The Mysterious and Often Perplexing Nature of Mild TBI and Persistent Post-Concussion Syndrome

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Plan of Events

- Natural Course of Traumatic Brain Injury (TBI)
- Classification of mTBI
- What does science say? (Outcome Research)
- The “Miserable Minority”
- Quick look at Sports Concussion
- The Post-Concussion Syndrome (What is it really?)

The Nature of an Injury

- An injury's natural course
- Expected outcome
- How do you know what to expect?
- By the nature of the injury based upon:
  - Objective injury markers (e.g., x-ray)
  - Demographics of the individual (e.g., age)
  - Health of the individual (e.g., comorbid/prenorbid illnesses)
- What if it does not "add up"?
- Based on science
Primary Mechanisms of Injury (Closed Head Injury)

- Traumatic movement:
  - 1. Impact contusions.
    - Ethmoid bone
    - Sphenoid wings
  - 2. Diffuse Axonal Injury.


Primary Mechanisms of Injury (Closed Head Injury)

- Severe movement creates bruising in a typical pattern.
- Results in common pattern of dysfunction as well.
- Coup-contrecoup.
- Closed Head Injury - TBI Diffuse Pattern
- Stereotypic pattern of recovery:
  1. Alteration of consciousness
  2. Confusion and anterograde amnesia (PTA) (possible retrograde amnesia - RA).
  3. Continuous memory and gradual increase in recovery/compensation

### Natural History - Closed Head Injury

#### Premorbid Level of Functioning

- TBI
- Gradual Cognitive Improvement
- Plateau

#### Timeline

- Younger
- Older
- RA
- PTA

### Severity of TBI

- Severity based on injury characteristics *not outcome!*
  - Glasgow Coma Scale
  - Length of LOC (eyes or following command)
  - Imaging findings
  - Neurological signs
  - Length of RA
  - Length of PTA
Definitions of mTBI - American College of Rehabilitation Medicine (Kay, et al., 1993)

A patient with mild TBI is a person who has had a traumatically induced physiological disruption of brain function as manifested by at least one of the following:
1. Any period of LOC;
2. Any loss of memory for events immediately before or after the accident;
3. Any alteration in mental state at the time of the accident (e.g., feeling dazed, disoriented, confused);
4. Focal neurological deficit(s) that may or may not be transient.

But where the severity of the injury does not exceed the following:
1. Loss of consciousness of 30 minutes;
2. After 30 minutes, an initial GCS score of 13-15; and
3. Posttraumatic amnesia (PTA) not greater than 24 hrs.

Definitions of mTBI - CDC Definition (2003)

Injury to the head resulting from blunt trauma or acceleration or deceleration forces with one or more of the following conditions attributable to the head injury during the surveillance period:
1. Any period of observed or self-reported transient confusion, disorientation, or impaired consciousness;
2. Any period of observed or self-reported dysfunction of memory (amnesia) around the time of the injury;
Definitions of mTBI - CDC Definition (2003)

3. Observed signs of other neurological or neuropsychological dysfunction, such as:
   a) Seizures acutely following head injury;
   b) Among infants and very young children: irritability, lethargy, or vomiting following head injury;
   c) Symptoms among older children and adults such as headache, dizziness, irritability, fatigue, or poor concentration, when identified soon after the injury, can be used to support the diagnosis of mTBI, but cannot be used to make the diagnosis in the absence of LOC or altered consciousness. Further research may provide additional guidance in this area;

4. Any period of observed or self-reported loss of consciousness lasting 30 minutes or less.

Definitions of mTBI - CDC Definition (2003)

More severe injuries were excluded from the definition of mTBI if they included one or more of these:

- LOC longer than 30 minutes
- PTA longer than 24 hours
- Penetrating craniocerebral injury

Definitions of mTBI - WHO Definition - derived from ACRM & CDC (Holm et al. 2005)

