Incidence, Anatomy, and Physiological Effects of Concussive Brain Injury

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Mild Traumatic Brain Injury

Concussion: Concutere (to strike together)
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TBI Defined

• TBI is caused by a bump, blow or jolt to the head or a penetrating head injury that disrupts the normal function of the brain.

• The severity of a TBI may range from “mild,” i.e., a brief change in mental status or consciousness to “severe,” i.e., an extended period of unconsciousness or amnesia after the injury.

• The majority of TBIs that occur each year are concussions or other forms of mild TBI.

The most common cause of head injuries is:

1. Gun shot wounds
2. Marital discord
3. Falls
4. Motor vehicle accidents

Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2010
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Two Primary Mechanisms of Blunt Brain trauma

• Linear Blunt
  - Example: Falling to the ground and hitting the back of the head. The falling motion propels the brain in a straight line downward.

• Rotational Blunt
  - Example: When a player is spun, rolled, turned, his head may strike object; this contact to the head can cause a rotational motion.
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Computer Modeling of Forces
(expressed as pressure, kPa)

The Predicted Intracranial Pressure Wave Following a Concussive Blow is Shown in the upper image. Note the Drastic Change From Positive Pressure (pink, coup) to Negative Pressure (blue, contre-coup) Across the Brain.

Within the Brain Following a Strong Blow to the Head. The Predicted Sheer Stresses (lower image) Differentiate Concussive From Non-concussive Injury. Note the High Sheer Stress (pink) in the Central Core of the Brain.

Cecilia V. Mendez, M.D., Robin A. Hurley, M.D., FANPA, Maryse Lassonde, Ph.D., Liying Zhang, Ph.D. and Katherine H. Taber, Ph. J Neuropsychiatry Clin Neurosci 17:297-303, August 2005

Axonal Injury

• Initially described by Strich (pathologist) in 1956.
  – Axonal degeneration/disintegration
  – Not diffuse per say but predominates in discrete regions of the brain.
  – Axon retraction.
  – Foci of hemorrhage.
  – Long term survivors:
    • Microglial clusters
    • Foci of demyelination
    • Ventricular enlargement

Pathophysiology of DAI

- From rotational forces.
- The injury to tissue is greatest in areas where the density difference is greatest.
- For this reason, approximately two thirds of DAI lesions occur at the gray-white matter junction.

Axonal Injury

- **Location** of injury depends on 2 factors:
  1. Depends on the plane of rotation.
  2. Independent of the distance from the center of rotation.
- **Magnitude** of injury depends on 3 factors:
  1. Distance from the center of rotation.
  2. Arc of rotation.
  3. Duration and intensity of the force.
Typical Locations for DAI

- The lesions typically are ovoid or elliptical, with the long axis parallel to the direction of the involved axonal tracts.
- Not Superficial
- Grey – white junction
- Corpus callosum
- Brain stem (dorsal midbrain)
- Basal ganglia/internal capsule
- Hemispheric white matte

Thalamo-Cortical Connectivity Loss in TBI

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Noninvasive Neurochemical Assessment

- Volumetric proton magnetic spectroscopic imaging has found significant changes in with reduced N-Acetylaspartate (NAA)/Creatine (Cr), increased Choline (Cho)/Cr, and reduced NAA/Cho ratios.

- The results show evidence of widespread metabolic changes in regions that appear normal on diagnostic MR images.

http://www.kumc.edu/
Routine Brain MRI and CAT scans usually show abnormalities in mTBI.

- True
- False
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Neuroimaging

- Studies have not been able to correlate abnormal findings on regular MRI with either post concussive symptoms or long term outcome. FMRI:


(CDC) Mild Traumatic Injury Workgroup

- Conceptually defined MTBI as
  - “an injury to the head as a result of blunt trauma or acceleration or deceleration forces that result in one or more of the following conditions:
    - (1) Any period of observed or self-reported transient confusion, disorientation, impaired consciousness, dysfunction of memory around the time of injury, or loss of consciousness lasting less than 30 minutes
    - (2) Observed signs of neurological or neuropsychological dysfunction, headache, dizziness, irritability, fatigue or poor concentration.”

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Interior Skull Surface

The base of the skull is rough, with many bony protuberances. These ridges can cause trauma to the temporal lobes during rapid deceleration.

