The Management of Concussion in the Pediatric & Adolescent Population

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Disclosure

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Overview

- Definition
- Epidemiology
- Historical Management
- Current Concussion Management Guidelines
- Return to Play Criteria
- Concussion Clinic Setting Evaluation
  - Role of ImPACT Neuropsych testing
- Resources for Physicians

How to recognize the moods of an Irish setter
Just what is a Concussion (mTBI)?

- “Concussion” – from the Latin concussus or concutere, meaning “to shake” or “be shaken violently”
- “…a pathophysiological process involving the brain, induced by traumatic biomechanical forces.
- Concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness or memory dysfunction.
- Concussion typically results in a functional disturbance with the rapid onset of short-lived impairment of neurological function that resolves spontaneously…”


What is a Concussion?
What is a Concussion?

- Concussion can be caused by a direct blow to the head, face, neck, or elsewhere on the body with an “impulsive” force transmitted to the head.
- Typically associated with grossly normal structural neuroimaging studies
- Symptoms and signs do not always occur immediately after injury – may evolve over time
- Resolution of the clinical and cognitive symptoms typically follows a sequential course
Emotionality

Physical Symptoms

Cognitive Symptoms

Sleep Disturbance

Signs & Symptoms of Concussion

Physical
- Headache
- Dizziness
- Nausea
- Balance problems
- Feeling “dinged” or “stunned”
- Visual disturbances
- Photophobia
- Tinnitus
- Diplopia
- Simply “not feeling right”.

<table>
<thead>
<tr>
<th>Post Concussion Symptom Scale</th>
<th>None</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Pressure in head</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Neck Pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Balance problems/dizzy</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Nausea or vomiting</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Vision problems</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Hearing problems/tinging</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Don’t feel right</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Feeling “dinged” /“dazed”</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Conclusion</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Feeling like “in a fog”</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Fatigue or low energy</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>More than emotional</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Irritability</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(follow up symptoms only)</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sadness</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Nervous or anxious</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Trouble falling asleep</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sleeping more than usual</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Signs & Symptoms of Concussion

**Cognitive**
- Confusion
- Post-traumatic amnesia
- Disorientation
- Poor concentration
- Memory disturbance
- Feeling mentally “foggy”
- Slowed reaction times

**Sleep Disturbance**
- Diff falling/staying asleep
- Excessive fatigue
- Daytime somnolence

**Emotional Signs & Sx’s**
- Sadness
- Moodiness
- Emotional lability
- Nervousness

Commonly reported symptoms

High School and College Athletes: within 3 days of injury

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>71%</td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>58%</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>57%</td>
</tr>
<tr>
<td>Dizziness</td>
<td>55%</td>
</tr>
<tr>
<td>Fogginess</td>
<td>53%</td>
</tr>
<tr>
<td>Fatigue</td>
<td>50%</td>
</tr>
<tr>
<td>Visual Blurring/double vision</td>
<td>49%</td>
</tr>
<tr>
<td>Light Sensitivity</td>
<td>47%</td>
</tr>
<tr>
<td>Memory dysfunction</td>
<td>43%</td>
</tr>
<tr>
<td>Balance problems</td>
<td>43%</td>
</tr>
</tbody>
</table>

Lovell, Collins et al., 2004; N=215
Epidemiology

- Estimated 1.7 - 1.8 million/year
  - 300,000 sports-related TBI with LOC (Thurman et al., 1999)
- High School athletics (Powell et al., 2002)
  - 3 year time span, 236 schools surveyed
    - 23,566 total injuries
      - 1,291 concussions (5.5%)

Sports-related Concussion

- 26% of Closed Head Injuries → Athletics
- Children under 5 yrs. suffer relatively few concussions from participating in sports and recreation activities.
- Concussion frequency increases as age increases and peaks between the years of 15-24.
  - 0.8 injuries per 100,000 persons in children under 5
  - 5.1 per 100,000 in youth ages 5-14
  - 6.6 per 100,000 in those aged 15-24.
Epidemiology

- > 10% of all contact sport athletes sustain concussions yearly
- > 50% of all concussions occur in football (>90,000/year)
- Estimated that up to 20% of football players will sustain a concussion per season.
- “Bell ringers” or mild concussions account for > 50% of all concussive injuries
- Concussions resulting in LOC account for only 8% to 19% of injuries (Collins et al., 2003; Schultz et al., 2004).
- Estimated 1.7 million sports-related concussions per year (CDC Toolkit for Physicians, 2007).
  - Majority are sustained by children and adolescents
    - 7.6 million H.S. athletes ➔ 1.1 million in H.S. football
Children are Different!

