTA < 24 hours

Moderate Injury
- 20 minutes to 6 hours LOC
- GCS = 9-12

Severe Injury
- 6+ hour LOC
- GCS = 3-8

MTBI Definition (AAPM&R/ACRM)

At least one of the following:
- any period of loss of consciousness
- any loss of memory for events immediately before or after the accident
- any alteration in mental state at the time of the accident
- focal neurologic deficit that may or may not be transient
- BUT the severity does not exceed the following:
  - loss of consciousness of 20 minutes
  - an initial Glasgow Coma Scale score of 13-15 after 30 minutes
AND
- Post-traumatic amnesia of no more than 24 hours’ duration.

ANATOMIC IMAGING DILEMMA

- Annually, mTBI represents 80-90% of all head injuries in the US. 18x2 ; CDC reference ~1.1 million
- Based on animal studies, we know that Diffuse Axonal Injury occurs in MTBI, 3
- Despite that, MTBI patients present with normal conventional MR scans despite neuropsychological or clinical impairment (Post-concussive symptoms)4,5

<table>
<thead>
<tr>
<th>TABLE 38-2</th>
<th>Glasgow Coma Scale</th>
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<tbody>
<tr>
<td><strong>BEHAVIOR</strong></td>
<td><strong>RESPONSE</strong></td>
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<tr>
<td>Eye opening response</td>
<td>Spontaneously</td>
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<td></td>
<td>To speech</td>
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<td></td>
<td>To pain</td>
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<td></td>
<td>No response</td>
</tr>
<tr>
<td>Best verbal response</td>
<td>Oriented to time, place, and person</td>
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<td></td>
<td>Confused</td>
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<td></td>
<td>Inappropriate words</td>
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<td>Incomprehensible sounds</td>
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<td></td>
<td>No response</td>
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<tr>
<td>Best motor response</td>
<td>Obey's commands</td>
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<td></td>
<td>Move to localized pain</td>
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<td></td>
<td>Flexion withdrawal from pain</td>
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<td></td>
<td>Abnormal flexion (decorticate)</td>
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<td></td>
<td>Abnormal extension (decerebrate)</td>
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<td></td>
<td>No response</td>
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<tr>
<td><strong>Total score</strong></td>
<td>Best response</td>
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<td></td>
<td>Comatose client</td>
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<tr>
<td></td>
<td>Totally unresponsive</td>
</tr>
</tbody>
</table>

**Acceleration – Deceleration Injury**

Coup-Contrecoup Injury

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**Diffuse Axonal Injury**

Results in:
- Disrupted pathways
- Swelling of the neuron
- Destruction of myelin
- Broken axons

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**Diffuse Axonal Injury**

- Injury causes focal misalignment of neurofilaments which impairs axoplasmic transport and causes local accumulation of organelles.
- Axonal swelling and expansion ensues, and axonal disconnection occurs 30–60 hrs after injury.

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**Imaging**

Imaging has improved and we are poised for some significant breakthroughs relating not only to geography but function and system integrity as well.

- CT and CTA special X-ray tests that produce cross-sectional images of the body using X-rays and a computer. CT scans are also referred to as computerized axial tomography. With Contrast (Angiography) CTA
- MRI is magnetic resonance imaging. It uses magnetic fields and radio waves to make images without using x-rays. The scans, are 3-dimensional and shown on a screen. MRI shows very detailed images that pass through bone to show soft tissue like blood vessels, and brain tissues.

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**Research in Imaging**

- SPECT: Single Photon Emission Computed Tomography 3-D brain blood flow (still experimental)
- MRS: Magnetic Resonance Spectroscopy – Biochemical scan shows the amount of energy the brain is using.
- fMRI: Functional Imaging – real time blood oxygenation linked to neural activity (Showing promise in differentiating PVS vs. Minimally Conscious
- PAT: Photo Acoustic Tomography; optics and ultrasound in a single high-contrast vascular imaging device.
- Diffuse Tensor Imaging – T3- can show DAI

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**Diffusion Tensor Imaging**

**Sagittal section of the Corpus Collosum**
**Diffuse Tensor Imaging**

- Shows axonal integrity: i.e. functional impact of DAI
  - Measure water diffusion in multiple directions
  - Diffusion is high in intact axons
  - Diffusion is reduced after axonal injury
- Shows connectivity
- May eventually show the link between NP evaluation and neuronal damage in MTBI
- Better understanding of DOC and concussion
- Better diagnosis of above = better treatment plans

- White Matter Normal Brain; Axial section

**One Measure is Not Enough**

- Finally, given the complex anatomic, neurobiological and pathophysiological processes occurring in the setting of TBI, it may well be that no single imaging modality or technique can completely define and characterize the extent and severity of injury.
  - Peter Ricci; Craig Hospital Brain Injury Summit Jan, 2015
- What about biomarkers?
- What about genetic predisposition?
- How do we predict long-term outcome?

