Active Rehabilitation for Concussion Management

Presentation Objectives

- Review of the pathophysiology of a concussion
- Overview of epidemiology, Iowa law, and best practice standards
- Discuss acute post-injury management
- Highlight the importance of immediate evaluation and symptom management
- Review the latest evidence that support active rehabilitation
- Discuss graduated return to learn and return to play protocols

Defining Concussion

Traumatic brain injury (mTBI) induced by biomechanical forces and a pathophysiological process affecting the brain

- Direct or indirect blow to any part of body
- Acute rapid onset of symptoms due to neurologic impairment
- Neuropathological changes that present primarily as functional disturbances
- Absence of structural lesions on traditional neuroimaging
- Range of symptoms that follow a sequential course
Pathophysiology

- Linear and rotational forces acting on brain
- Sudden stretching of the neuronal and axonal membranes causes mass disruption of ion channels
- Damage can continue over a matter of days

Signoretti, S. et al, 2011

“Energy Crisis”

Neurometabolic Cascade Following Traumatic Brain Injury (Giza & Howard, 2007)

Post-concussive Brain Vulnerability

Energy Crisis Window of Vulnerability Second Impact

Signoretti et al, 2011
Epidemiology

• 2005-2009 more than 2 million outpatient visits and almost 3 million ED visits for mTBI in children
• ED visits and hospitalizations for TBI related events have increased
• 82% of youth concussions diagnosed in primary care setting
• 14-18 year olds represent about half of children dx with concussion
• Younger children and those with medicaid tend to seek initial care in ED.

TBI in Youth

• Most common causes of ED visits for TBI in youth:
  • < 10: playground accidents and falls
  • 10-19 years boys: football and biking
  • 10-19 years girls: soccer and biking
  • 15-24: MVC

Rate of Occurrence

<table>
<thead>
<tr>
<th>Sport</th>
<th>Rate per 10,000 AES</th>
<th>Sport</th>
<th>Rate per 10,000 AES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Football</td>
<td>6.4</td>
<td>Boys’ Basketball</td>
<td>1.6</td>
</tr>
<tr>
<td>Boys’ Ice Hockey</td>
<td>5.4</td>
<td>Girls’ Softball</td>
<td>1.6</td>
</tr>
<tr>
<td>Boys’ Lacrosse</td>
<td>4.0</td>
<td>Cheerleading</td>
<td>1.4</td>
</tr>
<tr>
<td>Girls’ Lacrosse</td>
<td>3.5</td>
<td>Girls’ Gymnastics</td>
<td>0.7</td>
</tr>
<tr>
<td>Girls’ Soccer</td>
<td>3.4</td>
<td>Girls’ Volleyball</td>
<td>0.6</td>
</tr>
<tr>
<td>Boy’s Wrestling</td>
<td>2.2</td>
<td>Boys’ Baseball</td>
<td>0.5</td>
</tr>
<tr>
<td>Girls’ Field Hockey</td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girl’s Basketball</td>
<td>2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys’ Soccer</td>
<td>1.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Occurrence by Level of Contact

<table>
<thead>
<tr>
<th>Contact</th>
<th>Limited Contact</th>
<th>No Contact</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Football</td>
<td>Cheerleading</td>
<td>Swimming</td>
<td>Playing</td>
</tr>
<tr>
<td>Soccer</td>
<td>Baseball</td>
<td>Dancing</td>
<td>Gym Class</td>
</tr>
<tr>
<td>Basketball</td>
<td>Volleyball</td>
<td>Swinging</td>
<td>Playground</td>
</tr>
<tr>
<td>Ice Hockey</td>
<td>Bike riding</td>
<td>Monkey bars</td>
<td>Recess</td>
</tr>
<tr>
<td>Lacrosse</td>
<td>Softball</td>
<td>Track</td>
<td>Other</td>
</tr>
</tbody>
</table>

Haarburger-Krupa et al. 2018

### Signs and Symptoms

#### Acute
- Headache
- Dizziness
- Nausea
- Vomiting
- Dazed/Stunned
- Confused
- Paresthesia
- Amnesia

#### Post acute
- Balance problems
- Visual problems
- Light sensitivity
- Noise sensitivity
- Emotional changes
- Sleep disturbances
- Cognitive changes