VS.

TABLE 1. 1989-1998 NCAA Injury Surveillance System Concussion Data

<table>
<thead>
<tr>
<th>Sports with head protection</th>
<th>Concussion as a percent of all game injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice hockey</td>
<td>7.5</td>
</tr>
<tr>
<td>Men’s lacrosse</td>
<td>5.2</td>
</tr>
<tr>
<td>Football</td>
<td>4.5</td>
</tr>
<tr>
<td>Softball</td>
<td>3.6</td>
</tr>
<tr>
<td>Baseball</td>
<td>2.7</td>
</tr>
<tr>
<td>Sports without head protection</td>
<td></td>
</tr>
<tr>
<td>Field hockey</td>
<td>13.0</td>
</tr>
<tr>
<td>Women’s soccer</td>
<td>11.0</td>
</tr>
<tr>
<td>Man’s soccer</td>
<td>9.0</td>
</tr>
<tr>
<td>Women’s lacrosse</td>
<td>8.5</td>
</tr>
<tr>
<td>Women’s basketball</td>
<td>8.0</td>
</tr>
<tr>
<td>Wrestling</td>
<td>4.3</td>
</tr>
<tr>
<td>Men’s basketball</td>
<td>3.1</td>
</tr>
</tbody>
</table>
Children are different…

- Thought most brain growth completed by age of 5 yrs., likely 95% by this time.
- Area of the brain, the prefrontal cortex ("CEO" of function), is growing again before puberty.
- Overproduction of synapses around the age of 11 or 12 then a pruning during adolescence. Loss of 1% of grey matter per year.
- Changes in the corpus callosum and the cerebellum also occur during adolescence.
- "Use or lose it" time period

Children are Different…

- Increased vulnerability due to rapidly emerging neurodevelopmental pathways
- "Plasticity" may not be protective in concussion
Children are different…

- Frontal cortex is not fully myelinated until the early 20s.
- Studies are showing that it takes longer for high school athletes to recover from concussions than adults.

### Recovery Rates Vary by Age/Dependent Measure

<table>
<thead>
<tr>
<th>Author</th>
<th>Level</th>
<th>Age Dependent</th>
<th>Time to Complete</th>
<th>Time to Return to Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowell et al. 2015</td>
<td>15</td>
<td>12-18</td>
<td>2 weeks</td>
<td>1 day</td>
</tr>
<tr>
<td>Radtke et al. 2016</td>
<td>College</td>
<td>18-22</td>
<td>1 month</td>
<td>2 weeks</td>
</tr>
<tr>
<td>McConahey et al. 2016</td>
<td>College</td>
<td>18-22</td>
<td>3-4 weeks</td>
<td>3 days</td>
</tr>
<tr>
<td>Galloway et al. 2016</td>
<td>College</td>
<td>18-22</td>
<td>1-2 weeks</td>
<td>1 day</td>
</tr>
<tr>
<td>Bleck et al. 2016</td>
<td>College</td>
<td>18-22</td>
<td>1-2 weeks</td>
<td>3 days</td>
</tr>
<tr>
<td>Simon et al. 2016</td>
<td>High School</td>
<td>13-18</td>
<td>1-2 weeks</td>
<td>7 days</td>
</tr>
<tr>
<td>McCann et al. 2016</td>
<td>High School</td>
<td>13-18</td>
<td>1-2 weeks</td>
<td>7 days</td>
</tr>
</tbody>
</table>

Children are different…

- Lack of proper technique
  - Less-refined movement and coordination at earlier ages
- Reduced neck and shoulder strength/stability
- Less frequent practices
- Lack of concussion awareness & education
  - Parents, coaches, athletes
Children are different…

- Barlow, et al. (2010)
  - 670 patients with mTBI
  - Followed 1 year out from injury
  - 13.7% of school-aged children (6-18 yrs.) remained symptomatic 3 months out from injury
  - 2.3% were symptomatic 1 year out

Pre-school mTBI and behavior

- McKinley, et al. (2008)
  - mTBI 0-5 yrs of age
    - GCS > 13
    - LOC < 20 minutes
    - Hosp < 2 days
    - No skull fracture
  - Inpatient vs. outpatient
  - Control group
  - ADD/ADHD & ODD/CD symptoms
    - Rutter and Conners questionnaires
    - Assessed each year from 7-13 years
Pre-school mTBI and Behavior

- Increased ADD/ADHD and ODD/CD symptoms in the inpatient mTBI group
- No difference in outpatient group compared to control
- Severity of mTBI more important than age?