**Biomarker Research**

  - A good review of the biomarkers that are being studied and appear to hold the most promise
  - Discusses diagnosis and prognosis issues
  - Discusses some of the issues relating to concussion vs. MTBI

**Face Validity**

- 1.54 million brain injuries in the US; 20% or 306,000 are attributed to sports
- 103,000 of these do not see an MD; 168,000 receive virtually single service outpatient care (ER, MD visit)
- 35,000 were hospitalized
- Includes playground, basketball, baseball and football
- Second Impact Syndrome; rare condition; a second concussion occurs before a first concussion has properly healed causing rapid and severe brain swelling that could lead to permanent disability or death. 20 cases in the last 10 years. Does not occur in adults. (McCrory P, Davis G, Makdissi M. Second impact or cerebral swelling after sporting head injury. Curr Sports Med Rep. 2012;11:21-23.)
NFL and Concussion

- NY Times: 2009 "A study commissioned by the National Football League reports that Alzheimer's disease or similar memory-related diseases appear to have been diagnosed in the league's former players vastly more often than in the national population - including a rate of 19 times the normal rate for men ages 30 through 49." [http://tinyurl.com/kcxwldm](http://tinyurl.com/kcxwldm)
- $765 mil settlement [http://tinyurl.com/mcwgcd](http://tinyurl.com/mcwgcd)

Head Games: football's concussion crisis
Author: Chris Nowinski - Sports legacy institute

Harrison S. Martland

- 1928: Punch Drunk jama,91:1103-1107
- First full time paid pathologist Newark City Hospital 1909-27; CME Essex County
- Studied boxers: "...recognized a peculiar condition occurring in prize fighters ... punch drunk"
- Gait problems, slowing of muscle responses, vertigo, mental deterioration.
- Ryan:1987; 9-25% professional boxers developed "Chronic Boxers Encephalopathy", now referred to as Chronic Traumatic Encephalopathy

Chronic Traumatic Encephalopathy; CTE

- Per the 2014 Zurich Consensus
  - Owing to the nature of the case reports and pathological case series that have been published, it is not possible to determine the causality or risk factors with any certainty.
  - What role if any does age, coexisting medical conditions, D&A use etc. play?
- Begs the question: What is the incidence in the general population?

- Repetitive brain injury sustained during participation in contact sports is considered one of the etiologies of CTE pathology. Contact sports in which CTE pathology has been reported include American football, baseball, boxing, ice hockey, rugby soccer and wrestling.
- Of the 66 individuals found in the Mayo Clinic Brain Bank with exposure to contact sports, 21 had pathology consistent with CTE. No CTE was found in any of the matched subjects.
**Lasting Sequelae**

Aureback, 1987

For up to one year 1 in 5 patients have persistence of one symptom.

1 in 20 will have persistence of a constellation of five or more symptoms.

1 in 20 complain of symptoms beyond one year.

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**Why the Selected Few?**

“Single uncomplicated” minor head injury produces no permanent disabling impairment in the great majority of patients who are free from history of significant drug or alcohol use, neuro-psychiatric disorder or previous head injury.


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**Contributory Factors**

- Cumulative effect; Do you know if this is the person’s first TBI?
- Psychological and emotional issues; People who experience conditions such as depression and anxiety fare poorly after MTBI.
- Other Conditions such as HBP, diabetes, early cognitive decline associated with aging can complicate recovery.
- Overall general health

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**Common Changes after MTBI**

- Anxiety/Mood
- Ocular-motor
- Vestibular
- Cervical pain
- Cognitive
- Headache
- Migraine

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**Most Common Symptoms Early**

- Headache
- Dizziness
- Blurred vision
- Lack of awareness/confusion
- Nausea/Vomiting
- Loss of memory
- Slurred speech
- Vague stare

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**Delayed Onset of Symptoms**

“There is a cascade of chemical reactions triggered by the temporary disruption of the brain’s delicate electrochemical balance which occurs as a result of a concussion.

Leaves the brain in an ‘energy crisis’, which may escalate over the next twenty-four to seventy-two hours as the brain attempts to heal itself.”

(Rosemarie Scolaro Moser, PhD, Ahead of the Game)
**Late Symptoms**

- Persistent headache
- Memory problems
- Decreased attention
- Easily fatigued
- Irritability
- Blurred vision
- Anxiety/Depression
- Sensory overload/overwhelm

**Psychosocial Issues**

- Irritability
- Anxiety
- Depression (shaken sense of self)
- Indifference
- Inflexibility
- Emotional instability
- Family stress

**Vestibular Symptoms**

- Dizziness
- Vertigo
- Blurred vision
- Disruption in saccades
- Headache
- Nausea
- Visuospatial
- Tinnitus: 8th nerve

Avoiding head movement limits central nervous system adaptation and symptom resolution. (Silverberg, Noah D and Iverson, Grant L, Jour Head Trauma Rehab, 2013)

**Visuospatial**

- Visuospatial skills allow us to visually perceive objects and the spatial relationships among objects.

