Concussion: Classification, Confusion & Controversies

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Overview

1. TBI Epidemiology
2. Definitions
   - Mild TBI (MTBI)
   - Concussion
   - Post-concussive syndrome (PCS)
3. Controversies
4. Non-physical symptoms
5. Physical Symptoms

“If we’re going to prioritize, we’re going to need some priorities.”
At least 1.4 million new cases of TBI per year (all levels of severity)

- 50,000 Deaths
- 235,000 Hospitalizations
- 1,111,000 Emergency Department Visits
- ??? Receiving Other Medical Care or No Care

* Average annual numbers, 1995-2001
TBI Epidemiology

Of the 1.4 million documented, new TBIs per year . . .

- About 75% are “mild” (GCS ≥ 13)
- Falls #1 reason for visit to ED
- MVA #1 reason for hospitalizations and death
- Male : Female 1.5 : 1
- 80,000 - 90,000 estimated to have permanent disability

Of the existing patients with TBI . . .

- About 90% have mild TBI
- At least 5 million with some permanent disability (2% of adult population)
- Cost in 2000 $60 billion (direct & indirect)
Case #1: Ima Payne

33yo female s/p low speed MVA in parking lot, Escalade hit by Festiva

- No LOC, but dazed a few seconds, c/o headache, transient loss of vision, emotionally labile.

- In ED, c/o neck pain, headache, dizziness, visual blurring. Anxious

- Meds: Paxil, Vicodin, Ativan

- Cervical & head CT’s normal.

- Symptoms worsened over the next 2 weeks
Case #2: Biff Tuffskin

19yo male, college football player, helmet-to-helmet collision

- LOC 2-3 minutes, disoriented, perseverative ~15 minutes, GCS 13, no recall of ambulance ride or ED visit

- Post-traumatic amnesia about 10 hours. Retrograde amnesia of 5-6 hours (recalls breakfast that day).

- Normal head CT.

- 2 weeks later, c/o mild neck pain and headache, mild dizziness and nausea with exertion, no cognitive complaints
Ima Payne & Biff Tuffskin

Did either one have a traumatic brain injury? If so, what degree?

Did either one have a concussion? If so, what degree?

By definition . . .
Both of them had a TBI
  ➢ Ima Payne – mild
  ➢ Biff Tuffskin – mild

Both of them had a concussion
  ➢ Ima Payne – mild, Grade I
  ➢ Biff Tuffskin – severe, Grade III

The answer is “yes” or “no,” depending on the interpretation

- Albert Einstein
Definition of Mild TBI (MTBI)  
(American Congress of Rehabilitation Medicine, 1993)

- *Any* alteration of mental status
- Loss of consciousness (LOC)  
  < 30 minutes
- *Any* retrograde amnesia
- Post-traumatic amnesia (PTA)  
  < 24 hrs
- Glasgow Coma Scale 13-15
- Normal CT

“And now, God help us, Rachmaninoff’s Concerto in C Minor”
Definition of Concussion
(Centers for Disease Control and Prevention, 2007)

- “MTBI” & “Concussion” are interchangeable
- Loss of consciousness (LOC) not necessary
- “Complex pathophysiologic process affecting the brain, induced by traumatic biomechanical forces secondary to direct or indirect forces to the head, disrupting brain function”
- Neuroimaging typically normal
- Physical, cognitive, emotional, sleep-related symptoms
- Variable duration of symptoms (minutes → years)
Concussion Symptoms

- Confusion
  - Retrograde and/or Posterograde (Post-traumatic) Amnesia
  - Perseveration
  - Attention/Memory
- Emotional lability
- Headache
- Dizziness
- Tinnitus
- Nausea/Vomiting
- Vision changes
## Classification: Concussion Grading Scales