Children are different…

- Hastening the resolution of symptoms is paramount
- “Use it or lose it” time period for the developing brain
- “Pause button” analogy
- Difficulty acquiring new skills both during and after brain healing
Initially K+ is released from damaged cells and Ca++ flows into the neurons causing swelling and activates proteases which breakdown the integrity of the cell. This results in hyperglycolysis and due to the inability to increase the blood flow, a metabolic crisis results. Glutamate, an excitatory neurotransmitter, likely plays a role as excess in the damaged area surrounding the injury causes degeneration and apoptosis.

**Common Concussion “Myths”**

- A child must be rendered unconscious to sustain a concussion
- Having your “Bell Rung” is not big deal
- You can “push through” a concussion
- Children will report if they feel “bad” after a hit or fall
- Concussions are ONLY from a head injury
- Concussion symptoms appear immediately
- Concussions ONLY occur in football, boxing, and hockey
- ’s experience more concussions than ’s in the same sport
- All physician’s are well educated on the management guidelines of concussions
Problems in Identification and Management of Concussion

- Lack of awareness in athletes, coaches, parents
- Lack of up-to-date knowledge within the medical community
- Lack of clinical tools to assess and manage concussion
- Lack of appropriate medical care systems
  - Primary vs. Specialty care (concussion clinics)

Sports Concussion (mis)management: Topics of Concern

- Prior guidelines not data driven
  - Over 20 different concussion grading scales based on subjective data
- Self-reporting by athletes is not always accurate and/or honest and are SUBJECTIVE
- CT and MRI are used too often
  - Diagnoses changes in anatomic structure and a concussion is primarily a biochemical/physiological/FUNCTIONAL abnormality
- Inconsistencies in physician recommendations on Return to Play because of inconsistent knowledge and lack of accepted guidelines.
Changes in Concussion Management: Guideline Evolution

1st International Symposium on Concussion in Sport, Vienna, Nov, 2001
- Organized by International Ice Hockey Federation, FIFA, and International Olympic Committee
- Concussion defined as “…a pathophysiological process involving the brain, induced by traumatic biomechanical forces.”
- “Concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness or memory dysfunction.”
- “Concussion typically results in a functional disturbance with the rapid onset of short-lived impairment of neurological function that resolves spontaneously.”
Does loss of consciousness matter?

- Answer: PROBABLY NOT!

  - After Concussion, no difference in LOC vs. non-LOC groups of neuropsych testing
  - Study casts doubt on importance of LOC as predictor of neuropsych test performance
  - Does not provide support for guidelines that rely heavily upon using LOC regarding grade and return to play decisions

Summary statement of the 2nd International Conference on Concussion in Sport, Prague, 2004

- Concussion severity can only be determined after all signs/symptoms have cleared, neurologic exam wnl, cognitive function returned to baseline.
  - Abandoned previous used grading scales
- LOC is associated with early deficits but not concussion severity
- Data suggests that the nature, burden, and duration of post-concussion symptoms are more important than the presence of post-traumatic amnesia
Summary statement of the 2nd International Conference on Concussion in Sport, Prague, 2004 “Guidelines Redux”

- Pediatric concussion guidelines similar to adults with concept of “cognitive rest” with scholastic and ADL performance while symptomatic
  - Ages 5-18 years
- Classification of Concussion based on duration of symptoms
  - Simple vs. Complex

Simple vs. Complex Concussions

- **Simple**
  - Symptoms & Signs resolve within 10 days
  - No recurrence with progressive return to play
  - By definition, no risk for post-concussive syndrome
  - LOC transient, “blacked out”

- **Complex**
  - Symptoms & Signs persist > 10 days
  - LOC > 1 minute
  - Prolonged cognitive impairment
  - Referral to sports concussion specialist recommended
3rd International Conference on
Concussion in Sport
30 October 2008 | 9:00 – 17:00hrs
hosted by FIFA at the Home of FIFA in Zurich

Zurich, 2008 CIS Consensus Statement

- Abandon the simple vs. complex terminology
- Majority (80-90%) of concussions resolve in a short (7-10 day) period, although the recovery time frame may be longer in children and adolescents.
- SCAT2 form developed (SAC + BESS)
- Sideline: A player with diagnosed concussion should not be allowed to return to play on the day of injury. Occasionally in adult athletes, there may be return to play on the same day as the injury.
  - Recognized delayed onset of symptoms
Zurich, 2008 CIS Consensus Statement

**Concussion Management**
- Reinforced Physical AND Cognitive Rest
- Graduated RTP: when asymptomatic at rest
  - stepwise progression, proceed to next level if asymptomatic at current.
  - Each step to take a *minimum* of 24 hours; would take approximately one week to proceed through the full rehabilitation protocol

