Concussion in Children and Adolescents

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Relevance

- 60% managed by primary care physician
- 10% managed by specialist
- 94% managed by athletic trainer


Definition

- Direct blow to any body part with an “impulsive” force transmitted to the head
- Rapid onset (can evolve) of short-lived impairment of neurologic function that resolves spontaneously
- Functional disturbance rather than structural injury
- Range of clinical signs and symptoms +/- LOC
- Resolution of features typically follows a sequential course
- NOTE: no grading levels


Pathophysiology

- Neuronal depolarization
  - Open sodium/potassium channel
  - Neurons cannot fire
- Local lactic acid accumulation
  - Increased ATP demand to restore Na-K pump
- Decreased cerebral blood flow with mismatch of cerebral glucose supply and demand
  - Days to weeks
  - Cognitive dysfunction and symptoms


Epidemiology

- Lifetime prevalence of 20%
- 3.8 million sport-related TBI annually
- Sports: collision sports
- Recreational: bike, ski, skate board, ice skate
- MVC

Sideline: Transfer to ED

- Prolonged loss of consciousness (eg. over one minute)
- Concern for a cervical spine injury
- High risk for intracranial bleed
- Examination findings suggestive of skull fracture
- Post-traumatic seizure
- Significant acute worsening of the patient's condition

ED Assessment

- Presence of multiple trauma (ATLS)
- Cervical spine assessment (NEXUS)
- Risk for intracranial injury (PECARN)

C Spine Clearance: NEXUS

Brain CT scan criteria: PECARN

Diagnosis

- Trauma with rapid linear and/or rotational acceleration of the brain
- Onset of signs and symptoms of concussion soon after injury
- Standardized assessments
  - Balance assessment
  - Neurocognitive function (compared to baseline performance)
- Exclusion of structural intracranial injuries
- Exclusion of other medical diagnoses with similar features
Balance Error Scoring System

**TABLE 1**
Balance Error Scoring System (BESS)

<table>
<thead>
<tr>
<th>Scoring Errors</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Swaying from side to side</td>
<td>1</td>
</tr>
<tr>
<td>2. Swinging from side to side</td>
<td>1</td>
</tr>
<tr>
<td>3. Hip rotation or lean</td>
<td>1</td>
</tr>
<tr>
<td>4. Eye opening or closing</td>
<td>1</td>
</tr>
<tr>
<td>5. Stumbling or falling</td>
<td>2</td>
</tr>
</tbody>
</table>

**Differential Dx: Acute Conditions**
- Intracranial injury
- Heat illness
- Hypoglycemia
- Dehydration
- Syncope

**Differential Dx: Chronic Conditions**
- Primary headache
  - Migraine headache
  - Tension-type headache
  - Cluster headache
- Psychiatric disorder
  - Sleep disruption
  - Irritability
  - Change in appetite
  - Change in body weight
  - Depressed mood
- Overtraining/burnout
- Malingering
- Uncorrected vision

**Management: Data**
- Observational studies in high school and college athletes
- Clinical experience
- Consensus guidelines
- Limited evidence for management in children under 12 yr old
Prevent Additional Injury
- Remove from further competition that day
- Avoid risky recreational activities
- Avoid pressure from friends, coaches, family
- Neurocognitive rest/social media
- Not return until full recovery is evident
- Avoid deconditioning and social isolation

Second Impact Syndrome
- Additional injury even with low energy collisions
- Case series 94 patients (Boden)
  - 42% had sustained previous head injury same season
  - 40% playing with residual neurologic symptoms
  - 9% of patients died
- Observational study over 10 years (Kucera)
  - 422 players who died had concussion within past 4 weeks
  - 3-4 deaths second impact syndrome

Physical Rest
- Brief period of physical rest (24-48 hrs)
- Gradual and progressive return to non-contact non-risk physical activity (no strict rest) until symptoms resolve
- Rapid return to vigorous exertion exacerbates symptoms
- 2400 children, 5-18 yrs old
  - 70% physical activity within 7 days
  - 30% full physical rest
  - 20% to 40% persistent postconcussive symptoms at day 28