**Vestibular Sensory Overwhelm**

Vestibular disorders can be central or peripheral or mixed.
**MTBI Sleep Disturbances**

- Sleep complaints usually present in the first few days and weeks after injury.
- Of 443 patients studied with MTBI, 13.3% of the patients reported sleep complaints 10 days post injury.
- Sleep complaints increased to 33.5% at 6 weeks.

**MTBI Sleep Disturbances (continued)**

- Patients with sleep complaints at 10 days post injury were 2.9 times more likely to experience sleep difficulties at 6 weeks post injury.
- More likely to suffer from irritability, depressive symptoms, and headaches at both 10 days and 6 weeks post injury, suggesting the acute sleep complaints predict psychological and somatic symptoms amongst individuals with mild TBI. (Caput et al. 2013)

**Successful Management of MTBI**

**Rest After MTBI – Is This the Best Medicine?**

“‘No single factor protects better against post concussion syndrome than the experience of gradually returning to activity without feeling worse.’”

(Neuropsychological Treatment of Mild Traumatic Brain Injury, Kay, 1993)

“Interventions that target the rest-activity balance may improve MTBI care.”


**Rest After MTBI – Is This the Best Medicine?**

- Restful pattern of activity throughout the day with minimal physical and mental exertion.
- Being sedentary after an illness or injury is one of the most common risk factors for chronic disability.
- Extensive rest can exacerbate or prolong recovery from comorbid vestibular disorder, depression, PTSD, chronic fatigue, and pain disorders.

(Silverberg & Lucon, Journal of Head Trauma Rehabilitation, 2013, Vol. 28, No. 4)

**Treatment for MTBI**

- Immediate intervention - initial evaluation made by Emergency Medicine, Occupational Health, Neurology, etc...
- Make referrals for assessment and treatment per clinical trajectories and treatment pathways. May need to utilize any of the following:
  - Physiatrist (PM&R) - pain management & sleep
  - Psychiatry - mood stability, anxiety, depression
  - Neuropsychology - cognitive assessment
  - Otorhinolaryngology
  - Neuroophthalmology
  - ENT Specialist
- A medical specialist usually becomes the main conduit of the team in designing and monitoring response to treatment.
Treatment for MTBI

- Therapy Disciplines - training and expertise in MTBI/Concussive Care
  - Interdisciplinary Therapy evaluations to address cognitive, physical and psychological issues
  - Individualized hierarchy of activity resumption
  - Monitor adherence to the protocol
  - Screen for obstacles to activity resumption
    ("Is Rest After Concussion the Best Medicine?" Silverberg and Iverson, JHTR, 2013)
- Utilize Case Management for care coordination to liaison directly with the physician, treatment specialists, consultants, employer to monitor progress and compliance with rehabilitation.

Role of Neuropsychological Evaluations

- Study of brain-behavior relationships
- Detect existence and severity of deficits
- Provide Differential Diagnosis
  - Cumulative effect (repeat concussion)
  - D&A (Substance Abuse)
  - Psychological and emotional issues
  - Other medical conditions
- Identify recovery potential
- Identify effort (symptom magnification / malingering)

Functional Approach

- Stable schedule that is individualized
- Structured/generalized setting for therapy
- Repetition and practice of strategies and skills throughout the day
- Therapy in an integrated clinical setting, community and home
- Focus on return to previous life roles and work

Mild TBI – Key Facts

- There are physical, metabolic, and chemical changes to the brain with a concussion/MTBI
- After sustaining one concussion, a person is three times more likely to sustain a second concussion compared to other players who have not been concussed.
  (UVHS Neurogram, March 2006)
- Early identification is critical particularly in young athletes to prevent further injury (eg. Second Impact Syndrome)

Course of Recovery

- Most people get better/ Rapid improvement in first 30 days
- About 15-20 % have persist symptoms
- 5% have symptoms that last long term
- Symptoms that occur in first 3 months are not likely to recur once resolved

Benchmark Testing

- ImPACT: Immediate Post Concussion Assessment Cognitive Test
- SCAT 2: Sport Concussion Assessment Tool 2
- C3 Logix: Ipad based measures dynamic vision/balance as well as attention and motor planning
- Baseline vs. post concussion testing
- Currently used in the NFL, NHL, NBA, Colleges and Universities across the US and abroad, High Schools across the US and abroad
- Does Benchmark testing make its way in to the non sports arena?
The End.....
Questions & Comments