### Signs and Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Time of Injury, n (%)</th>
<th>1 Month Postinjury, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>32 (96.7)</td>
<td>16 (48.5)</td>
</tr>
<tr>
<td>Nausea</td>
<td>25 (75.8)</td>
<td>12 (36.4)</td>
</tr>
<tr>
<td>Balance problems</td>
<td>26 (78.8)</td>
<td>12 (36.4)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>30 (96.9)</td>
<td>11 (33.3)</td>
</tr>
<tr>
<td>Fatigue</td>
<td>32 (97.0)</td>
<td>17 (51.5)</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>29 (87.9)</td>
<td>11 (33.3)</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>29 (84.8)</td>
<td>12 (36.4)</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>20 (60.6)</td>
<td>11 (33.3)</td>
</tr>
<tr>
<td>Irritability</td>
<td>10 (54.5)</td>
<td>7 (33.3)</td>
</tr>
<tr>
<td>Slowness</td>
<td>11 (33.3)</td>
<td>4 (12.1)</td>
</tr>
<tr>
<td>Nervousness</td>
<td>12 (35.3)</td>
<td>8 (24.2)</td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>30 (96.9)</td>
<td>16 (50.0)</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>23 (68.7)</td>
<td>11 (33.3)</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>15 (45.5)</td>
<td>7 (24.1)</td>
</tr>
<tr>
<td>Visual problems</td>
<td>19 (57.6)</td>
<td>3 (9.09)</td>
</tr>
</tbody>
</table>

Ruchfort et al., 2017
Symptom Resolution

• Adults: 10-14 days
• Children (13-18 years): 4-6 weeks
• Generally have favorable outcome
• 70-80% of times symptoms resolve 1-3 months
• 10-30% of time symptoms > 3 months
• Severity of initial symptoms = longer recovery
• Low level symptoms = quicker recovery
• Physiological dysfunction > clinical measures

Post Concussion Goals

• Healthy child
• Successful return to learn (RTL)
• Safe return to play (RTP)
• Prevention of second injury

Concussion Challenges

• Recognition difficult
• Post injury physical examination typical
• Recovery road individualized
• Comorbid conditions complicate recovery
• Until recently no clinical practice guidelines
• Lack of expertise in clinical setting
• Lack of RTP protocols
### Iowa Code 280.13C HF 2442

- School sports
- Grades 7-12 only
- Distribution of concussion information to families
- Staff annual education about concussions
  - (IHSAA and IGHSAU websites)
- Immediate removal from play
- No return to play that day
- Written clearance by LHCP
- EMCP added
- Required adoption of RTL and RTP
- Limited liability for schools who follow RTP protocols.

### Best Practice

![BJSM](image-url)

5th International Consensus Conference on Concussion in Sport
Part 1: Consensus statement, tools and 4 systematic reviews
Editors: Paul McCrory, Willem Meeuwisse, Jill Dvorak & Lars Engberg

### Best Practice

![Concussion Management Guidelines](image-url)

Concussion Management Guidelines for Iowa Schools
Best Practice

- School sports only
- Grades 7-12 only
- Annual Concussion information to families
- Staff education
- Immediate removal from play
- No return to play that day
- Written clearance by LHCP
- RTL before RTP

Best Practice

- ALL sports
- ALL ages
- Concussion education in school
- Monitoring and no driving
- LHCP evaluation < 24 hrs
- Concussion protocol activated ASAP
- Multidisciplinary

CDC Clinical Guidelines

- Diagnosis of mTBI
  - no CT
  - Identify risk factors to warrant CT
  - No routine MRI
  - No SPECT
  - No X-ray
  - Use age appropriate validated symptom scale
  - No use of biomarkers

- Counsel 70-80% of children no symptoms > 1-3 months
- Counsel individual trajectory of recovery
- Standard assessment tools should not be exclusively used
**CDC Clinical Guidelines**

- **Prognosis of mTBI**
  - Assess premorbid hx as part of sports physicals
  - Counsel risks for delayed recovery
  - Screen for known risk factors of persistent symptoms
  - May use validated prediction rules to provide prognostics

- **Assessment of mTBI**
  - A: Use combination of tools to assess recovery of mTBI
  - B: Use validated symptoms scales to assess recovery
  - C: Cognitive computer testing
  - D: Balance testing

- **RTL of mTBI**
  - Medical and school based teams to help guide increase in academic activities as tolerated
  - RTL to based on severity of symptoms
  - Consider long term accommodations (504) for prolonged symptoms
  - Collaboration to monitor and adjust RTL
  - Refer for neurocognitive testing
CDC Clinical Guidelines

