The Journey from Mild TBI and Sports Concussions to Chronic Traumatic Encephalopathy

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University of Virginia School of Medicine
### University of Virginia TBI Study

Glasgow Coma Scale: All Head Injury Admissions  
(n = 1248)

<table>
<thead>
<tr>
<th>Glasgow Coma Scale</th>
<th>No. Patients</th>
<th>% of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 - 8</td>
<td>260</td>
<td>21%</td>
</tr>
<tr>
<td>9 - 12</td>
<td>304</td>
<td>24%</td>
</tr>
<tr>
<td>13 - 15</td>
<td>684</td>
<td>55%</td>
</tr>
</tbody>
</table>
3 months post injury – 34% of mild head injured patients who were previously employed had not returned to work (n=310)
UVA MILD HEAD INJURY: RESEARCH CRITERIA

- Glasgow Coma Scale > 12
- Loss of Consciousness < 20 minutes
- Length of Hospitalization (No Collateral Injuries) < 48 hours
- No Neuroimaging Evidence of Structural Impairment (Levin)
Percentages of Mild Head Injured Patients Across the Halstead Impairment Indexes

Rimel et al 1981, Barth et al 1983)
Mild Head Injury: The Silent Epidemic

Wall Street Journal, 1982
Mild Acceleration-Deceleration Brain Injury

“Acceleration induced head injury in the monkey: I. The model, its mechanical and physiological correlates.”

(Gennarelli et al, 1981)
Axonal degeneration induced by experimental noninvasive minor head injury

John A. Jane, M.D., Ph.D., F.R.C.S.(C), Osward Steward, Ph.D., and Thomas Gennarelli, M.D.
Neurochemical Model of Concussion in Fluid Percussion

David Hovda, Ph.D., UCLA Dept. of Neurosurgery

- Increase in extracellular potassium and sodium, and intracellular calcium
- Initial hypermetabolism and hyperglycolysis to restore homeostasis
- Subsequent hypometabolism:
  - Uncoupling of cerebral blood flow and glucose utilization creates relative ischemia in regard to metabolic demands of tissue
University of Virginia Study of Mild Head Injury in Football

SLAM

Sports as a Laboratory Assessment Model
SLAM

• Focus on Sports Concussion as a Laboratory for Clinical Research
  • Application to MTBI in the general population

• Focus on Sports Concussion as a Sports Medicine Issue
  • Improving sports safety/reducing risk
Why do we need baseline neurocognitive assessments in sports?

- “Nobody in football should be called a genius. A genius is a guy like Norman Einstein.”

-- Football commentator and former player, Joe Theismann
University of Virginia Football Study

TOTAL (10 Universities) 2350 Players

Post-injury Protocol:
  Concussions 195
  Orthopedic Injuries 59
  Student Controls 48
TRAIL MAKING B
Pre-Season and Post-Injury Performances
(Timed in Seconds)
Percentage of Players Reporting Symptoms Following Mild Concussion

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Pre-season</th>
<th>24-Hours</th>
<th>5 Days</th>
<th>10 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headaches</td>
<td>27.0</td>
<td>70.6</td>
<td>54.3</td>
<td>27.2</td>
</tr>
<tr>
<td>Memory</td>
<td>2.3</td>
<td>33.9</td>
<td>26.7</td>
<td>8.8</td>
</tr>
<tr>
<td>Dizziness</td>
<td>2.3</td>
<td>34.8</td>
<td>21.6</td>
<td>9.4</td>
</tr>
</tbody>
</table>
UVA Mild Head Injury in Football
(Barth, et al., 1989)

• 10 University Prospective Study (n=2350)
• 195 Concussions
• 107 Student/Red Shirt Athlete Controls
• Single Concussion:
  – Attention and Complex Problem Solving Deficits
  – Inability to Take Advantage of Practice Effect
  – 5 to 10 Day Recovery Curve

Virtually every college, high school, and professional study since the UVA study has found similar recovery curves following mild concussion [3 to 10 day recoveries]
Critical Issues in Sports Concussion

• When is it safe for a player to return to play?

• What are the effects of multiple concussions? Timing of concussions? Latency effects?
The Importance of Return-To-Play Decisions: Striking Another Balance

• Avoid potential negative outcomes
  – Protect the health of the athlete and avoid:
    • Second Impact Syndrome
    • Acute and Chronic Cognitive Deficits
    • Severe Emotional Problems
    • Chronic Traumatic Encephalopathy

• Carry out the mission/goal
  – Return to game and play well
  – Avoid being lost for future games
Potential Negative Medical Outcomes Associated With Return-To-Play Decisions:

SECOND IMPACT SYNDROME

- Occurs in athletes with prior concussion following relatively minor second impact (controversial and based upon single case studies)
- Catastrophic increase in intracranial pressure due to dysfunction of autoregulation of cerebral circulation
- Most often occurs in athletes < 24 years old

LOW INCIDENCE – HIGH POTENTIAL ACUTE IMPACT

Schneider, 1973; Saunders; 1984; Cantu, 1998. Evidence Level 4
Potential Negative Medical Outcomes Associated With Return-To-Play Decisions:

**ACUTE AND CHRONIC COGNITIVE DEFICITS**

Acute cognitive deficits 3 to 10 days post single concussion.