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
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</thead>
<tbody>
<tr>
<td>Cantu</td>
<td>No LOC</td>
<td>LOC &lt; 5 min</td>
<td>LOC &gt; 5 min</td>
</tr>
<tr>
<td>(1986)</td>
<td>PTA &lt; 30 min</td>
<td>or PTA &gt; 30 min</td>
<td>or PTA &gt; 24 hr</td>
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<tr>
<td>Cantu</td>
<td>No LOC</td>
<td>LOC &lt; 1 min</td>
<td>LOC &gt; 1 min</td>
</tr>
<tr>
<td>(2001)</td>
<td>or PTA or Sx</td>
<td>and PTA or Sx</td>
<td>or PTA &gt; 24 hr</td>
</tr>
<tr>
<td></td>
<td>&lt; 30 min</td>
<td>&gt; 30 min &lt; 24 hr</td>
<td>or Sx &gt; 7 days</td>
</tr>
<tr>
<td>CMS*</td>
<td>No LOC or PTA</td>
<td>No LOC, + PTA</td>
<td>Any + LOC</td>
</tr>
<tr>
<td>(1991)</td>
<td>+ Confusion</td>
<td>+ Confusion</td>
<td></td>
</tr>
<tr>
<td>AAN**</td>
<td>No LOC</td>
<td>No LOC</td>
<td>Any + LOC</td>
</tr>
<tr>
<td>(1997)</td>
<td>Sx &lt; 15 min</td>
<td>Sx &gt; 15 min</td>
<td></td>
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</tbody>
</table>

* Colorado Medical Society  ** American Academy of Neurology

- *Any* alteration of mental status
- Loss of consciousness < 30 minutes
- Any retrograde amnesia
- Post-traumatic amnesia < 24 hrs
- Glasgow Coma Scale 13-15
- Normal CT

• American Congress of Rehabilitation Medicine

All concussions fall within the definition of Mild TBI
(except for Cantu Grade 3 which falls into Moderate TBI because of PTA > 24 hours)

*So what’s this? I asked for a hammer! A hammer! This is a crescent wrench! ... Well, maybe it’s a hammer. ... Damn these stone tools!"
Post-Concussive Syndrome (PCS): DSM-IV

- Neuropsychological testing with attention & memory problems
- 3 or more of the following symptoms for 3 months:
  1. Fatigue
  2. Sleep disorder
  3. Headache
  4. Vertigo/Dizziness
  5. Irritability/Aggression
  6. Anxiety
  7. Depression/Lability
  8. Personality changes
  9. Apathy

Before paper and scissors
Concussion vs. Post-Concussive Syndrome

- If Concussion = MTBI, does PCS = MTBI?

- MTBI, Concussion & PCS are often used interchangeably (though not correctly)

- Concussive symptoms are generally considered organic/neurological

- PCS is more controversial, including biopsychosocial issues

“You have a serious illness of an undisclosed nature.”
Controversies regarding PCS/MTBI

- MTBI is prone to both over-diagnosis and under-diagnosis
- Besides accuracy of initial diagnosis, causality of persistent symptoms is a major controversy
- Subjective symptoms without objective findings
- Biological (traumatic) vs. Psychological or Sociological

“Now here’s one of the mysteries of the universe. ... Which came first?”
Post-concussive Syndrome

- Neuropsychological and Clinical psychological evaluations critical, but interpretation may vary
- Pre-injury history
  - Depression & Pain
- Investigate other factors than brain injury for symptoms persistent > 3 months
- Early intervention for education and prevention of enabling shown to be helpful in preventing PCS

“Wait a minute here, Mr. Crumbley. ... Maybe it isn’t kidney stones after all.”
Cognitive Dysfunction: Other Factors

- **Pain**
  - Headache
  - Neck Pain
- **Emotional Dysfunction**
  - Pre-injury
  - Post-injury
- **Poor sleep**
- **Iatrogenesis**
- **Medications**
- **Secondary Gain**
  - Conscious: Malingering
  - Unconscious: Somatoform
Non-specificity of subjective symptoms

“Normal” people meeting PCS criteria
- 36-76% of college students (Iverson, 2003)
- Over 50% of randomly surveyed adults (van der Windt, 2008)

Depressed pts meeting PCS criteria
- 50-90% depressed pts (Iverson, 2006)

Chronic pain pts meeting PCS criteria
- 81% chronic LBP (Iverson, 1997)

Litigants meeting PCS criteria
- 32 – 93% of litigants without brain injury claims (Lees-Haley, 1993 & 2001)
- Litigation & compensation the only consistent factors in delayed recovery (Carroll, 2004)