**Modifying Factors in Concussion Management**
- A range of ‘modifying’ factors may influence the investigation and management of concussion and in some cases, may predict the potential for prolonged or persistent symptoms

### Zurich, 2008 CIS Consensus Statement: “Modifying Factors”

**Symptoms**  
- Number, Duration (>10 days), Severity

**Signs**  
- Prolonged LOC (> 1 minute)

**Sequelae**  
- Concussive Convulsions

**Temporal**  
- Frequency, repeat, timing

**Threshold**  
- Less impact force required

**Age**  
- < 18 years

**Co-morbidities**  
- Migraine, Mental illness, ADD/ADHD, LD, Sleep disorders

**Medication**  
- Psychoactive drugs

**Behavior**  
- Dangerous Style of Play

**Specific Sport Participation**  
- Contact/Collision
Zurich, November, 2012

Consensus Statement recently published in March: 

- Reinforced 3rd Int’l Conf recommendations
- Importance of Vestibular Testing
- Role of Neuropsychological testing
- More conservative management for < 13 yrs of age
- Development of SCAT3 and Child-SCAT3
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- Inconsistencies in physician recommendations on Return to Play because of inconsistent knowledge and lack of accepted guidelines.

Self-reporting of Concussion

Collins and Lovell, 2003

- Previous studies show 3.6% in HS Football
- In this study 30% had a concussion prior to current season
- During season 15.3% had concussion and only 47.3% reported the injury.
  - ATC (76.7%)
  - Coach 38.8%
  - Parent (35.9%)
  - Teammate (27.2%)
  - Others (include MDs) 11.7%
Self-reporting of Concussion

Kaut KP, et al., 2003
- Collegiate athletes
- RTP same game after blow to head
  - 61% with headache
  - 28% with dizziness, imbalance

Reasons for not reporting injury
- Athlete didn’t believe it was serious enough to report
- Not wanting to leave the game or practice
- Not knowing the injury was a concussion
- Not wanting to let teammates down
- Residual belief that it is macho to play hurt!!

2004;14:13-17
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To Image or not to Image…

- When?
  - Acute changes/worsening
  - High risk mech of injury (e.g. MVC)
  - Severe cognitive deficits
  - Prolonged duration of symptoms
  - ? LOC > 1 minute
  - Focal neurologic exam findings
- For the majority of concussions imaging is wnl.
- CT-scan, MRI most common
- Role for fMRI, PET-scan?
Sports Concussion (mis)management: Topics of Concern

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- CT and MRI are used too often
  - Diagnoses changes in anatomic structure and a concussion is primarily a biochemical/physiological/functional abnormality
- Inconsistency in physician recommendations on Return to Play because of limited knowledge in management and lack of accepted guidelines.
Prior Return to Play Guidelines Vague
- Allowed RTP if Sx’s cleared < 15 minutes

Current Concussion Management
- The initial cornerstone of concussion management is *rest until all symptoms resolve*
  - It is unsafe to return to play while symptomatic
- This includes *both physical and cognitive rest* and must be emphasized to the patient and parents
  - TV, video games, reading
  - School attendance, homework
  - Physical activity
  - Any “brain stimulation”
- Return to activity *is graduated* and the patient should be asymptomatic for 24 hrs *(min)* prior to moving to the next level.
  - Asymptomatic = No physical, cognitive, emotional symptoms
Progressive Return to Play Strategy (Prague, 2004)

(1) **No activity; complete rest.** When asymptomatic proceed to Step 2.
(2) Light aerobic exercise (i.e. walking, stationary cycling). No resistance training.
(3) Sport-specific exercise (i.e. skating in hockey, running in soccer). Progressive addition of resistance training.
(4) Non-contact, sport-specific training drills
(5) Full-contact training **after** medical clearance
(6) Return to Game play

Current Concussion Management

- **Physical & Cognitive Rest and School**
  - **No P.E. or recess until fully cleared**
  - Academic decline not uncommon
    - Reading comp., memory, slow processing, prolonged test taking
    - Schoolwork, school environment may exacerbate symptoms
  - **Clinician, school administration communication is key**
    - ATC and school nurse or guidance counselor as liaison
  - Removal from school may be necessary initially
    - Half day attendance is an option
    - Needs to be considered re: allowable absences
  - May need short-term accommodations
    - Open book/untimed tests, pre-printed class notes, tutoring, prolonged deadlines to complete work
    - Postpone standardized testing
    - Role of development of an appropriate 504 Plan or IEP
Return to Play Considerations

