Concussion: From Athlete To Weekend Warrior

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St. Vincent Spine and Orthopedic Institute
Objectives

I. Recognize Signs of Concussion
II. Explain Pathophysiology of Concussion
III. Organize Management Plan For Concussion
IV. Explain Risks of Returning To Play Too Early
V. Develop Return To Play Guidelines
16 year old H.S. LB misses a tackle and receives a knee to his helmet. Positive L.O.C. for less than 30 seconds and then able to get up on his own and walk towards the sideline. After initial medical evaluation he sits on the bench for the 1st half. There is no appreciable neuro deficits on the sideline. What is the minimum timeframe that has to pass before he can return to the game?

a) 7 days with RTP on 8th day if asymptomatic
b) 5 days with RTP on 6th day if asymptomatic
c) 3 days with RTP on 4th day if asymptomatic
d) Next day
e) 2nd day
Question 2

A high profile patient who is a professional B-ball player comes into the office to discuss his past medical history. He has had 5 documented previous concussions over the course of his 7 year career. He had one concussion with LOC and always returned to competition within 7-10 days. Which of the following would be an accurate statement to consider when advising him to retire from his sport?

a) Assessment of each prior concussion particularly severity should not influence decision

b) There is higher risk after sustaining > 2 concussions in 7 year period

c) Subsequent concussions can resolve faster than previous

d) Normal MRI brain would lessen concerns

e) There is a potential risk for long-term neurocognitive deficits
Epidemiology And Prevalence

- NCAA
  - 0.43 per 1000 athletic exposures
- High School
  - 0.23 per 1000 athletic exposures
- Largest Number
  - Men’s Football
- Highest Rate
  - Women’s Ice Hockey
- Men Vs. Women
  - Basketball overall rate is 0.07 per 1000 exposures in men vs. 0.21 per 1000 exposures in women
<table>
<thead>
<tr>
<th>Physical</th>
<th>Emotional</th>
<th>Cognitive</th>
<th>Sleep-Related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>Irritability</td>
<td>Feeling mentally “foggy”</td>
<td>Drowsiness</td>
</tr>
<tr>
<td>Nausea</td>
<td>Sadness</td>
<td>Feeling slowed down</td>
<td>Sleeping more than usual</td>
</tr>
<tr>
<td>Vomiting</td>
<td>More emotional</td>
<td>Difficulty concentrating</td>
<td>Sleeping less than usual</td>
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<tr>
<td>Balance problems</td>
<td>Nervousness</td>
<td>Difficulty remembering</td>
<td>Difficulty falling asleep</td>
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<tr>
<td>Visual problems</td>
<td></td>
<td>Forgetful of recent information</td>
<td></td>
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<tr>
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<td></td>
<td>Confused about recent events</td>
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<td>Answers questions slowly</td>
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<tr>
<td>Sensitivity to noise</td>
<td></td>
<td>Repeats questions</td>
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<tr>
<td>Dazed</td>
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<tr>
<td>Stunned</td>
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Most Commonly Reported Symptoms Within 3 Days

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</table>
**Table 1 – Five major features of a concussion**

1. Concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an “impulsive” force transmitted to the head.

2. Concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously.

3. Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury.

4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course; however, it is important to note that in a small percentage of cases, postconcussion symptoms may be prolonged.

5. No abnormality on standard structural neuroimaging studies is seen in concussion.

School of hard knocks

A concussion occurs when a violent blow to the head causes the brain to slam against the skull beyond the ability of the cerebrospinal fluid to cushion the impact. Between 1996 and 2001, NFL teams reported nearly 900 concussions.

When a football player takes a hit to the head, speeds range from 17 to 25 miles per hour with a force averaging 98 times the force of gravity.

A study commissioned by the NFL revealed most hits occurred from a blow to the side of the head, often on the lower half of the face.

1. The shock wave passes through the brain and bounces back off the skull. The concussion usually occurs at the opposite side from the point of impact.