Bony ridges

Injury from contact with skull

Frontal Lobe

The frontal lobe is the area of the brain responsible for higher cognitive functions. These include:

- Problem solving
- Spontaneity
- Memory
- Language
- Motivation
- Judgment
- Impulse control
- Social and sexual behavior.
The temporal lobe plays a role in emotions, and is also responsible for smelling, tasting, perception, memory, understanding music, aggressiveness, and sexual behavior.

The temporal lobe also contains the language area of the brain.

The limbic system is the area of the brain that regulates emotion and memory. It directly connects the lower and higher brain functions.

A. Cingulate gyrus
B. Fornix
C. Anterior thalamic nuclei
D. Hypothalamus
E. Amygdaloid nucleus
F. Hippocampus
How to measure “severity”?  

- Concussion grading  
  - 16 different grading systems  
  - The newest of the 3 most commonly used is over 10 years old  
- Duration of loss of consciousness  
- Initial score on Glasgow Coma Scale (GSC)  
- Length of post-traumatic amnesia  
- Rancho Los Amigos Scale (1 to 10)

Post Traumatic Amnesia

**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 hours LOC GCS = 3-8
### Categories of Concussion

<table>
<thead>
<tr>
<th>Grade 1</th>
<th>Grade 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Spotty confusion</td>
<td>• Spotty confusion</td>
</tr>
<tr>
<td>• <strong>NO</strong> loss of consciousness</td>
<td>• <strong>NO</strong> loss of consciousness</td>
</tr>
<tr>
<td>• Concussion symptoms go away in</td>
<td>• Concussion symptoms or</td>
</tr>
<tr>
<td><strong>LESS than 15 minutes</strong></td>
<td>abnormalities last <strong>MORE than 15 minutes</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>ANY</strong> loss of consciousness,</td>
</tr>
<tr>
<td>either brief (seconds) or</td>
</tr>
<tr>
<td>prolonged (minutes)</td>
</tr>
</tbody>
</table>

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### American Academy of Neurology Position Statement

1. Any athlete who is suspected to have suffered a concussion should be removed from participation until he or she is evaluated by a physician with training in the evaluation and management of sports concussions.

2. No athlete should be allowed to participate in sports if he or she is still experiencing symptoms from a concussion.

3. Following a concussion, a neurologist or physician with proper training should be consulted prior to clearing the athlete for return to participation.

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Position Statement Approved by the AAN Sports Neurology Section, Practice Committee, and Board of Directors October 2010 (AAN Policy 2010-36).
American Academy of Neurology Position Statement

4. A certified athletic trainer should be present at all sporting events, including practices, where athletes are at risk for concussion.

5. Education efforts should be maximized to improve the understanding of concussion by all athletes, parents, and coaches.

Position Statement Approved by the AAN Sports Neurology Section, Practice Committee, and Board of Directors October 2010 (AAN Policy 2010-36).

Second Impact Syndrome

- Second concussion occurs before previous concussion injury is healed
- Loss of consciousness not required
- Second impact more likely to cause brain swelling and other widespread damage
- Can be fatal -- 50% mortality rate in most severe cases
- Higher risk of long-term problems
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Mild injury is important to discuss

- Long-term impact for 15%
- Don’t see that TBI is cause of deficits
- Repeated injury leads to problem emergence—“second impact syndrome”
- 300,000 sports and recreational injuries
- CT, MRI and EEG are usually normal

Early Signs and Symptoms

- Headache
- Amnesia for the event
- Anterograde amnesia
- Retrograde amnesia
- Vacant stare
- Confusion/Disorientation
- Communication impairment
- Emotional lability
- Memory deficit
- Attention/concentration
- Dizziness
- Visual abnormalities
- Decreased processing
- Irritability
- Poor coordination
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Emotional and Motivational Disturbance

- Irritability
- Agitation
- Restlessness
- Inappropriate social response
- Anxiety
- Paranoia
- Tires easily
- Sleep disturbance

- Belligerence
- Anger
- A-spontaneity
- Depressed
- Impulsiveness
- Rapid mood changes
- Loss of drive or initiative

Effects of mild TBI

- Problems disappear on their own in about 85% of cases
- Compensatory skills acquired
- Education prevents emotional upset (“shattered sense of self”)
Effects of mild TBI: outcomes