“It’s ten o’clock, and 75% of the people think all is well”
Controversies regarding PCS/MTBI

- No gold standard in the literature
- Variable and unexplainable outcomes
- Early studies conducted before widely used criteria established
- Many poorly designed studies
- Lack of differentiation of different degrees of MTBI
- Existing medical literature notes correlation more often than it can explain causation
## Prevalence of Symptoms: PCS vs. Chronic Pain

<table>
<thead>
<tr>
<th>Symptom</th>
<th>PCS</th>
<th>Chronic Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor Concentration</td>
<td>71%</td>
<td>14%</td>
</tr>
<tr>
<td>Irritability</td>
<td>66%</td>
<td>16%</td>
</tr>
<tr>
<td>Tired a lot more</td>
<td>64%</td>
<td>13%</td>
</tr>
<tr>
<td>Depression</td>
<td>63%</td>
<td>20%</td>
</tr>
<tr>
<td>Memory Problems</td>
<td>59%</td>
<td>20%</td>
</tr>
<tr>
<td>Headaches</td>
<td>59%</td>
<td>13%</td>
</tr>
<tr>
<td>Anxiety</td>
<td>58%</td>
<td>24%</td>
</tr>
<tr>
<td>Trouble Thinking</td>
<td>57%</td>
<td>6%</td>
</tr>
<tr>
<td>Dizziness</td>
<td>52%</td>
<td>7%</td>
</tr>
<tr>
<td>Blurry or double vision</td>
<td>45%</td>
<td>8%</td>
</tr>
<tr>
<td>Sensitivity to bright lights</td>
<td>40%</td>
<td>14%</td>
</tr>
</tbody>
</table>
Chronic back pain associated with pre-frontal and thalamic atrophy on MRI (Apkarian, 2004)

- 5-11% less gray matter than controls
- Equivalent to the loss of 10-20 years of aging
Pain in the Brain

fMRI differences in chronic back pain patients vs. normal population (Baliki, 2006)
Emotional Dysfunction

- Anxiety +/- PTSD, depression, anger, vindication
- Pre-existing vs. Situational
- Pt may not recognize or accept
- Concomitant pain & insomnia
- Psychological evaluation if possible
  - Identify psych factors contributing to cognitive and physical symptoms
Secondary Gain: Conscious vs. Unconscious

- Secondary Gain ≠ Malingering
- Pt may be an “unhappy somatizer involved in a social context which encourages rationalization, projection of blame, and complaining.”
- Mis-attribution of symptoms
  - Recall bias
  - Juxtaposition of Time
  - Iatrogenesis
- Medical-Legal Issues
- “Cogniform” proposed as an additional sub-category of Somatoform Disorders

<table>
<thead>
<tr>
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<th>Unconscious</th>
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<tr>
<td>External Gain</td>
<td>Malingering</td>
<td>Compensation Neurosis</td>
</tr>
<tr>
<td>Psychological</td>
<td>Factitious Disorder</td>
<td>Somatoform Disorder</td>
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Neuropsychological Testing

- Conclusions should be based upon history (including pre-injury), record review, and interpretation of test data
- Non-traumatic factors should be assessed including depression & secondary gain
- Numerous psychometric tests available, including validity measures
- Limitations of testing:
  - Estimation of pre-morbid function
  - “Abnormal” threshold for each test?
  - Sensitivity and Specificity
  - Examiner interpretation of data
  - Is there a truly objective way to measure personality/character?
Common Physical Symptoms of PCS/MTBI

- Headaches
- Neck Pain
- Visual disturbance
  - Focus, blurred vision
  - Rarely diplopia
  - Vision ↔ Dizziness
- Dizziness/Vestibular
- Nausea
Post-traumatic Headaches

- Usually musculoskeletal, not intra-cranial (eg, brain trauma)
  - Occipital Neuralgia
  - TMD/TMJ (Craniovertebral)
- Cervicogenic
  - C2-3, C3-4 facet joints
  - Cervical soft tissue
- Sometimes true migraine or secondary vascular
  - Transformed Migraine
Cranial Examination - TMJ