2. The impact can cause bruising of the brain, tearing of blood vessels and nerve damage.

Symptoms

Immediate
- Confusion
- Amnesia
- Loss of consciousness
- Ringing in the ears
- Nausea and vomiting
- Convulsions

Delayed
- Irritability
- Headaches
- Depression
- Sleep disorders
- Poor concentration
- Trouble with memory

Cumulative effects

Studies show that prior concussions may lower the threshold for subsequent concussion injury and increase severity of symptoms.

Sources: MayoClinic.com, Biokinetics, Washington Post, Science Daily, kidshealth.org, Kaiser Permanente

Andrew Lucas, Jeff Goertzen | The Denver Post
Concussive Pathophysiology

1) Influx of neurotransmitters (Glut./NMDA)
2) Sodium/Potassium Pump Works Overtime
3) Increase In Glucose Metabolism
4) Diminished Cerebral Blood Flow
5) Energy Crisis
6) Persistent Calcium-Mitochondrial Oxidation
7) Alternate Fuel-Lactate Induces Acidosis
Traumatic head injuries

A concussion occurs when a blow to the head results in the brain slamming against the skull.

**Symptoms**
Headache, dizziness, confusion, nausea, difficulty hearing and seeing, lack of concentration

**Concussion**
Brain collides with skull, which can cause bruising, torn tissues and swelling.

**Second impact syndrome**
When a player who is not fully recovered from a concussion suffers a second blow to the head, it can be fatal.

SOURCE: American Academy of Neurology, U.S. Centers for Disease Control and Prevention, KRT State Journal
1) Avoid Impact to the Head Again
2) Avoiding Worsening The Starvation Crisis
Auto-Regulatory Malfunction

**Concussion Pathophysiology**

*Period of Vulnerability*

Another concussion during this period can lead to irreparable damage or death.

![Graph showing period of vulnerability and concussion pathophysiology](image)
Athletic Concussion In Developing Brain

• The younger the brain the more resilient the brain is after injury?
  • Moderate fluid percussion in rats vs. weight drop model

• 1st Week After Injury
  • NMDA alterations
  • Increased cognitive impairment
  • Stagnant lesion size in rats with immobilization

• Repeated Injury > Two Isolated Events
  • Cognitive defect could present later without initial signs
Predisposing Factors

• Personal History of Headaches
• Family History of Headaches
• History of Concussion
• Underlying ADD/ADHD
• History of Depression/Anxiety
• Dyslexia
<table>
<thead>
<tr>
<th>Symptom</th>
<th>Preseason Baseline</th>
<th>Time of Injury</th>
<th>24 Hours Post-Injury</th>
<th>Day 3 Post-Injury</th>
<th>Day 4 Post-Injury</th>
<th>Day 5 Post-Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blurred Vision</td>
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<td>Dizziness</td>
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<td>Drowsiness</td>
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<td>Sleeping More than Usual</td>
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<td>Easily Distracted</td>
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<tr>
<td>Fatigue</td>
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<tr>
<td>Feeling “In a Fog”</td>
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<td>Feeling “Slowed Down”</td>
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<td>Headache</td>
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<td>Unusually Emotional</td>
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<td>Irritability</td>
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<td>Loss of Consciousness</td>
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<td>Loss of Orientation</td>
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<td>Memory Problems</td>
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<td>Nauseous</td>
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<td>Nervousness</td>
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<td>Personality Changes</td>
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<td>Poor Balance/Coordination</td>
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<tr>
<td>Ringing in the Ears</td>
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<td>Sadness</td>
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<td>Seeing Stars</td>
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<td>Sensitivity to Light</td>
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<td>Sensitivity to Noise</td>
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<tr>
<td>Sleep Disturbances</td>
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<td>Vacant Stares/Glassy Eyes</td>
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<td>Vomiting</td>
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</table>

