Pediatric Concussion:
A Multidisciplinary Approach

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Presentation Objectives

• Define concussion
• Understand the symptoms and evaluation of symptoms typically seen throughout the recovery process
• Outline the systematic approach to active management of concussions including tests and treatment
• Understand the components of Return-to-learn and Return-to-play protocols

Concussion

Concussion is a traumatic brain injury!

The pathophysiological definition of a concussion is: “A complex process that affects the brain, which is induced by traumatic biomechanical forces, that includes major features such as the sodium and potassium pump imbalance.”
Pathophysiology of Concussions

- Neuron: electrically excitable cell that processes and transmits information through electrical and chemical signals
- Axon: slender projection of a nerve that conducts electrical impulses away from a neuron
- Synapse: junction at which neurons communicate

Pathophysiology Continued

- Linear and rotational forces acting on brain
- Deformation of tissues occurs where white and grey matter move at different rates
- Axonal shearing occurs which causes abnormal firing and leaves neurons weak and swollen
- Damage can continue over a matter of days

Pathophysiology Continued

- Resulting in disruption of neuronal membranes resulting in potassium efflux and release of glutamate
- Resulting in depolarization and suppression of neuronal activity
- Associated impaired Na-K pump activity resulting in excessive ATP consumption and glucose utilization, resulting in lactate accumulation and cerebral blood flow decrease, resulting in an “energy crisis,” accumulation of cellular calcium and death
- Subsequent hypometabolic state persisting up to 4 weeks
Chronic Traumatic Encephalopathy (CTE)

- Diagnosis can only be made post-mortem
- Characterized by abnormal accumulation of tau proteins in the brain

CTE

- Clinical symptoms:
  - Behavioral: Emotionally explosive, impulsivity, paranoia
  - Mood: Overly sad/depressed, anxiety, apathy
  - Cognitive: Impaired neuropsych testing
  - Motor: Tremor, headache, unsteady gait, bradykinesia
- Cause and effect relationship between CTE and concussions has not yet been demonstrated
- The extent of other contributors to CTE has not yet been determined in published literature
  - Age-related changes, co-existing medical illness, alcohol/drug use, psychiatric or mental illness

Clinical Features of Concussions

<table>
<thead>
<tr>
<th>PHYSICAL</th>
<th>COGNITIVE</th>
<th>EMOTIONAL</th>
<th>SLEEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>Feeling Mentally Foggy</td>
<td>Irritability</td>
<td>Drowsiness</td>
</tr>
<tr>
<td>Nausea</td>
<td>Feeling Stressed</td>
<td>Sadness</td>
<td>Sleeping More than Usual</td>
</tr>
<tr>
<td>Vomiting</td>
<td>Difficulty Concentrating</td>
<td>More Emotional</td>
<td>Difficulty Falling Asleep</td>
</tr>
<tr>
<td>Balance Problems</td>
<td>Difficulty Remembering</td>
<td>Nervousness</td>
<td></td>
</tr>
<tr>
<td>Visual Problems</td>
<td>Confused About Events</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatigue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity to Light</td>
<td>Answering Questions Slowly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity to Noise</td>
<td>Repeating Questions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dazed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slurred</td>
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</tbody>
</table>
Symptom Resolution

- Average day of symptom resolution:
  - 15 days - 25%
  - 26 days - 50%
  - 45 days - 75%
  - 92 days - 90%

- Symptom resolution does not directly correlate with performance on neuro-cognitive testing and vice versa

Recognition of Concussions

- Factors that may complicate the recognition of concussions
  - Athlete may not recognize he/she has concussive signs and symptoms
  - Symptoms may not appear until several hours or even days after concussive episode
  - Athlete may not be forthcoming he/she is experiencing concussive symptoms
  - Does not need to be a loss of consciousness to be a concussion