- No symptoms is predictive of severity, duration (LOC, PTA, etc.)
  - Prior grading systems based on Sx’s not relevant
- Post-concussion Sx’s last longer than thought
- Sx’s do not recover in linear fashion
  - Sx’s may be greatest the day after injury
- Exercise, stress can exacerbate Sx’s if not recovered
  - Exercise testing important part of RTP protocol

Return to Play Considerations

- **No athlete should RTP even if Sx’s clear within 15 minutes**
- Inadequate “brain rest” can…
  - ↑ risk of repeat concussion
  - ↑ risk of more severe post concussive symptoms
    - Cognitive impairments
    - Emotional disturbances
  - Delay recovery
  - ↑ risk of catastrophic event
Concussion-related Emergencies

“Second Impact” Syndrome
- Observed primarily in athletes < 21 years of age
- Rapid brain swelling and herniation following a second head injury sustained before the resolution of post-concussive symptoms of a previous concussion.
  - Second blow often minor
  - Typically, no LOC and athlete remains on feet but initially dazed
  - Within 15 seconds to minutes, athlete collapses
- Pathophysiology
  - Vasomotor paralysis → cerebral edema → increased ICP → herniation
  - 50% mortality and nearly 100% morbidity

Long Term Effects

Post-Concussion Syndrome
- Persistent physical symptoms → headache, dizziness
- Emotional lability → depression, irritability
- Cognitive Impairment → academic decline
  - Reduced GPA in athletes with > 2 concussions compared to controls (Moser et al., 2005)
- Attention and/or memory deficits
- Sleep cycle disruption

Chronic Traumatic Encephalopathy
Long Term Effects

- Chronic Traumatic Encephalopathy
  - Brain tissue degeneration
  - Tau protein deposition
  - Dementia, Emotional lability

Chris Henry, 26 years old
- Cincinnati Bengals, WR
  - Previously youngest dx’d with CTE

Owen Thomas, 21 years old
- U Penn, Wharton School of Business
- 2nd team All-Ivy League, lineman
  - NO hx of documented concussions
  - Hx of emotion change, depression
Chronic Traumatic Encephalopathy

- 18 y.o multi-sport athlete
  - +Hx of multiple concussions

Return to Play

The final decision regarding when and if a concussed athlete can return to competition is made on an individual basis and will depend on:
- Athlete’s concussion history
- Severity of the injury
- Duration of signs and symptoms
- Time between injuries
- Severity of blow causing concussion
- Availability of experienced personnel to conduct repeated assessments and monitoring recovery.
Predisposition for future injury?

Risk of repeat concussion:
- Players with 3+ previous concussions $\rightarrow$ 3.5x more susceptible to incur repeat concussion
- Players with 2 previous $\rightarrow$ 2.8x (95%CI: 1.6-4.7) risk
- Players with 1 previous $\rightarrow$ 1.5x (95%CI: 1.0-2.1) risk

Recurrent Concussion risk?

- 11/12 (92%) in-season repeat concussions occurred within 10 days of the first injury
- 9/12 (75%) occurred within 7 days of the first injury
Recurrent Concussion risk?

Why risk may be greatest within 7-10 after injury
- (1) Pre-disposed due to style of play
- (2) Are some athletes more susceptible to concussion?
  - Apolipoprotein Eε4 allele
- (3) Age/level of play may expose certain athletes to greater forces than not sustaining concussion
- (4) Do players with ↑ # of concussions simply receive more playing time?
- (5) More susceptible due to inherent changes in the brain after initial concussion
  - Still symptomatic / brain not yet fully healed

Acute Concussion Management on the Sideline

- Remove from game immediately
  - NO RETURN SAME DAY
- Sideline neurologic and mental status evaluation
  - Orientation, memory, balance
- Ensure child is attended by adult at all times
  - Serial sideline reevaluation q10-15 minutes
- No medication unless Physician prescribed
- Physician evaluation next day
  - To ED if acutely worsening N/V, HA, ↓ MS
- “When in doubt….Sit them out”
Concussion-related “RED FLAGS” for acute emergency management within first 24-72 hours:

Referral to ED with sudden onset of any of the following:

- Severely worsening HA
- Repeated vomiting
- ↑ drowsiness / difficult to awaken
- Difficulty recognizing people or places
- Neck pain
- Seizures

- Increasing confusion or irritability
- Unusual behavioral change
- Focal neurologic signs
- Slurred speech
- Weakness or numbness in arms/legs
- Change in state of consciousness

Concussion Management in the ED

- Is imaging necessary?
  - Concussion = metabolic, functional disturbance -- not structural


- 69% of peds pt’s dx’d with concussion received imaging in ED
  - majority was CT
- Conc child w/ nl MS, no focal neuro abnl, no skull fx
  - As low as 0.02% risk of significant intracranial pathology

