Sports Concussion: What Do We Really Know?

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Overview

• Significance
• Diagnosis
  – Sideline diagnosis v Management
  – Concussion Tools
• Return-to-Play
  – Protocol v Process
  – Active rest
• Future
The FACTS - Sports

- NFL ~1,800
- College Football ~54,250
- High School Football ~1,139,000
- Grade School & Junior High Football >3,000,000

Research being done here

Soccer >3,000,000

Ice Hockey >500,000

Most of the players here
Concussion Defined

• A syndrome of immediate and transient neurologic impairment induced by a biomechanical force
• Physiologic dysfunction without significant anatomic disruption
• Most mild of spectrum of TBI
Figure 1. Neurometabolic cascade following experimental concussion. $K^+$, potassium; $Ca^{2+}$, calcium; CMRgluc, oxidative glucose metabolism; CBF, cerebral blood flow. (Reprinted with permission. Giza CC, Hovda DA. Ionic and metabolic consequences of concussion. In: Cantu RC, Cantu RI. Neurologic Athletic and Spine Injuries. St Louis, MO: WB Saunders Co; 2000:80–100.)
FIG. 3. Cerebral blood flow changes over time after fluid percussion injury (FPI, 2.47 ± 0.08 atm). Values are expressed as percentage of CBF values in uninjured group for each brain region and time. Statistical comparisons were made between mean values for control and injured groups. a, $p < 0.05$; b, $p < 0.01$; c, $p < 0.001$. 
Increased energy demand

+ 

Decreased energy supply

**ENERGY CRISIS:** *Neuronal Dysfunction*

UCONN HEALTH
Mechanisms of Injury

- Direct
  - Blow to the head

- Indirect
  - Impact elsewhere
Biomechanics

- rapid deceleration
- sequential acceleration-deceleration
- rotation
- deformation
Epidemiology

- Contact/collision sports: football, hockey, lacrosse, soccer, boxing
- Approximately 3.8 million head injuries/year in the US
- 20% of high school and collegiate football players
- Many concussions are unreported
- — denial, lack of insight, result of injury
Signs of Concussion

• Nausea/Vomiting
• Drowsiness
• Vacant stare
• Confusion
• Loss of consciousness
• Mood changes
• Uncoordinated/Unsteady
Common Symptoms

- Headache
- Fatigue
- Amnesia
- Dizziness
- Vision changes
- Poor balance

- Light sensitivity
- Sound sensitivity
- Changes in sleep patterns
- Difficulty concentrating
Consequences

- Post Concussive Syndrome (>3 months) or Persistent Symptoms (adults >10-14 days, children >4 weeks)
  - headache
  - depression
  - prolonged mild neuropsychological effects
  - susceptibility to repeat concussions

- Second Impact Syndrome
  - second brain injury before the brain has a chance to recover
  - brain swelling, permanent damage and possible death
Chronic Traumatic Encephalopathy (CTE)

- 1928 Dr. Harrison Martland
  “Dementia Pugilistica”
- 2007 Dr. Omalu
- 2009 Dr. Ann McKee
  “Chronic Traumatic Encephalopathy in Athletes”
- 3 professional athletes
CTE

CLINICAL

• Memory disturbances
• Behavioral and personality changes
• Parkinsonism
• Speech and gait abnormalities

PATHOLOGICAL

• Atrophy of cerebral hemispheres, medial temporal lobe, thalamus, mammillary bodies, brainstem
• Ventricular dilatation and a fenestrated cavum septum pellucidum
Tau Protein

- Extensive tau immunoreactive tangles
- Preferential involvement of the superficial cortical layers, frontal and temporal cortices
- Prominent perivascular, periventricular and subpial distribution
- Beta-amyloid less prominent
Chronic Neurocognitive Impairment

- Demonstrable neurologic, cognitive or behavioral impairment generally measured using validated tests or neuropsychological tools
- Longer exposure to contact sports
- Nonprogressive

Kutcher; Continuum:Sports Neurology 2014
Classification

• Possible Concussion
  – Symptoms similar to concussion (not most likely cause)
  – No clear head trauma
  – Situational, consider immediate return

• Probable Concussion
  – Symptoms of concussion (most likely cause)
  – Questionable head trauma
  – Observation on sideline

• Definite Concussion
  – Clear symptoms of concussion (definite cause)
  – Witnessed head trauma
  – Evaluate in training room

Kutcher, Giza; Continuum:Sports Neurology 2014
Special Concerns

- Children
- Athletes with ADHD, migraine, depression, learning disabilities, sleep disorders
- Female athletes
Children

- High levels of participation
- Limited medical training of coaches
- No on-site medical care
- Requires age-appropriate evaluation
- Longer recovery
Medical Conditions

• Availability of a medical history is crucial-HIPAA concerns
• Challenge of sorting symptoms of concussion versus pre-existing condition
• Amplified symptom severity
• Longer recovery
Female Athletes

- Participation of female athletes is rising
- Soccer, cheerleading, lacrosse
- Longer recovery
- Persistent symptoms
AAN Evidenced-Based Guideline

The Evaluation and Management of Concussion in Sport

• Review of medical literature from 1955 to 2012
• 13,499 titles and abstracts, 577 full length papers
• For athletes with concussion, what interventions enhance recovery, reduce the risk of recurrent concussion, or diminish long-term sequelae?
AAN Evidenced-Based Guideline