Rates in High School Sports

<table>
<thead>
<tr>
<th>SPORT</th>
<th>INJURY RATE/1000 ATHLETE EXPOSURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Football</td>
<td>0.47–1.03</td>
</tr>
<tr>
<td>Girls’ Soccer</td>
<td>0.36</td>
</tr>
<tr>
<td>Boys’ Lacrosse</td>
<td>0.28–0.34</td>
</tr>
<tr>
<td>Boys’ Soccer</td>
<td>0.32</td>
</tr>
<tr>
<td>Girls’ Basketball</td>
<td>0.21</td>
</tr>
<tr>
<td>Wrestling</td>
<td>0.18</td>
</tr>
<tr>
<td>Girls’ Lacrosse</td>
<td>0.10–0.21</td>
</tr>
<tr>
<td>Softball</td>
<td>0.07</td>
</tr>
<tr>
<td>Boys’ Basketball</td>
<td>0.07</td>
</tr>
<tr>
<td>Boys’ &amp; Girls’ Volleyball</td>
<td>0.05</td>
</tr>
<tr>
<td>Baseball</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Iowa Law 280.13C

- Iowa Law regarding concussion management pertains to school sports only
  - Does not include club teams
- All schools must distribute concussion information to athletes and parents prior to any participation
- All coaches, officials, athletes, parents, health care providers must receive education about concussions
  - IHSAA and IGHSAU websites include materials
- Student athletes must be immediately removed from play if exhibiting concussion symptoms
  - Cannot return until “evaluated and cleared to play by a licensed health care provider trained in the evaluation and management in concussions and other brain injuries”
  - If suspected concussion, child should not return to competition/practice that day

Leading Cause of Non-fatal TBI

- Youth under age 19
  - Bicycling
  - Football
  - Playground
  - Basketball
  - Soccer
  - Baseball
  - ATV

Systematic Management

1. Field/Sidelines
   - Removal from play
   - Field Assessment
   - Emergency management
2. Acute
   - Physician Monitoring
   - CT Scan
3. Post-Injury
   - Home rest
   - Limited mental and physical activity
   - Neurocognitive Testing
   - Referral to concussion clinic
   - SLP/PT/OT
On the Field/Sideline

1. Medically stabilize the child and rule out a spinal cord injury
2. Perform a sideline concussion assessment tool and medical examination to assess whether a concussion is suspected
3. Remove from play immediately if there are any suspicion of injury and continue to monitor on the sideline
4. Triage child for follow-up management
   - Emergency department or primary care provider

Indications for Urgent Care/ED

- Repeat vomiting
- Unilateral Pupil diameter change
- Severe or progressive worsening headache
- Seizure activity
- Unsteady gait or slurred speech
- Weakness or numbness in extremities
- Unusual behavior
- Altered mental status resulting in GCS < 15

Second Impact Syndrome

- Rare condition in which a second concussion occurs before a first concussion has properly healed
  - Impact needs to be severe for second impact syndrome to occur
- Can be within a matter of days or weeks or it can occur in the same day if individual is not properly treated after the first concussion
- Brain loses the ability to auto regulate intracranial and cerebral perfusion pressure
  - Resulting in:
    - Cerebral edema and possible brain herniation.
    - Loss of consciousness after the concussive event followed by secondary brain damage which creates ionic fluxes, acute metabolic changes, and cerebral blood flow alterations.
- All of these characteristics enhance the vulnerability of the brain and greatly increase the risk of death.
Second Impact Syndrome

• Symptoms:
  – Dilated pupils
  – Loss of eye movement
  – Unconsciousness
  – Respiratory failure
  – Death

• Symptoms usually occur immediately following the second impact and progress rapidly

• Populations at Risk for Second Impact Syndrome
  – Anyone who has suffered an initial concussion
  – Athletes especially in sports such as boxing, baseball, football, hockey, and skiing.

Second Impact Syndrome

• Prognosis
  – In many cases it is often fatal
  – True second impact syndrome involves brain herniation and death usually within minutes
  – A patient suspected of suffering from second impact syndrome should immediately be:
    • Stabilized with special emphasis on airway management
    • Consultation with neurosurgery
  – When not fatal, long-term effects will likely be similar to those of severe traumatic brain injury

Second Impact Syndrome

If there are any doubts about whether the person is suffering from the effects of the concussion or are demonstrating concussion like symptoms, it’s crucial to keep them out of situations that could lead to another concussion resulting in second impact syndrome.
Systematic Management

1. Field/Sidelines
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Acute Care

• Triage to Emergency Department
  - CT Scan
  - Neurological examination
  - Hydration
  - Monitor for emesis
  - Monitor for seizures