- Management of mTBI
  - Consider head CT with severe headaches or worsening symptoms
  - Nonopiod management
  - Rebound headache counseling
  - Chronic headaches multifactoral
  - Vestibular ocular therapy may be beneficial
  - Sleep hygiene
  - Identify etiology of cognitive dysfunction
  - Multidisciplinary evaluation

Community Resources

- 2016 Berlin Consensus Guidelines released in 2017
- IDPH Concussion management Guidelines for Iowa Schools
- REAP
- CDC Heads Up
- Brain Injury Alliance of Iowa (BIAI)
- Iowa Concussion Consortium (ICC)
- Local specialty concussion clinics
- Sports Medicine

So Now What!?
Continuum of Care

<table>
<thead>
<tr>
<th>Injury</th>
<th>0-72 hours</th>
<th>&gt; 72 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate Care</td>
<td>Acute Care</td>
<td>Follow-up Care</td>
</tr>
</tbody>
</table>

Immediate Care

1. Cervical spine assessment
2. Red Flags
3. Standardized sideline assessment tool
4. Remove from Play

- Not lucid or fully conscious a SCI should be assumed until proven otherwise.
- Neck pain at rest?
- If NO pain active ROM of neck?
- Can athlete feel and move arms and legs?
- Parasthesia?
- Loss of bowel and/or bladder control?
Immediate Care

- Red Flags
  - Neck pain at rest
  - Double vision
  - Weakness or tingling (paresthesia) in arms or legs
  - Severe or increasing headache
  - Seizure or convulsion
  - Loss of consciousness
  - Deteriorating conscious state
  - Vomiting
  - Restless, agitation, or combative

Immediate Care

3. Assess for signs and symptoms of a concussion

<table>
<thead>
<tr>
<th>Symptoms and Severity</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation</td>
<td>Neurological</td>
</tr>
<tr>
<td>Memory</td>
<td>Balance</td>
</tr>
</tbody>
</table>

Acute Care

- Follow up with PCP within 24 hours
  - Recent CDC practice guidelines for HCP
  - Physical examination (typically normal)
  - Scat 5 (symptom checklist)
  - Pursuits, saccades, convergence
  - Education
  - Hydration
  - Nutrition
  - Sleep hygiene
  - **Activate** Return to Learn (RTL)
  - **Activate** Return to Play (RTP)
Follow Up Care

- Follow up > 72 hours
  - PCP, Concussion Clinic if available, sports medicine physician.
  - SCAT5 (symptom checklist)
  - Returned to school or work
  - Ongoing or new symptoms
  - Sleeping
  - Exacerbating factors
  - Alleviating factors
  - Re-evaluation of RTL and RTP protocols
  - Medication management

Referrals

<table>
<thead>
<tr>
<th>Concussion Clinic/ Sports Medicine</th>
<th>Multidisciplinary evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational Therapy</td>
<td>Vision concerns</td>
</tr>
<tr>
<td>Physical Therapy</td>
<td>Balance and coordination concerns</td>
</tr>
<tr>
<td>Vestibular Therapy</td>
<td>Dizziness, tinnitus</td>
</tr>
<tr>
<td>Speech Language Therapy</td>
<td>Executive functioning and cognitive</td>
</tr>
<tr>
<td>Developmental Optometry</td>
<td>Nystagmus, overshooting, convergence</td>
</tr>
<tr>
<td>Mental Health</td>
<td>Depression, anxiety</td>
</tr>
<tr>
<td>Neurology</td>
<td>Headaches lasting &gt; 6 months</td>
</tr>
<tr>
<td>Massage Therapy</td>
<td>Cervical pain</td>
</tr>
<tr>
<td>Chiropractor</td>
<td>Cervical pain</td>
</tr>
</tbody>
</table>

Active Rehabilitation

ChildServe Concussion Clinic

- Physician Services
  - Physical Exam
  - Neuro Exam
  - SCAT5
  - INJURY

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

- Multidisciplinary Team
  - Return-to-education
  - Return-to-play/activity
  - Education
  - Accommodations

- Community
  - Education
  - Prevention
  - Collaboration
  - Support
Evidence for Early Physical Activity

- Howell et al. (2016)
  - Participants aged 13-18, higher levels of physical activity after the injury were associated with a shorter symptom duration
- Grool et al. (2016)
  - Lower rates of Post Concussive Syndrome of those who completed early physical activity (within 7 days of injury)
- Buckley et al. (2016)
  - Non-rest group of college students achieved asymptomatic status sooner than the rest group