- Exposure to radiation
  - Adult vs. pediatric CT settings
  - Malignancy risk is cumulative
  - After one CT-Head  \( \rightarrow \) 1:2000 for < 2 yo child and 1:10,000 for 15 yo
Concussion Management in the ED

- Clinical Hx
- PEx including full neurologic exam, balance, gait
  - Focality? Asymmetry? Stable over time?
- Gross majority can be discharged home

**D/C instructions are key!**
- Follow-up with medical provider < 72 hrs
  - Lovell, et al., 2004 → 28% of conc peds pt’s d/c’d from ED did not receive instruction to f/u w/MD
  - Genuardi et al., 1995 → d/c instructions did not include activity restrictions of physical and cognitive rest

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Concussion Management in the ED

- Ponsford, et al., 2001
  - Reduction of post-concussion Sx’s and behavioral changes at 3 mos. post-conc if pt & family informed of expected Sx’s, varying time course for resolution, and rec’d management strategies
- ED Physician, Nurse should review “red flag” signs/symptoms suggestive of slowly evolving intracranial pathology (e.g. SDH)
- Home from school until MD follow-up is appropriate in some cases!
Concussion Management in the Office

Complete evaluation of a Concussion often involves…
- Clinical History
- Physical Evaluation
- Balance Testing
- Neuropsychological Testing
- Neuro Imaging
- Rehabilitation
- Prevention/Counseling

The RTP decision should be *individualized*, and not based on a rigid timeline

Concussion Management in the Office

Clinical history
- Immediate post-concussion
- Changes since injury
- Current status
- Always corroborate details
  - Parents, video?
- 3 Components
  - Characteristics of the injury
  - Types and severity of symptoms
  - Risk factors that can lead to a protracted period of recovery.
Clinical History

- Injury Characteristics
  - Mechanism of Injury
  - Cause
  - Post-traumatic amnesia
    - Retrograde vs. Anterograde
  - Loss of consciousness
  - Seizure

- Post-Concussion Symptom Scale scoring

### Post Concussion Symptom Scale

<table>
<thead>
<tr>
<th>Symptom</th>
<th>None</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>“Pressure in head”</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Neck Pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Balance problems/dizzy</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Nausea or vomiting</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Vision problems</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Hearing problems/ringing</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>“Don’t feel right”</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Feeling “dizzied”/“dazed”</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Confusion</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Feeling like “in a fog”</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Fatigue or low energy</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>More than emotional</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Irritability</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(follow up symptoms only)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sadness</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Nervous or anxious</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Trouble falling asleep</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sleeping more than usual</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Clinical History

- Risk Factors for prolonged recovery
  - Concussion history
    - Number, severity, time to recovery
  - Headache History
    - Migraines
  - Developmental History
    - Developmental Delay, MR
  - Psychiatric History
    - ADD/ADHD, Depression/Anxiety

Physical Examination

- HEENT
- Neck
  - C-spine, Sperling’s Maneuver
- Musculoskeletal
  - MMT, ROM
- Neurologic
  - Cranial nerves, Heel/toe, Romberg
  - 30 second balance testing +/- aerobic challenge
Cognitive Examination

Sports Concussion Assessment Tool (SCAT)
- Recall
- Numbers/months in reverse
- Serial 7’s
- Basic MMS questions

Computerized Neuropsych Testing

- Computer based testing currently available:
  -- Cogsport
  -- Headminders
  -- ANAM
  -- ImPACT

These tests have been found to be as valid as the old pencil/paper tests.

Mandated use in the NFL (2007), National Hockey League (2007), NASCAR, professional snow sports, Major League Baseball (2008), soccer and rugby leagues around the world, and over 400 NCAA colleges (even the WWF)
Computerized Neuropsychological testing for Concussion Rehabilitation

ImPACT: A Tool for Evaluating Concussion (Immediate Post-Concussion Assessment and Cognitive Testing)

- Computerized test developed by clinical researchers at the University of Pittsburgh Medical Center (UPMC)
- Developed to allow for a more objective assessment of concussion and recovery
- Accounts for individual differences in cognitive ability and symptom reporting through the use of baseline testing
- Provides a common metric which allows for effective collaboration between athletic trainers, coaches, physicians, and neuropsychologists in concussion management
- Utilized throughout professional and amateur sports across the country and internationally
WHAT DOES ImPACT MEASURE?