Indications for Imaging

Suspicion of intracranial structural injury
  - Severe headache
  - Seizures
  - Focal neurological findings
  - Repeat vomiting
  - Significant drowsiness or difficulty awakening
  - Slurred speech
  - Poor orientation to person, place, or time
  - Significant irritability
  - Neck pain
  - LOC greater than 30 seconds
Systematic Management

1. Field/Sidelines
   - Removal from play
   - Field Assessment
   - Emergency management

2. Acute
   - Physician Monitoring
   - CT Scan

3. Post-Injury
   - Refer on to appropriate healthcare professionals
   - Home rest
   - Light mental and physical activity

Why Refer?

- Manage symptoms
- Prevent acute and chronic complications
- Monitor medications
- Reassurance and guidance of family/caregivers, school, teachers, coaches, and peers.
- Reintegration into academics, work, physical activity, driving, and sports.

Where to Initially Refer?

- Healthcare professionals trained in concussion management
  - I.E. specialized concussion program
- Physical Therapy for balance, coordination, vestibular assessment.
- Occupational Therapy for vestibular and ocular evaluation.
- Speech and Language Therapy for executive functioning tasks and compensatory techniques
ChildServe Concussion Clinic

- **Physician Services**
  - Physical Exam
  - Neuro Exam
  - SCAT 3
  - ImPACT

- **Therapy Services**
  - Vestibular Ocular
  - Ocular Motor
  - Balance and Coordination
  - Physical Conditioning
  - Cognitive

- **Multidisciplinary Team**
  - Return to academics
  - Return to play/activity
  - Education
  - Prevention
  - Collaboration
  - Support
  - Accommodations

- **Community**
  - Education
  - Accommodations
  - Prevention
  - Collaboration
  - Support

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**ChildServe Concussion Clinic**


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**Evaluation and Ongoing Treatment**

- Individualized goals dependent on observed deficits impacting return to learn and return to play/activity
- Generally recommend 1-2 times per week
- 30-60 minute sessions
- Neurocognitive testing for comparison with baseline (ImPACT)
- Vestibular ocular assessment
- Physical conditioning
  - Heart rate max progression
  - Head below heart activity
  - Sports or activity specific training
- Referral back to physician services for clearance back to full return
Ongoing Treatment and Therapy

- Ocular Motor Assessment
  - Smooth Pursuits
  - Horizontal and Vertical Saccades
  - Convergence
  - Divergence
  - Horizontal Visual Ocular Reflex (VOR)
  - Vertical Visual Ocular Reflex (VOR)
  - Visual Motion Sensitivity (VMS)
  - Visual Scanning
  - Anti-saccades

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Ongoing Treatment and Therapy

- Vestibular Ocular Assessment
  - Using ocular system separate from vestibular system
    - Peripheral vision
    - Central vision
  - Use ocular system with vestibular system
    - Maintain visual fixation while moving head
    - Coordinate eye and head movement together
  - Vestibular assessment

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Ongoing Treatment and Therapy

- Balance and Coordination
  - Static balance
    - Eyes open/eyes closed
  - Dynamic balance
    - Eyes open/eyes closed
    - Crossing midline
  - Vestibular system activation
Ongoing Treatment and Therapy

- Physical Conditioning
  - Progressing heart rate to maximal exertion
  - Head below heart activity
  - Impact related endurance training
    - Jogging/running
    - Jumping
  - Resistance training
  - Sport or activity specific training
    - Strengthening
    - Speed
    - Agility

- Cognitive Linguistic Assessment
  - Orientation
  - Immediate recall
  - Concentration
  - Executive functioning
  - Short term memory
  - Long term memory
  - Cognitive strategies for functional use

Additional Referrals

- Vision
  - Optometrist
  - Developmental Optometrist
  - Ophthalmologist
- Manual Intervention
  - Osteopathic manual medicine (OMM)
  - Chiropractic care
  - Craniosacral
  - Massage
  - Physical Therapy
- Nutrition coaching
- Neuropsychology or psychology
- Neurology
- Cardiology
The objective of return-to-academics is to provide the child, family, school, and teachers with progressive academic guidance and recommendations.