**TOTAL SYMPTOM SCORE:**
What is the Child-SCAT3?¹
The Child-SCAT3 is a standardized tool for evaluating injured children for concussion and should be used in children aged from 5 to 12 years. It is supplemental to the SAC and should not be used in children aged 13 years and over. If you are not qualified to use the SAC, please use the SAC. The Child-SCAT3 is designed for use by medical professionals. If you are not qualified, please use the Sport Concussion recognition Tool. Preseason baseline testing with the Child-SCAT3 is recommended. It is helpful for interpreting post-injury test scores. Specific instructions for use of the Child-SCAT3 are provided on page 3. If you are not familiar with the Child-SCAT3, please read through these instructions carefully. The test can be freely copied in its current form for distribution to individuals, teams, groups and organizations. Any revision or reproduction in a commercial format requires approval by the Concussion in Sport Group.

What is a concussion?
A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific signs and/or symptoms (some examples listed below) and most often does not involve loss of consciousness. Concussion should be suspected in the presence of any one or more of the following:
- Symptoms (e.g., headache), or
- Physical signs (e.g., unsteadiness), or
- Impaired brain function (e.g., confusion) or
- Abnormal behavior (e.g., change in personality), or

SIDELINE ASSESSMENT
Indications for Emergency Management

NOTE: A hit to the head can sometimes be associated with a more serious brain injury. If the concussed child displays any of the following, then do not perform the Child-SCAT3. Child-SCAT3; instead activate emergency procedures and urgent transportation to the nearest hospital:
- Glasgow Coma score less than 15
- Cerebral signs
- Seizures
- Evidence of skull fracture
- Coma
- Evidence of neurosurgery (e.g., Shunt)
- Multiple injuries

1 Glasgow Coma Scale (GCS)

<table>
<thead>
<tr>
<th>Eye response (E)</th>
<th>Motor response (M)</th>
<th>Best verbal response (V)</th>
<th>Orientation</th>
<th>Coma</th>
</tr>
</thead>
<tbody>
<tr>
<td>No eye opening</td>
<td>No motor response</td>
<td>No verbal response</td>
<td>Alert</td>
<td></td>
</tr>
<tr>
<td>Eye opening in response to pain</td>
<td>External to pain</td>
<td>Incomprehensible sounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eye opening to speech</td>
<td>Abnormal flexion to pain</td>
<td>Inappropriate words</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eyes opening spontaneously</td>
<td>locals to pain</td>
<td>Confused</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Oriented</td>
<td>Alert</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Best motor response (RM)</td>
<td>Alert</td>
<td></td>
</tr>
</tbody>
</table>

Potential signs of concussion?
If any of the following signs are observed after a direct or indirect blow to the head, the athlete should stop participation, be evaluated by a medical professional, and not be permitted to return to sport the same day if a concussion is suspected.

- Any loss of consciousness?
- Seizure?
- Balance or motor incoordination (stumble, slow, labored movements, etc.)?
- Disorientation or confusion (ability to respond appropriately to questions)?
- Loss of memory?
- Unilateral weakness?

2 Sideline Assessment – Child-Maddocks Score³165

I am going to ask you a few questions, please listen carefully and give your best effort.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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<tbody>
<tr>
<td>Where are we at now?</td>
<td>Alert</td>
</tr>
<tr>
<td>Is it before or after lunch?</td>
<td>Before</td>
</tr>
<tr>
<td>What did you have last lesson/class?</td>
<td>Science</td>
</tr>
<tr>
<td>What is your teacher’s name?</td>
<td>Mrs. Johnson</td>
</tr>
</tbody>
</table>

Child-Maddocks score

Note: Child-Maddocks score is for sideline diagnosis of concussion only and is not used for return-to-play decisions.