Active Rehabilitation

- Physical Activity Progression
  - Light Aerobic activity (walking the dog)
  - Impact related aerobic activity (Jogging, running, jumping)
  - Head below heart activity (mountain climbers, sit ups)
  - Resistance training (weight lifting)
  - Sport or activity specific training (strengthening, speed, agility, reaction time)

Active Rehabilitation

- Comprehensive Medical History
- Physical Exam
- Balance and Coordination
- Vestibular/Ocular Motor Testing
- Computerized Neurocognitive Testing
- Cognitive Linguistic Assessment
Balance

Balance Error Scoring System (BESS)

Vestibular/Ocular Motor Testing

- VOR: Associated with the highest percentage of concussed patients reporting symptom provocation (81%)
- Concussed Patients:
  - Total symptom score of ≥2
  - NPC ≥5 cm

Baseline Symptoms | Headache | Dizziness | Nausea | Fogginess |
------------------|----------|-----------|--------|----------|
Smooth pursuits   | 0-10     | 0-10      | 0-10   | 0-10     |
Saccades-horizontal |          |           |        |          |
Saccades-vertical |          |           |        |          |
Convergence       |          |           |        |          |
VOR-horizontal    |          |           |        |          |
VOR-vertical      |          |           |        |          |
Visual Motion     |          |           |        |          |
Sensitivity       |          |           |        |          |

Mucha, et al 2014

Vestibular/Ocular Motor Screen (VOMS)

- VOMS video
  https://www.youtube.com/watch?v=CJF6kJcFGqE
- Abbreviated version
  https://www.youtube.com/watch?v=LyxcLTSsF_w
Visual Scanning Testing

King Devick

- Journal of Neurological studies (Rizzo et al.)
- 2016
- King Devick Objective Measures:
  - 25 concussed patients compared to 42 controls
  - Concussed patients demonstrated
    - Significantly longer reading times
    - Significantly longer intersaccadic intervals
    - Larger deviation of saccade endpoints from the center of the numbers
    - Greater number of saccades

Vestibular-Ocular Motor Testing

Dynavision
Computerized Neurocognitive Testing

Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT)

- Verbal Memory
- Visual Memory
- Reaction Time
- Processing Speed
- Impulse Control

Schatz et al., 2012

- Athletes 81 symptomatic concussed athletes compared to non-concussed controls tested within 3 days of injury
  
<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>91.4%</td>
<td>69.1%</td>
</tr>
</tbody>
</table>

- 37 asymptomatic concussed athlete compared to non-concussed controls tested within 3 days of injury
  
<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>94.6%</td>
<td>97.3%</td>
</tr>
</tbody>
</table>

Cognitive Linguistic Assessment

- Orientation
- Immediate recall
- Concentration
- Executive functioning
- Short term memory
- Long term memory
- Cognitive strategies to be successful in school or work
**Post-Concussion Syndrome (PCS)**

- **Diagnosis**
  - ICD 10 definition: “persistence of a constellation of physical, cognitive, emotional, and sleep symptoms beyond the usual recovery period”
  - No tests available to diagnose
  - 3-month duration or more of concussion related symptoms:
  
<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headaches</td>
<td>Chronic</td>
</tr>
<tr>
<td>Fatigue</td>
<td>Chronic</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>Persistent</td>
</tr>
<tr>
<td>Impaired memory</td>
<td>Persistent</td>
</tr>
<tr>
<td>Difficulty with mental tasks</td>
<td>Persistently</td>
</tr>
<tr>
<td>Difficulty sleeping</td>
<td>Persistently</td>
</tr>
<tr>
<td>Reduced tolerance to stress</td>
<td>Persistently</td>
</tr>
</tbody>
</table>

*DSM (5th ed), 2013, Makdissi et al 2017*
Post-Concussion Syndrome (PCS)

- Risk Factors for PCS
  - On field dizziness – 6.3 fold increase in PCS risk (Iverson, 2007)
  - Lack of early physical activity (Grool, 2016)
  - High initial symptom load (Howell, 2016)
  - Female sex (Howell, 2016)
  - Premorbid conditions (Asken, 2017)

<table>
<thead>
<tr>
<th>Previous concussion</th>
<th>Headache/migraine history</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning disability</td>
<td>ADHD</td>
</tr>
<tr>
<td>Depression</td>
<td>Anxiety</td>
</tr>
</tbody>
</table>

How many is too many?