• Presence of experienced licensed health care professional improved early recognition and recovery
• Greatest risk for a second concussion within ten days of the first injury
• Body checking in youth hockey, half visors, quarterbacks, artificial turf result in prolonged recovery
NCAA, CATS CONSENSUS

• Pre Season: Full-contact practices limited to 4/week and not consecutive for two-a-days

• In Season: Full-contact practices limited to 2/week and no more than 20 in regular season
Concussion Assessment

• Clinical Examination: SCAT5, MLB, NFL sideline assessment tool, BESS

• Computerized cognitive testing: ImPACT, Axon, King-Devick, C3 logic

• Biomarkers: APOE4/ SRC/S100B/UCHL-1/GFAP/pNFH/all-spectrin/Tau/NSE/CKBB/MBP/Amyloid/APP
Concussion Assessment

• Functional Imaging-based on event-related changes in the brain
  – fMRI-measures changes in blood oxygenation and blood flow
  – PET-measures brain metabolism based on glucose utilization
  – EEG-measures electrical activity
Electroencephalography
Three Phases of Concussion Management

- **Phase I:** Acute rest
- **Phase II:** Relative rest
- **Phase III:** Graduated exertion

**INJURY**

**TIME**

- Injury Onset
- Injury Resolution

Symptom Threshold
Return-to-Play

• Rest (physical)
• Rest (mental)
• Eat
• Sleep
• Drink
Rest

- What is the right amount of rest?
- 1-2 days v 5 days of rest
- 5 day group required 3 days longer for 50% of symptoms to resolve
BDNF

• Brain Derived Neurotrophic Factor
• Protein encoded by the BDNF gene
• Griesbach GS, Neuroscience 2004
• Forced exercise-Stress-No rise in BDNF
• What is the sweet spot?
Return-to-Play

<table>
<thead>
<tr>
<th>Rehabilitation Stage</th>
<th>Functional Exercise at Each Stage of Rehabilitation</th>
<th>Objective(s) of Each Stage</th>
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</thead>
<tbody>
<tr>
<td>1. No activity</td>
<td>Symptom-limited physical and cognitive rest</td>
<td>Recovery</td>
</tr>
<tr>
<td>2. Light aerobic exercise</td>
<td>Walking, swimming, or stationary cycling, keeping intensity $&lt;70%$ of maximum permitted heart rate; no resistance training</td>
<td>Increase heart rate</td>
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<tr>
<td>3. Sport specific exercise</td>
<td>Skating drills in ice hockey, running drills in soccer; no head-impact activities</td>
<td>Add movement</td>
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<td>4. Noncontact training drills</td>
<td>Progression to more complex training drills, eg, passing drills in football and ice hockey; may start progressive resistance training</td>
<td>Exercise, coordination, and cognitive load</td>
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<tr>
<td>5. Full-contact practice</td>
<td>After medical clearance, participation in normal training activities</td>
<td>Restore confidence and assessment of functional skills by coaching staff</td>
</tr>
<tr>
<td>Return to play</td>
<td>Normal game play</td>
<td></td>
</tr>
</tbody>
</table>
• SCAT 5 is useful immediately after injury, loses usefulness 3-5 days after injury
• Symptom checklist helps track recovery
• Baseline neurocognitive testing not required
• Increased activity after 24-48 hours of rest
• Strategy vs Protocol

McCrory et al Br J Sports Med 2017
• Persistent symptoms vs Post-concussive syndrome
• Severity of symptoms in initial few days best predictor of recovery
• No cause-and-effect relationship between CTE and sports-related concussions

McCrory et al Br J Sports Med 2017
Counseling Athletes

• Absolute contraindications:
  – Persistent signs and symptoms at rest or with exertion
  – Abnormal findings on exam
  – Imaging abnormalities
  – Neuropsychological changes
  – Deterioration in performance
Counseling Athletes

• Relative contraindications:
  – Persistent post concussive symptoms beyond months
  – Decreased injury threshold
Questions

• How long does it take for a concussion to resolve?
• At what age should athletes begin participation in high-velocity collision sports?
• How to best prevent concussion?
  – Equipment
  – Rules
  – Legislation
  – Education
TRUTH

DOESN’T HAVE A SIDE

My Alarming Discovery about the Danger of Contact Sports

DR. BENNET OMALU

with Mark Tabb

Foreword by WILL SMITH
Questions

• How do things get better?
  – Light therapy
  – Diet
  – Diagnostics
Case 1

- 23 y/o world ranked professional bull rider presents for evaluation of his ninth concussion in two years. Six of which were accompanied by LOC.
- The most recent (and most severe) occurred three months prior to this evaluation.
- LOC for approximately one hour, retrograde amnesia and anterograde amnesia for five days.
- Symptoms of hypersomnia, photophobia, phonophobia, stuttering speech resolving.
Case 1

- Neurologic exam normal except for anisocoria OS>OD with normal pupillary response
- Head CT normal at time of injury
- Cervical CT showed congenital fusion C5-6
- MRI did not reveal any active disease process but did show changes consistent with prior brain contusions on susceptibility-weighted imaging
- Neuropsychometric testing indicated cognitive dysfunction localizing to language-dominant hemisphere and frontal lobes
Case 1

• Patient advised to retire from bull riding
• After a year off returned to bull riding in western Canada
• Eventually allowed to return to PBR after passing “baseline tests”
• Reached a ranking of 4th in the world in November 2016
• On January 9, 2017 patient committed suicide after multiple bouts of depression
“If you’ve seen one concussion… you’ve seen one concussion”
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