BACKGROUND

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date/time of injury:</th>
</tr>
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<tbody>
<tr>
<td>Exam.:</td>
<td>Date of assessment:</td>
</tr>
<tr>
<td>Sport:</td>
<td>Age:</td>
</tr>
<tr>
<td>Team/school:</td>
<td>Gender:</td>
</tr>
<tr>
<td>Current year:</td>
<td>Right/Left:</td>
</tr>
<tr>
<td>School:</td>
<td>Dominant hand:</td>
</tr>
<tr>
<td>Mechanism of injury: (“tell me what happened?”):</td>
<td></td>
</tr>
</tbody>
</table>

For parent/carer to complete:
How many concussions has the child had in the past?
When was the most recent concussion?
How long was the recovery from the most recent concussion?
Has the child ever been hospitalized or had medical imaging done (CT or MRI) for head injury?
Has the child ever been diagnosed with headaches or migraines?
Does the child have a learning disability, dyslexia, ADD/ADHD, seizure disorder?
Has the child ever been diagnosed with depression, anxiety or other psychiatric disorder?
Has anyone in the family ever been diagnosed with any of these problems?
Is the child on any medications? If yes, please list:

CHILD-SCAT3 SPORT CONCUSSION ASSESSMENT TOOL 3 | PAGE 1 © 2013 Concussion in Sport Group
SCAT 3

• > 13 year old athletes
  • Child SCAT 3
• Glasgow Coma Scale
• Maddock Score
  • Questions related to current related events
• Cognitive Score
• Symptom Evaluation
• Neck Score
• Balance Error Score System
  • Gait Examination
Concussion Management: Areas of Focus

Acute management

- Rule out more serious intracranial pathology
  - CT, MRI, neurologic examination primary diagnostic tests

Post-injury management

- Prevent against cumulative effects of injury
  - Less biomechanical force causing extension of injury
- Prevent presence of post-concussion syndrome

Determination of asymptomatic status essential for reducing repetitive and chronic morbidity of injury

Harmon KG, et al.[3]
<table>
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<tr>
<th>PHASE</th>
<th>REHABILITATION</th>
<th>OBJECTIVE</th>
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<tr>
<td>Phase 1</td>
<td>Baseline</td>
<td>Patient must be on physical and cognitive rest with no symptoms for at least 24 hr.</td>
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<tr>
<td>Phase 2</td>
<td>Increase heart rate</td>
<td>The goal is to increase heart rate for 5-10 min through mild activity such as walking, light jogging, or an exercise bike.</td>
</tr>
<tr>
<td>Phase 3</td>
<td>Moderate exercise</td>
<td>In this phase the goal is limited body and head movement through more moderate intensity activities such as brief running or moderate weight lifting.</td>
</tr>
<tr>
<td>Phase 4</td>
<td>Noncontact exercise</td>
<td>The goal is to increase intensity but avoid contact. Activities could include more intense running, stationary biking, or noncontact sport-specific drills.</td>
</tr>
<tr>
<td>Phase 5</td>
<td>Practice</td>
<td>Reintegrate into full contact practice.</td>
</tr>
<tr>
<td>Phase 6</td>
<td>Play</td>
<td>Return to competition.</td>
</tr>
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From May KH, et al.\textsuperscript{11}
When To Refer To Specialist?

1) The symptoms have not gone away after 10-14 days, or
2) The symptoms worsen at any time,
3) Patient has a history of multiple concussions or risk factors for prolonged recovery. This may include a history of migraines, depression, mood disorders, or anxiety, as well as developmental disorders such as learning disabilities and ADHD.
Concussion Treatment

- REST
- REST
- REST
- REST
Concussion Treatment

- Rest
- Monitor Concussion Symptoms
- Vestibular Oculomotor Therapy
- Neuro-ophthalmology program
- Speech Therapy
- Pharmacologic Management
- Graded Exercise Program
Pharmacologic Management

Yes

• Tylenol
• Fish Oil
• Gabapentin
• SSRIs-antidepressants
• Melatonin
• Topamax

No

• NSAIDs
• Vitamin E
• Multi-vitamins
• Ambien-sleep agents
• Narcotics
• Sumatriptan?
Diet In Concussion Management

- Lean protein and low fat diets
OMT in Concussion

- Goal - Reduce Pain
- Cervical Myofascial Strain/Whiplash
  - HVLA?
  - Caution with oculomotor deficits
Post-Concussion Syndrome Treatment