- No evidenced-based guidelines
- Individualized
- Comorbidities
- 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-concussion syndrome (PCS)
- Student/family priorities
- Realistic expectations

Prevention

- Helmets do NOT prevent concussions
- Safe techniques in practices and games and on playgrounds
- Safe playground equipment
- Enforcement of rules
  - Checking in ice hockey
  - Heading in soccer
- Preseason baseline testing adopted by schools or with sports physicals
- Health education curriculum
- Community based concussion management
- Creating positive and open culture
Clinical Community

- Advanced neuroimaging techniques to help demonstrate concussion is associated with changes in the brain structure and function which correlate with symptoms
- Assessment of blood, saliva, CSF biomarkers
- Role of genetics in predicting risk of injury, prolonged recovery, long term neurological health problems, and effects of repetitive head impact exposure
- Research to develop diagnostic criteria for CTE prior to death

Chronic Traumatic Encephalopathy

- Degenerative brain condition
- 4 stages
- Repetitive brain trauma (concussion or subconcussive)
- Not just associated with football (boxing, military)
- Postmortem diagnosis
- Been around for years (punch drunk, dementia pugilistica)
- Tau protein tangles
- Wide range of symptoms
- Multi-factorial: # of concussions, genetics, alcohol, drugs
- Some may have tangles but don’t present clinically
- Many of professional athletes without CTE
- Keep a positive attitude

Iowa Community

- Iowa Concussion Consortium (ICC)
- REAP distributed to all schools April 2016
- New legislation for concussion management April 2018
- BIAI
- IDPH Concussion Management guidelines
- CTE Hope
Future

- Best practice recommendations required by law
- More specialized training in community
- Trained brain injury HCP on sidelines for all sporting events
- Baseline testing requirements for all students all schools

Case Study #1

- 16 year old female
- Volleyball concussion
- PID #31
- Concussion #6
- Headaches, occasional dizziness, neck pain
- Med hx: no depression, no anxiety, no trouble sleeping, no migraines, no family history of above, 3 week resolution of previous mTBI
- No medications
- Returned to school with some symptoms, but keeping grades up and has returned to driving

Case Study #1

- SCAT 5 20/22  30/132
- VOMS mild increase in symptoms
- King Devick some impairment
- Dynavision no impairment
- Balance no impairment
- IMPACT high average functioning

- Stage 5 of RTL
- Stage 2 of RTP
- Active Rehab
- No volleyball rest of season
- Chiropractor
Case Study #2

- 15 year old male
- Football concussion
- PID #17
- Concussion #3
- Headaches, dizziness, and sensitivity to noise
- Med hx: ADHD, no depression or anxiety, trouble sleeping, quick recovery of previous mTBIs
- No medications
- Returned to school with some symptoms, but keeping grades up

Case Study #2

- SCAT 5 14/22 22/132
- VOMS moderate increase in symptoms
- King Devick some impairment
- Dynavision no impairment
- Balance no impairment
- IMPACT average functioning

- Stage 4 of RTL
- Stage 3 of RTP
- Active Rehab
- No football rest of the season, but baseball drills, no active batting and no scrimmaging

Case Study #3

- 18 year old male
- Drag racing concussion with other ICl hospitalized
- PID #14
- Concussion #4
- Reports no symptoms
- Med hx: depression, anxiety, trouble falling asleep, long recovery of other mTBI
- Tylenol and ibuprofen prn
- Graduated from high school works for family mechanic garage, no college plans
Case Study #3

- SCAT 5 6/22 10/132
- VOMS moderate increase in symptoms
- King Devick moderate impairment
- Dynavision some impairment
- Balance no impairment
- IMPACT low average functioning
- Stage 3 of RTP- long term
- Active Rehab
- No more contact sports including drag racing ever

Websites

- Berlin consensus statement
  https://bjsm.bmj.com/content/early/2017/04/28/bjsports-2017-097699
- CDC Heads Up Campaign
  https://www.cdc.gov/HEADSUP
- CDC clinical practice guidelines
  https://jamanetwork.com/journals/jamapediatrics/article-abstract/2688456
- SCAT 5
  https://bjsm.bmj.com/content/bjsports/early/2017/04/26/bjsports-2017-097506SCAT5.full.pdf
- IDPH Concussion Management Guideline for Schools
- REAP

References

References

References