Cognitive Rest: Symptoms Worsened By Cognitive Effort
- Typically 1-2 days cognitive rest before return to school
- Avoid all mental activity that makes them feel worse
- Limit social visits in and out of home and trips
- May engage in light mental activities
- Return to school when tolerating 30-45 minutes of concentration
- Return to school after a maximum of 5 days rest

Cognitive Rest: Asymptomatic
- Avoid
  - Video games
  - Loud music
  - Prolonged screen time
  - Mental activities requiring high levels of focus and concentration
  - Standardized tests
- These patients continue to attend school
  - Rest breaks in nurse office or reduced class time

Cognitive Rest
- Avoid overtaxing a functionally injured brain
- Prevent metabolic overload
- 395 athletes age 8-23 yrs
  - Highest degree of cognitive activity took the longest time to recover
- 72 students
  - Cognitive “overexertion” associated with worsening symptoms
- 49 high school and college athletes
  - One week of cognitive and physical rest 1-30 days after concussion decreased postconcussive symptoms

Avoid Prolonged Cognitive Rest

- Prolonged rest with absence from school may be harmful
- 99 patients 11-22 years
  - One group strict cognitive rest for 5 days
  - Other group 1-2 days rest followed by gradual return
  - Significantly more daily postconcussive symptoms during 10 days of follow up
  - No difference in neurocognitive or balance outcomes

Symptom Management

Headache

- Acetaminophen and NSAIDs first few days
- Prolonged use discouraged (rebound, ineffective)
- Prior migraine triggered by CHI
- Prolonged: cervicogenic; refer to PT
- Nonpharmacologic therapy: biofeedback, psychotherapy
- Not justification for absence from school
- Should not return to play until headache resolves

Sleep Disturbance

- Melatonin
  - School age children: 3mg
  - Adolescent: 6mg
- Trazodone
  - Limited experience with children
  - Morning hangover and suppresses REM
- Benzodiazepine: avoid

Avoid Prolonged Cognitive Rest


Symptoms of concussion recorded by the High School School Reporting Information (Ohio Injury Surveillance System [OHISS])

<table>
<thead>
<tr>
<th>Symptom recorded</th>
<th>No. of concussion resulting in symptoms</th>
<th>Percentage of concussion resulting in symptoms*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>623</td>
<td>60</td>
</tr>
<tr>
<td>Emotional lability</td>
<td>658</td>
<td>61</td>
</tr>
<tr>
<td>Difficulty focusing</td>
<td>346</td>
<td>37</td>
</tr>
<tr>
<td>Confusion/Deorientation</td>
<td>250</td>
<td>26</td>
</tr>
<tr>
<td>Vision changes/lightheadedness</td>
<td>204</td>
<td>20</td>
</tr>
<tr>
<td>Nausea</td>
<td>127</td>
<td>13</td>
</tr>
<tr>
<td>Dizziness</td>
<td>96</td>
<td>9</td>
</tr>
<tr>
<td>Anorexia</td>
<td>129</td>
<td>12</td>
</tr>
<tr>
<td>Insomnia</td>
<td>103</td>
<td>10</td>
</tr>
<tr>
<td>Tinnitus</td>
<td>58</td>
<td>6</td>
</tr>
<tr>
<td>Inability</td>
<td>58</td>
<td>6</td>
</tr>
<tr>
<td>Loss of consciousness</td>
<td>38</td>
<td>3.5</td>
</tr>
<tr>
<td>Fatigue</td>
<td>89</td>
<td>8.5</td>
</tr>
</tbody>
</table>

* Percentages do not total 100%, as children could present with more than 1 symptom.