• Problems are not attributed to TBI
• Compensatory skills are not learned
• Best approach is early education and information
• Best rehab assessment is neuropsychology
Cumulative Rate of Major Depression After Traumatic Brain Injury as a Function of Depression

Impact on Individual depends on:

- Severity of initial injury
- Rate/completeness of physiological recovery
- Functions affected
- Meaning of dysfunction to the individual
- Resources available to aid recovery
- Areas of function not affected by TBI

Bombardier, C. H. et al. JAMA 2010;303:1938-1945
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Treatment and Referral Options

- Early:
  - Reassurance and observation
- Later 12-24 weeks:
  - Cognitive evaluation
    - Neuropsych testing
    - ImPACT testing
  - Cognitive remediation
    - Speech and language therapist
    - Day treatment for more severe cases
  - Vestibular PT for vertigo/dizziness

Treatment and Referral Options

- Referrals to consider:
  - CT/MRI/PET/MEG
  - Psychiatry referral
  - Neuro-Psychology
  - Neurology
  - Sleep specialist
  - P.T., Vestibular therapy
  - O.T.
  - Speech/cognitive therapy
  - Day treatment program
  - Community ABI programs
  - Vocational Rehab

- Medication options:
  - It depends!
    - OTC analgesics
    - Valproic acid ER
    - Antidepressants
      - Tricyclics
    - SSRI's
    - SNERI's
    - Attention deficit meds
    - Others
Its OK to return to play when:

1. The coach says he needs the player.
2. The patient says they're ok.
3. When the patient is asymptomatic.
4. When the MRI is normal.

Return to Play

1. It is very important to **NEVER** return to play (physical education class, sports, practice, or game) while still experiencing symptoms of a concussion.

2. Management of concussive injuries should not only focus on the physical demands but also the cognitive/mental exertion placed on the recovering brain.

3. The presence and/or reoccurrence of post-concussion symptoms are a sign that the athlete has **NOT** fully recovered from this injury.


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Gradual Return to Physical Activity

<table>
<thead>
<tr>
<th>Stage</th>
<th>Functional Exercise</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No Activity</td>
<td>Complete physical and cognitive rest</td>
<td>Recovery</td>
</tr>
<tr>
<td>2. Light aerobic exercise</td>
<td>Walking, swimming or stationary cycling keeping intensity &lt;70% maximum predicted heart rate. No resistance training</td>
<td>Increase HR</td>
</tr>
<tr>
<td>4. Non-contact training</td>
<td>Progression to more complex training e.g. passing drills in football and hockey. May start progressive resistance training</td>
<td>Exercise, Coord. Cog load</td>
</tr>
<tr>
<td>5. Full contact practice</td>
<td>Participate in normal training activities</td>
<td>Restore confidence asses skill by coach</td>
</tr>
<tr>
<td>6. Return to play</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Gradual Return to Cognitive Activity

1. **Athletes who are reporting numerous symptoms such as headache, dizziness, fatigue, and inability to concentrate should be encouraged to limit scholastic activities and other cognitive stressors.**

2. **ACE Care Plan:**
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## ACUTE CONCUSSION EVALUATION (ACE) Form

<table>
<thead>
<tr>
<th>Patient's Name</th>
<th>Age</th>
<th>Gender</th>
<th>Sport</th>
<th>Activity</th>
<th>Concussion Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Headache</td>
</tr>
</tbody>
</table>

## Severity of Concussion

<table>
<thead>
<tr>
<th>Severity Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>Minor symptoms or no symptoms</td>
</tr>
<tr>
<td>Moderate</td>
<td>Moderate symptoms or no symptoms</td>
</tr>
<tr>
<td>Severe</td>
<td>Severe symptoms or no symptoms</td>
</tr>
</tbody>
</table>

## sideline concussion protocol (SCP)

1. **Rest:** Avoid physical activity until symptoms are gone.
2. **Gradual Return:** Progressively increase activity levels.
3. **Follow-Up:** Monitor symptoms and adjust plan accordingly.

## References


## Additional Information

- **Prevention Tips:** Wear appropriate protective gear, follow guidelines, and stay hydrated.
- **Healthcare Providers:** Seek medical advice if symptoms persist.
- **Patient Education:** Understand the signs and symptoms of concussion.

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**Please note:** This document is for educational purposes only. Always consult with a healthcare professional before making any medical decisions.
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Thank You!!

“He can go back in the game. It’s just a bruise.”

Additional references