Operational criteria for clinical identification include:

a. One or more of the following:
   i. Confusion or disorientation
   ii. LOC for 30 minutes or less
   iii. PTA for less than 24 hours
   iv. Other transient neurological abnormalities such as focal signs, seizure, intracranial lesion not requiring surgery

b. GCS score of 13-15 after 30 minutes postinjury or later upon presentation for health care
Definitions of mTBI - WHO Definition - derived from ACRM & CDC (Holm et al. 2005)

c. These manifestations must not be:
   
   i. Due to drugs, alcohol, medication
   
   ii. Caused by other injuries or treatment for other injuries (e.g., systemic injuries, facial injuries, or intubation)
   
   iii. Caused by other problems (e.g., psychological trauma, language barrier, coexisting medical conditions)
   
   iv. Caused by penetrating craniocerebral injury

In a nutshell: mTBI

- Closed Head Injury based TBI
- Alteration of consciousness
- LOC for less than 30 minutes
- PTA no longer than 24 hours
- GCS 13-15 after 30 minutes

What about neuroimaging?

- This is less settled
- Complicated MTBI v Uncomplicated mTBI
- My opinion - Should be uncomplicated
- Positive imaging makes it complicated mTBI

Neurocognitive Outcome Research

- Two eras: Pre-1995 and post-1995

- Early era research compared mTBI subjects to healthy controls and were largely convenience samples.
  - Found significant long-term differences between mTBI and controls.

- But a significant methodological insight came in 1995 that changed everything.
Prospective study: Consecutive ED admits, classified by TBI severity (length of coma)

436 head injured participants (HI)

121 general-trauma controls (orthopedic)

Controlled for age, education, gender, socioeconomic status, stress, pain

Comprehensive NP battery

HI group performed significantly worse than trauma controls on most measures.

Magnitude and pervasiveness of the impairments depended on the severity of the head injury (does response relationship)

This study provides information about expected ranges of impairment as a function of different severity levels.

Data Piles Up Since Then - Multiple Meta-Analytic Studies

Numerous studies have been completed addressing the issue of ongoing cognitive and emotional problems after a single, uncomplicated mTBI.

They are overwhelmingly consistent

Meta-Analytic Studies are studies of studies to determine if the effect size of the experimental concern is demonstrable repeatedly.

There have been at least 7 meta-analytic studies on mTBI with similar results.

Only one suggested possible long term problems (Pertab, James, & Bigler, 2009), but they reanalyzed previous meta-analyses and took out 7 of the 25 studies.
Binder et al. (1997)

A review of mild head trauma. Part I: Meta-analytic review of neuropsychology studies

- Analysis of 8 studies of adults: 11 total samples
- Studied at least 3-months post mTBI
- Selected on basis of history of mTBI rather than based on being symptomatic.
- 314 patients with mTBI
- 308 control subjects
- Overall effect size ($g_{pooled \text{ sd}}$) was 0.07 - not significant
  - But Cohen's $d = 0.12$ (control group sd) was significant at $p < 0.03$
- These small effect sizes were equivalent 2 points on WAIS-R & WMS-R.
- They are smaller than the tests' standard error of measure.

Schretlen & Shapiro (2003)

A quantitative review of the effects of traumatic brain injury on cognitive functioning

- Included sports concussion and traditional prospective clinical studies in their meta-analysis
- Persons with mTBI essentially returned to baseline level of performance within 1 to 3-months post-trauma.
- Overall cognitive test performance of those with mTBI was essentially indistinguishable from that of matched controls at 1-month post-trauma.

Frencham, Fox, & Maybery (2005)

Neuropsychological studies of mild traumatic brain injury: A meta-analytic review of research since 1995

- 17 studies since Binder et al. (1997)
- 634 mTBI
- 485 Controls
- Speed of processing measures had the largest effect size
- Weighted effect size at the post-acute phase (> 3-mo) was 0.28 and not significant.
- Time since injury was a significant moderator variable
- Effect sizes tending to zero with increasing time post-injury.
Belanger et al. (2005)

Factors moderating neuropsychological outcomes following mild traumatic brain injury: A meta-analysis

- 39 studies
- 1463 mTBI
- 1191 Controls
- Unselected or prospective samples of mTBI cases: Effect size ($d = 0.04$)
- No residual neuropsychological impairment by 3-months
- But clinic based samples and samples with litigants had greater cognitive sequelae ($d = .74$ & $d = .78$)
- Litigation was associated with stable or worsening of cognitive functioning over time.