Sleep Disturbance

Healthy sleep practices for children

1. Bedtime and wake up times should be about the same on school nights and non-school nights. There should not be more than 1 hour difference from one day to another.
2. Establish a routine: for example, go to bed, get up, shower, etc.
3. Avoid screen time in the hour before bedtime.
4. Avoid caffeine and spicy foods before bedtime.
5. Use a sleep diary and keep track of sleep habits.
6. Use bed rests in cases of sinusitis, allergies, or asthma.
7. Keep a consistent sleeping environment: temperature, fan, etc.
8. Use a sleep schedule: go to bed and wake up at the same time every day.
9. Avoid napping during the day.
10. Use a reflective approach to bedtime.

Other Symptoms

- **Nausea**
  - Odansetron first 2 days
  - Avoid Phenothiazine antiemetics (drowsiness, orthostasis, dystonic reaction)

- **Dizziness**
  - Physical and cognitive rest
  - PT may help

- **Worsening symptoms**
  - Physical and cognitive rest
  - Neuroimaging

Persistent Symptoms (> 4 weeks)

- 49 children 11-17 years old
- Collaborative treatment
  - Cognitive-behavioral therapy
  - Psychopharmacologic consultation
  - Symptom reduction at 6 month
  - 87% vs 58% without high level post concussive symptoms
  - 78% vs 46% with reduction in depression symptoms

Persistent Symptoms

- **Sleep disruption**
  - Sleep hygiene

- **Vestibular symptoms**
  - Balance problems, dizziness, blurred vision
  - PT may benefit

- **Psychological or emotional symptoms**
  - Irritability, sadness, anxiety, emotional lability
  - Light sub-symptom threshold aerobic exercise
  - Psychologic assessment and counseling
  - Antidepressant by psychiatrist if prolonged

- **Cognitive symptoms**
  - Confusion, feeling in a fog, difficulty remembering, concentrating
  - Attention to somatic, vestibular, sleep, psychologic symptoms improves

Pharmacotherapy

- Symptoms exceed the typical recovery period
- Symptoms are negatively affecting the patient’s quality of life
- Clinician knowledgeable in assessment and management of concussion

Return to Learn

- Can concentrate on a task 30-45 minutes
- **Academic adjustments**
  - Limited course load
  - Shortened classes or school day
  - Increased rest time
  - Aids for learning
  - Postponement of high-stakes testing
- **Academic accommodations**
  - Individualized education plan

Indications for Subspecialty Referral

- Persistent symptoms of concussion (> 10 days)
- Patients with multiple concussions occurring with progressively less for and/or associated with more intense symptoms
- Uncertain diagnosis of concussion


McGraft N. Supporting the student athlete's return to the classroom after a sport-related concussion. J Athl Train 2012; 48:60.
Return to Play

- Successful return to school
- Symptom free and off medications
- Normal neurologic examination
- Baseline balance and cognitive performance

Graduated Return to Play

- No less than 24 hours at each step
- Minimum of 5 days before return to full play
- If return of symptoms, rest, then start at previous level
- Progressive Stages:
  - Light aerobic exercise
  - More intensive training
  - Sports-specific exercises
  - Non-contact participation
  - Full practice
  - Game play


Retirement from Contact Sports

- Are concussions occurring with progressively less force?
- Are the symptoms experienced after concussion of increasing intensity?
- Is the cognitive dysfunction experienced after a concussion becoming more severe?
- Is the duration of recovery progressively increasing?
- Is the sport and position high-risk?

Prognosis

- 90% high school athletes are symptom-free and cleared for play within one month of injury
- Prolongation of symptoms
  - Strenuous cognitive and physical exertion early on
- Second impact syndrome
  - Recover to collision sports while still in recovery
- Chronic Traumatic Encephalopathy
  - Permanent changes in mood, behavior, cognition, somatic symptoms
  - Severe: dementia, Alzheimer disease

John Urschel
Baltimore Ravens
3 yrs in NFL
2017

Prevention

- Education
  - 167 HS athletes: 60% did not disclose concussion symptoms
  - 204 HS athletes: < 50% reported concussion
- Age limits
  - Body checking, 1500 hockey players age 11-12
  - Concussion decreased by 64%
  - No difference between tackle football and flag football
- Fair play