- Demographic/Concussion History Questionnaire
- Concussion Symptom Scale
  - 21 Item Likert scale (e.g. headache, dizziness, nausea, etc)
- Eight Neurocognitive Measures
  - Memory
  - Working Memory
  - Attention
  - Reaction Time
  - Mental Speed
  - Verbal Memory
  - Visual Memory, Reaction Time
  - Processing Speed
  - Summary Scores

ImPACT Testing

- Detailed Clinical Report
  - Automatically computer scored
  - Outlines demographic, symptom, neurocognitive data
- Repeat testing used to follow recovery from concussion
  - Return to baseline signals time to begin progressive return to play
  - Allows for safer – and possibly earlier -- return to play based upon each individual’s rate of recovery, not generalized grading scales
How Long Does It Take The Athlete To Recover from Concussion?


ImPACT Overall Injury Sample 2000-2002

- Over 4,500 athletes in baseline sample
- 410 athletes suffered concussion during season
  - Evaluated within 2 days of injury
  - Re-evaluated at days 5 and 8 post-injury
  - 243 high school, 141 college, 26 other athletes
- 272 male concussions, 138 female concussions
- Compared to 100 HS and College controls
The diagram shows the comparison of ImPACT MEMORY COMPOSITE scores between Concussed and Control athletes over time (Baseline, 2 days, 5 days, 8 days post-injury). The scores are presented as a percentage, with lower scores indicating poorer performance.

- **Baseline**: N=410
- **2 days**: N=410
- **5 days**: N=410
- **8 days**: N=410

Significant differences were observed between the groups at 2, 5, and 8 days post-injury, with p-values of <.0001, <.0001, and <.03, respectively. The N.S. (not significant) indicates that there were no significant differences at baseline.

*Significant difference between groups out to at least 8 days post-injury.*


---

The diagram also shows the comparison of ImPACT REACTION TIME COMPOSITE scores between Concussed and Control athletes over time (Baseline, 2 days, 5 days, 8 days post-injury). The scores are presented as a value on the y-axis, with higher scores indicating poorer performance.

- **Baseline**: N=410
- **2 days**: N=410
- **5 days**: N=410
- **8 days**: N=410

Significant differences were observed between the groups at 2, 5, and 8 days post-injury, with p-values of <.005, <.0004, and N.S., respectively. The N.S. (not significant) indicates that there were no significant differences at baseline.

*Significant difference between groups out to 5 days post-injury.*


*Lower score indicates poorer performance.*

*Higher score indicates poorer performance.*
Ochsner Concussion Management Program

- Focus is upon patients aged 21 years and under
- Complete evaluation/management of a Concussion
  - Clinical History
  - Physical Evaluation
    - Balance Testing
  - ImPACT testing
  - **Individualized,** Progressive RTP
    - RTP based upon persistence of symptoms
      - Physical, cognitive, emotional, sleep, etc.
    - Not a “cookie-cutter” approach using older, no longer accepted grading scales
  - Prevention/Counseling/Education
    - Communication with coaches, athletic trainers, parents, etc.

It’s not just “Return to Play”

(2) Academics

- Accommodations
  - Open book/untimed tests
  - Pre-printed class notes
  - Tutoring (Teacher or Peer)
  - Reduced workload, no double-work
  - Preferential seating
  - Reduced visual/auditory stimuli
  - Extended time for projects/assignments

- Attendance
  - Absences, Half day attendance
Ochsner Concussion Management Program

24-72 Hours
Concussion

Day 5-10

Baseline Testing
(Normative data available for decision making when baseline data not available)

Beyond (if necessary)

Ochsner Concussion Management Program
Effective Sports Concussion Program
Pre-Injury

Pre-Injury Concussion Education
Parent, athlete, Coach, ATC
Emergency Dept
Primary Care Physician
Other Medical Specialist
School Personnel
(School RN, Psychologist)

Injury Monitoring
Preseason BL Testing
Athlete Concussion Suspected
On-field evaluation ATC/MD

Evidence of concussion?
No

Early Identification
Decision

Return To Play (RTP)
Effective Sports Concussion Program
Post-Injury

Evidence of concussion?
Yes
No

Post-Injury Communication/Coordination

Decision
Parent contacted
PCP contacted
ED evaluation?

Post-Injury Clinical Evaluation (24 hours)
Neuropsychological & Balance Testing Symptoms
Comparison to "BL"

Post-Injury Clinical Evaluation (24-72 hours)
Neuropsychological & Balance Testing Symptoms
Comparison to "BL"

Management/ Treatment
Medical
Sports
Academic
Home

Yes
No

Gradual Exertional RTP Protocol (ATC)

Stage 1 Recovery? (at rest)
Initiate RTP?

Yes
No

Stage 1 Recovery? (w/ exertion)
Initiate RTP?