Belanger & Vanderploeg (2005)

The neuropsychological impact of sports-related concussion: A meta-analysis

- Sport-related concussion
- 21 studies
- 790 cases of concussion
- 2014 control subjects
- Found acute effects within first 24 hours of 1 sd or more on learning, memory, & global cognitive functioning
- No residual deficits were seen on testing conducted 10 days or more post-trauma.

Carroll et al. (2004)

Prognosis for mild traumatic brain injury: Results of the WHO collaborating centre task force on mild traumatic brain injury

- Reviewed 428 studies related to prognosis of mTBI
- 120 were acceptable after critical review of their scientific merit.
- Result was “best evidence synthesis on prognosis after mTBI.”
- For adults, “cognitive deficits and symptoms are common in the acute stage, and the majority of studies report recovery for most within 2-12 months.”
- “Where symptoms persist, compensation/litigation is a factor, but there is little consistent evidence for other predictors.”
Carroll et al. (2004)
Prognosis for mild traumatic brain injury: Results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury

“The best evidence consistently suggests there are no mTBI attributable, objectively measured, cognitive deficits beyond 1-3 months' post-injury in the majority of cases. Self-reported symptoms are common after mTBI; however there is little consistency in findings about how long such symptoms persist” (p. 101).

“On the other hand, symptoms usually resolve rapidly in athletes after a sports concussion, although it could be argued that they may under-report symptoms in order to resume play” (p. 101).

Carroll et al. (2004)
Prognosis for mild traumatic brain injury: Results of the WHO collaborating centre task force on mild traumatic brain injury

“Litigation and/or compensation have been consistently identified as prognostic of poor outcome in those cases that experience persistent symptoms and disability after mTBI, although again, no confirmatory study has been performed” (p. 102).

“No study reported that severity of the mTBI was an independent predictor of persistent post-concussion symptoms” (p. 102).

Carroll et al. (2004)
Prognosis for mild traumatic brain injury: Results of the WHO collaborating centre task force on mild traumatic brain injury

“There is an ongoing debate as to whether whiplash injuries to the head and neck can commonly result in MTBI, and our task force reviewed the available evidence. The evidence shows that mild cognitive complaints do occur after whiplash, but are not specific to MTBI and are not likely due to a brain injury per se” (p. 102).

“These same cognitive complaints are also reported in patients with chronic pain, depression, anxiety, post-traumatic stress disorder, chronic fatigue syndrome, malingering and in patients involved in personal injury litigation” (p. 102).
So, Where did the Miserable Minority Come From?

- Much of the forensic private practice in neuropsychology is driven by persistent postconcussive complaints long after a mTBI.
- It is frequently stated that roughly 15% of persons with mTBI have permanent impairment.
- “Miserable Minority” (Ruff, Camenzuli & Mueller, 1996)

So, Where did the Miserable Minority Come From?

- Michael Alexander (1995) wrote: “At one year after injury approximately 15% of mTBI patients have not recovered” (p. 1256).
- Others have cited this reference and number as common knowledge, including the CDC until 2007.
- *In fact, it is clinical *lore.**
- Iverson (2005) wrote, “This estimate...is frankly wrong” (p.306).
- So how/why did Alexander create it?

So, Where did the Miserable Minority Come From?

- Come to find out, Alexander cited two studies to support his conclusion.
  - McLean, Temkin, Dikmen, & Wyler (1983)
  - Rutherford, Merrett, & McDonald (1979)

- Involved mild AND moderate AND severe TBI
- The study followed 20 patients for only 1 month.
- No 1-year follow up!

[Rutherford et al. (1979)] Symptoms at one year following concussion from minor head injuries. *Injury*, 10, 225-230.