<table>
<thead>
<tr>
<th>STATE</th>
<th>PLACE</th>
<th>MODIFICATION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOME</td>
<td>Cognitive Rest</td>
<td>Light monotonic physical activity, no threats, limited or no sleep disturbances, complete healing form (pains, social needs, homework), no prolonged anxiolysis, no ulcer, no gastrointestinal symptoms, no anticoagulation therapy, no mental or behavioral problems. Prolonged psychosis, formal programs for learning support will be recommended.</td>
<td></td>
</tr>
<tr>
<td>SCHOOLS (Part Time)</td>
<td>Moderate accommodations, shortened dual schedule, half to breaks</td>
<td>Provides partial accommodation that may include: Education, social, and emotional needs, Focused activities, Social skills, and academic support. Modified accommodations (see attached recommendations).</td>
<td></td>
</tr>
<tr>
<td>SCHOOLS (Full Time)</td>
<td>Minimal accommodations, shortened dual schedule, built in breaks as needed</td>
<td>No standardized testing. Limited social interaction, limited group settings, limited cognitive demands, limited physical demands, limited emotional demands, limited social interaction, limited group settings, limited cognitive demands, limited physical demands, limited emotional demands.</td>
<td></td>
</tr>
<tr>
<td>SCHOOLS (Sexts)</td>
<td>Moderate accommodations, built in breaks as needed</td>
<td>No standardized testing. Limited social interaction, limited group settings, limited cognitive demands, limited physical demands, limited emotional demands.</td>
<td></td>
</tr>
<tr>
<td>SCHOOLS (2X)</td>
<td>Minimal accommodations</td>
<td>No standardized testing. Limited social interaction, limited group settings, limited cognitive demands, limited physical demands, limited emotional demands.</td>
<td></td>
</tr>
</tbody>
</table>

Return-to-Play/Activity

The objective of return-to-play is to provide the child, family, school, and coaches with progressive activity guidance and recommendations.
**Post-Concussion Syndrome**

- 3-month duration or more of concussion related symptoms
- **Causes**
  - Symptoms are caused by structural damage to the brain or disruption of neurotransmitter systems
  - Symptoms are related to psychological factors, especially since the most common symptoms — headache, dizziness and sleep problems — are similar to those often experienced by people diagnosed with depression, anxiety or post-traumatic stress disorder.
- **Diagnosis**
  - No tests available
  - Made by prolonged presence of symptoms and the affects on daily functioning

**Post-Concussion Syndrome**

- **Treatment**
  - Continue with therapies as recommended
  - Initiate discussions for long term accommodations
    - 504 Plan
    - IEP
    - Work
- **Other referrals if necessary**
  - Psychologist
  - Psychiatrist
  - Counselor
  - Neurology
  - Neuropsychology testing
  - Cardiology
  - Nutrition counseling
How many is too many?

• No evidenced-based guidelines
• Each situation needs to be evaluated on an individual basis
• Modifying factors to consider:
  – Multiple lifetime concussions
  – Structural abnormality on imaging
  – Persistent decreased academic or workplace performance
  – History of prolonged recovery with past concussions
  – Post-concussive syndrome

Prevention

• Equipment will **NOT** prevent a concussion
• Safe techniques
• Enforcement of rules or rule changes/Legislation
• Preseason baseline testing
• Education!

Presentation Objectives

• Define concussion
• Understand the symptoms and evaluation of symptoms typically seen throughout the recovery process
• Outline the systematic approach to active management of concussions including tests and treatment
• Understand the components of Return-to-learn and Return-to-play protocols
Resources

- http://www.cdc.gov/traumaticbraininjury/get_the_facts.html
- CDC HEADS UP http://www.cdc.gov/headsup/youthsports/
- American Academy of Pediatrics, Clinical Reports on Sports Concussion in Children; Sept, 2010
- Consensus statement in British Journal of Medicine http://bpsm.bmj.com/content/47/5/250.full.pdf+html
- http://sportsconcussion.bianj.org/
- http://momsteam.com/
- REAP program developed at Rocky Mountain Hospital in Colorado http://rockymountainhospitalforchildren.com/service/concussion-management-reap-guidelines

References