Yes
No

Stage 2 Recovery? (w/ exertion)
Initiate RTP?

Yes
No

Return To Play (RTP)
Ochsner Concussion Management Program

2010-11 Academic Year
- Baseline ImPACT testing for all St. Tammany Parish H.S. student-athletes
  - Coordinated by M.D. and each H.S. team’s athletic trainer
  - Part of pre-season practices
- Web-based testing allows for mass testing in school’s computer labs

2011-2012 Academic Year
- Jefferson Parish High Schools

Why Schools Should Use Neurocognitive Testing:
- Concussions are one of the most serious medical problems at the High School level
- Proper management of concussion is the best form of prevention of serious injury
- An increasing number of schools are being sued each year for concussion mismanagement
- Parents appreciate the information provided by ImPACT about their injured child
If used correctly…

**Neurocognitive testing will…**
- Help determine severity of concussion
- Provide valuable information to the athlete, parents, athletic trainers, physicians
- Provide information on academic deficits associated with concussion
- Promote safe return to play
- Reduce liability for school districts

**Will Not …**
- Prevent a concussion
- Eliminate the risk of concussion

Pharmacology

**Cognitive Sx’s**
- 1st line: Amantadine
  - Onset of action 5-7 days
- 2nd line: Methylphenidate, Straterra
  - Lower than normal doses

**Sleep Disturbances**
- 1st line: Melatonin
- 2nd line: Trazadone, Rozarem
- 3rd line: Ambien

**Emotional Lability**
- SSRI’s
- Psychotherapy

**Somatic Sx’s (e.g. HA)**
- PT, Modalities, Trigger point injections
- NSAID’s – limited use 2° to rebound
- Elavil, Verapamil, Beta-Blockers (propanolol)
- Topamax, Keppra
EFFORTS TO IMPROVE
MANAGEMENT OF CONCUSSIONS

- Research scientific data on head injuries
  - Incidence
  - Causes
  - Opportunities for reeducation
- *Educate coaches, athletes, & parents*
- *Educate the medical community*
- Focus on safe Return to Play decisions
- Research new techniques to prevent, evaluate, and manage concussions

Future Endeavors in the Management of Sports-Related Concussion

- Gender studies
- More pediatric-specific injury/management paradigms
- Virtual Reality tools for assessment/rehab
- Rehabilitation strategies (role for exercise therapy?)
- New imaging modalities (fMRI?)
- Prospective/retrospective studies (ImPACT database)
  - On-field injury severity predictors
  - Long-term outcomes
  - “Best practices” Neuropsychological testing
- State legislation for Concussion Management
Louisiana Youth Concussion Act

LA Senate bill 189 passed June 29, 2011
- Sponsored by Sen. Sheri Cheeks, Shreveport, LA
- 25th State with Concussion Law on the books
  - 1st in the Deep South
Louisiana Youth Concussion Coalition
- Work began on bill early April, 2011
- 3 Physicians
  - 2 PM&R, 1 NSurg
  - LSU MPH grad student
- New Orleans Saints
  - Michael Lewis, Fred McAfee
- NFL
  - Provided counsel, legal aide
- LSU Football
- BIALA

Louisiana Youth Concussion Act, 2011

(1) Any player suspected of a concussion removed from game or practice
(2) Player required to have written medical clearance from a medical professional, preferably trained in the management of concussion
  - MD, DO, NP, PA, or Neuropsychologist
(3) Annual education requirement for public/private schools and recreational sports leagues/clubs
  - Annual concussion course completion (e.g., CDC “Head’s Up” course)
    - Coaches, volunteers, officials
Louisiana Youth Concussion Act

Summary

- Concussion is a functional injury to the brain
  - LOC is not required to have a concussion
- Children ARE different!
- Initial, prompt recognition is key
- Rest, Rest, Rest – Physical AND Cognitive
  - It is unsafe to return to play while symptomatic
  - Serial exams until asymptomatic
- Progressive RTP is key
- Role for computerized neuropsych testing aids RTP
- “When in doubt, sit them out.”
Concussion Resources

- www.headinjury.com
- www.hockeycanada.ca
- www.impacttest.com
- www.cogsport.com
- Summary Statement of the 4th International Conference on Concussion in Sport held in Zurich, November, 2012

CDC “Heads Up: Concussion” program
www.cdc.gov/concussion/HeadsUp
Concussion Resources

- [www.thinkfirst.ca](http://www.thinkfirst.ca): Concussion management package available online for primary care providers
  - Acute Concussion Evaluation (ACE) Care Plan – Work Version
  - Acute Concussion Evaluation (ACE) Care Plan – School Version

Questions?

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