- Involves the joint itself as well as surrounding musculature
- Joint – Opening, lateral, anterior movement, palpation. Note pain, crepitus, locking
- Musculature – Temporalis, Masseter, Medial and Lateral Pterygoids
- TMJ disorders often associated with C2-3 facet joint problems
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Cervicogenic Headaches

- Pathophysiology and Pain
  Generators debated
- Multiple proposed contributing factors
  - Neurogenic
  - Soft Tissue
  - Osseous
  - Discogenic

“Sometimes I wonder if there’s more to life than unlocking the mysteries of the universe.”
Cervicogenic Headaches – Neurogenic Trigeminocervical Nucleus

- Area in the upper cervical spinal cord where descending sensory fibers from CN V converge with ascending sensory fibers from the cervical roots, as well as sensorimotor fibers of CN XI
- Suspected involvement in migraines
- May explain referral patterns from trapezius and SCM
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Cervicogenic Headaches – Neurogenic Peripheral Nerves

Cervical Roots
- Third Occipital Nerve (TON)
  - Emerges between C2-3

Peripheral Nerves
- Greater Occipital Nerve (GON)
  - Medial Sub-Occipitals
  - Irritation from aponeurosis
  - Referral to top of head, ocular and frontal regions
- Lesser Occipital Nerve (LON)
  - Lateral Sub-Occipitals
  - Referral to temporal, orbital and sinus regions
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  - Referral to temporal, orbital and sinus regions
Cervicogenic Headaches – Soft Tissue Trigger Points (TrP)

- Trigger Points (TrP) – areas of taut muscular bands, that when palpated, cause a referral pattern in a predictable fashion

- Various trigger points within the cranial, cervical and shoulder (periscapular) region can cause headaches

- TrP are unlikely to be a “solo” problem, eg, they occur in conjunction with other factors, especially posture
Cervicogenic Headaches – Osseous Cervical Facet Joints

- Also known as Zygapophysial, or Z-joints
- C2-3 and C5-6 facet joints most commonly affected joints with trauma
- C2-3 and C3-4 facet joints most commonly associated with persistent post-traumatic headaches
- However, lower cervical facet joints can cause secondary myofascial problems leading to headaches
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Vestibular Dysfunction

- Positional Vertigo (BPPV)
- Meniere’s Syndrome (Hydrops)
  - Labyrinthine Concussion
- Perilymph Fistula
- Temporal Skull Fracture
- Cervicogenic Vertigo
Vestibular Dysfunction

Inner Ear

Brain

Neck

Eyes
Positional Vertigo (BPPV)

- Symptoms induced with movement, especially cervical extension
- ENG helpful for diagnosis
Positional Vertigo (BPPV)

- Dix-Hallpike Maneuver (check for nystagmus)
- Epley Maneuver (canalithic repositioning)
- Brandt-Daroff Exercises
Meniere’s Syndrome (aka, Hydrops)

- Dizziness, Tinnitus, fullness, hearing changes
- Disturbance of fluid transport
- True Meniere’s with more significant trauma and earlier onset of symptoms
- Labyrinthine Concussion (+/- hearing loss)
- Meniere’s or Labyrinthine concussion often diagnosed when other tests are negative
Perilymph Fistula

- Dizziness with valsalva or blowing nose, loud noises (rarely), better with rest
- +/- hearing loss
- Symptoms can be identical to Meniere’s
- Diagnosis by fistula test
Temporal Skull Fractures
+/- hearing loss, facial paresis

- **Longitudinal**
  - Conductive

- **Oblique**
  - Conductive
  - Sensorineural
  - Vestibular Symptoms
  - Hemotympanum
Cervicogenic Vertigo

- **Dizziness/Imbalance following a severe neck injury**
- **Controversial Diagnosis, especially regarding frequency**
- **Theories include vascular compression (vertebrobasilar insufficiency) and alterations of sensory input to the vestibular system**
Post-Traumatic Vision Syndrome
- Dysequilibrium from ambient visual system dysfunction
- Visual symptoms often tied in with vestibular symptoms, headaches, nausea, neck pain
- Accommodation (focus)
- Convergence
- Tracking