• University of Buffalo Study
  • Eli et al
  • Graded Exercise Program
Four Corners Approach to Concussion Care

Family

Child/Teen (Student, athlete, son/daughter, friend)

Medical Systems
- Pre-hospital (EMS)
- Emergency
- Urgent care
- Primary care
- Specialty care

Athletic/Recreational
- Administrators
- Coaches
- Officials
- Parents
- Teammates
- Certified athletic trainer

School
- Administrators
- Teachers
- School nurse
- Counselor
- Psychologist
- Certified athletic trainer

CDC.[2]
IMPACT TESTING

• Review Data
  • 30% False Positive
  • 30% False Negative

• Sand-Bagging
  • Poor Baseline Testing

• Testing Options
Alternative Baseline Testing

- Dynamic Baseline Testing
- Value of Balance Testing
- Value of Cognitive Testing
- Monitoring Heart Rate
Concussion Prevention

- Rugby Style Tackling
  - 2014 New Hampshire Football Study
  - Serevi Seattle Based Company
  - Goal-Decrease Head Impact
Long-Term Sequelae of Multiple Concussions

- Cognitive impairment and executive function impairment
  - NP testing with multiple concussions vs. control
- Headache disorders
- Decreased perceived health related quality of life measures
- Psychiatric disorders including depression is increased with multiple concussions
- Dementia pugilistica: dementia associated with retired boxers
Chronic Traumatic Encephalopathy

• Diagnosed at autopsy
  • Increase in donation of brain tissue by professional athletes
• True incidence unknown

• Pathologic Findings
  • Superficial cortical layers
  • Atrophy-temporal, hemispheres, brainstem, thalamus
  • Tau-immunoreactive neurofibrillar tangles & astrocyte tangles
CTE Clinical Presentation

- Insidious cognitive decline
- Confusion
- Disorientation
- Behavioral changes
- Parkinsonian features
- Psychotic features
Second Impact Syndrome

- Catastrophic Brain Swelling
  - Symptomatic upon second impact
  - 2\textsuperscript{nd} impact < 1\textsuperscript{st} impact
- Pathophysiology
  - Cerebral dysautoregulation
- Extraordinarily rare
  - True incidence unknown
- Rapid deterioration
Ohio Legislation

• House Bill 143
  i. If coach or referee removes participant from sport then participant is not cleared to return to play in the same day
  ii. In order to return to competition a licensed physician must provide written documentation

• Coaches-online concussion course

• Is Baseline Testing Mandatory?
Equipment Changes

• Flex Helmet
  • Absorbs Impact

• Mouthguard
  • Prevention of concussion?

• Weight of the Soccer Ball

• There is no convincing evidence that new helmet technology, mouthpieces or protective head gear prevents concussion
Updated Zurich Guidelines
Question 1

- 16 year old H.S. LB misses a tackle and receives a knee to his helmet. Positive L.O.C. for less than 30 seconds and then able to get up on his own and walk towards the sideline. After initial medical evaluation he sits on the bench for the 1st half. There is no appreciable neuro deficits on the sideline. What is the minimum timeframe that has to pass before he can return to the game?

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e) 2nd day
A high profile patient who is a professional B-ball player comes into the office to discuss his past medical history. He has had 5 documented previous concussions over the course of his 7 year career. He had one concussion with LOC and always returned to competition within 7-10 days. Which of the following would be an accurate statement to consider when advising him to retire from his sport?

a) Assessment of each prior concussion particularly severity should not influence decision
b) There is higher risk after sustaining > 2 concussions in 7 year period
c) Subsequent concussions can resolve faster than previous
d) Normal MRI brain would lessen concerns
e) There is a potential risk for long-term neurocognitive deficits
Conclusion

• Understanding pathophysiology of concussion will help determine best time course in returning athlete to practice and game
• Dynamic Testing improves baseline testing accuracy while assisting the clinician with return to play of the athlete
• In treating concussion there must be a team approach
References