- 145 consecutively admitted mTBI cases, with 1-yr f/u.
- Although it was true that 19 persons (14.5%) still reported complaints at 1-year follow-up:
  - Only 131 were available for 1-yr f/u (13.1% of 145)
  - Eight (42%) were involved in lawsuits
  - Six (31%) showed malingering signs at 6 week assessment
  - Most complained of new symptoms at 1 year that were not reported at 6 weeks post-injury.
- There was no control group, an omission making it difficult to draw conclusions about population base rates for symptoms.

[Carroll et al. (2004)] PCS correlated strongest with litigation and secondary gain, but had no valid association with initial injury severity or any other neurological factor.

- Little dispute about Miserable Minority
- 15% is only a myth if one equates a symptom (subjective complaint) with brain impairment (objective finding).
- Complaint is not synonymous with disability.
- This important distinction was addressed by WHO:
So called, “Postconcussion” Syndrome

ICD-10 Diagnostic Criteria for PCS
A. History of head trauma with loss of consciousness precedes symptoms onset by maximum of four weeks.
B. Symptoms in three or more of the following symptom categories:
   i. Headache, dizziness, malaise, fatigue, noise intolerance
   ii. Irritability, depression, anxiety, emotional lability
   iii. Subjective concentration, memory, or intellectual difficulties without neuropsychological evidence of marked impairment
   iv. Insomnia
   v. Reduced alcohol tolerance
   vi. Preoccupation with above symptoms and fear of brain damage with hypochondriacal concern and adoption of sick role.

Postconcussion Syndrome:

- Headaches
- Memory complaints
- Concentration complaints
- Dizziness
- Anxiety
- Insomnia
- Depression
- Irritability
- Fatigue
- Sensitivity to light and noise

Postconcussion Syndrome: Base Rates!

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Headache</th>
<th>Dizziness</th>
<th>Irritability</th>
<th>Memory</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>College Students¹</td>
<td>36%</td>
<td>18%</td>
<td>36%</td>
<td>17%</td>
<td>42%</td>
</tr>
<tr>
<td>Chronic Pain²</td>
<td>80%</td>
<td>67%</td>
<td>49%</td>
<td>33%</td>
<td>63%</td>
</tr>
<tr>
<td>Depressed²</td>
<td>37%</td>
<td>20%</td>
<td>52%</td>
<td>25%</td>
<td>54%</td>
</tr>
<tr>
<td>PI Claimants (non-TBI)³</td>
<td>77%</td>
<td>41%</td>
<td>63%</td>
<td>46%</td>
<td>71%</td>
</tr>
<tr>
<td>mTBI²</td>
<td>42%</td>
<td>26%</td>
<td>28%</td>
<td>36%</td>
<td>25%</td>
</tr>
<tr>
<td>College Students³</td>
<td>40%</td>
<td>27%</td>
<td>44%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>College Students⁴</td>
<td>36%</td>
<td>32%</td>
<td>42%</td>
<td>46%</td>
<td>59%</td>
</tr>
<tr>
<td>PI Claimants (non-TBI)³</td>
<td>59/38%</td>
<td>31/11%</td>
<td>77/36%</td>
<td>70/42%</td>
<td>76/47%</td>
</tr>
</tbody>
</table>

¹Sawchyn, et al. (2000)
²Radanov, et al. (1992)
³Trahan, et al. (2001)
⁴Pas et al. (1991)
⁵Ingebrigtsen et al. (1998)
⁶Chan (2002)
⁷Wong et al. (2006)
⁸Iverson (2006) Mild/moderate
The so called, "Postconcussion Syndrome"

- **PCS is not specific to concussion!**
- PCS may not be specific to any illness
- PCS is common among healthy people
- PCS appears to be a general Stress Syndrome

So what do we need to watch for?
- Post hoc, ergo propter hoc
- Symptom complaints that do not match the natural course.
- Thorough evaluation by neuropsychologists who are up to speed on current literature for mTBI and PPCS.
- PPCS may be difficult to deal with until the medical/Insurance industry changes the diagnosis.

Thank you for your time!

Questions/Discussion

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