**HIGH INCIDENCE – HIGH ACUTE LOW-CHRONIC POTENTIAL IMPACT**

Barth, 1989; Lovell, 2003. Evidence Level 1 & 2

Possible chronic cognitive deficits with multiple concussions.

**LOW-MOD INCIDENCE – HIGH CHRONIC POTENTIAL IMPACT**

Potential Negative Medical Outcomes Associated With Return-To-Play Decisions:

SEVERE EMOTIONAL PROBLEMS

DEPRESSION

LOW INCIDENCE – HIGH POTENTIAL CHRONIC IMPACT

Potential Negative Medical Outcomes Associated With Return-To-Play Decisions:

CHRONIC TRAUMATIC ENCEPHALOPATHY

- Progressive degenerative neurological process found in some athletes who sustain multiple concussions and sub-concussive blows. This early degenerative process is characterized by cerebral atrophy and increased levels of tau protein in the form of neurofibrillary tangles, as well as cognitive impairment (dementia) and, in some cases, depression.

LOW-MOD INCIDENCE – HIGH POTENTIAL CHRONIC IMPACT

McKee /Cantu, 2009; Omalu, DeKosky 2005. Evidence Level 3 & 4
CHRONIC TRAUMATIC ENCEPHALOPATHY

Tau Protein: Amygdala (McKee et al. 2009)

Healthy Brain    Football Player    Boxer
CHRONIC TRAUMATIC ENCEPHALOPATHY

Tau Protein (McKee et al. 2009)

Early evidence of CTE in a recently deceased 18-year-old boy who suffered multiple concussions in high school football.
Return to Play and Practice

What Do We Know With Reasonable Certainty?

- Single uncomplicated concussion often results in acute neurocognitive and balance deficits and a rapid (3 to 10 day) recovery curve.
- Once an athlete has sustained a concussion, the risk for subsequent concussion increases 3 to 6 fold.
- Multiple concussions may increase the severity and duration of cognitive symptoms (multiple concussions may result in CTE).
- Children are likely at greater risk for slower recovery.
Return to Play: Consensus Statements and Evidence Based Guidelines

Zurich Consensus Conference on Sports Concussion (2013)

- One and Done: No return until symptom free with exertion
- Individually based decisions (one size does not fit all)
- Short period of rest and slow return to activity/school

Amer Acad of Neuro Evidence Based Return to Play Guidelines (2013)

- One and Done: No return until symptom free with exertion
- Individually based decisions (no set timeline for safe RTP)
- HS age and younger should be managed more conservatively
Conservative Approach to Return to Play and Practice

• If concussion is diagnosed, the player should be removed from play for that game/practice and until symptom free with exertion. Short period of rest is recommended followed by slow return to activities.

• When symptom free, neurocognitive retesting should be implemented to check against baseline test scores to mitigate inaccurate player symptom report.
## Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012

<table>
<thead>
<tr>
<th>Rehabilitation Stage</th>
<th>Functional exercise at each stage of rehabilitation</th>
<th>Objective at each stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No activity</td>
<td>Complete physical and cognitive rest</td>
<td>Recovery</td>
</tr>
<tr>
<td>2. Light aerobic</td>
<td>Walking, swimming, or stationary cycling</td>
<td>Increase heart rate</td>
</tr>
<tr>
<td></td>
<td>exercise keeping intensity &lt;70% MHR. No resistance training</td>
<td></td>
</tr>
<tr>
<td>3. Sport-specific</td>
<td>Skating drills in ice hockey, running drills</td>
<td>Add movement</td>
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<tr>
<td></td>
<td>exercise in soccer. No head impact activities</td>
<td></td>
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<tr>
<td>4. Non-contact</td>
<td>Progression to more complex training drills (passing). May start progressive resistance training</td>
<td>Exercise, coordination, cognitive load</td>
</tr>
<tr>
<td>training drills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Full contact</td>
<td>Following medical clearance, participate in normal培训 activities</td>
<td>Restore confidence, assessment of functional skills by coaching staff</td>
</tr>
<tr>
<td>practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Return to play</td>
<td>Normal game play</td>
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Conservative Approach to Return to Play and Practice

• Since there is no scientific evidence to support a cut-off for too many concussions in a season or in a lifetime, decisions should be made by the medical/athletic training staff (and the player), taking individual history into account.

• Recommend full neurological and neurocognitive examination when considered necessary by the team physician following multiple concussions. Trigger is significant neurologic symptoms.
Balanced Approach to Return to Play and Practice

• The criteria for medical-neuropsychological return-to-play are fairly clear and the decision based upon consensus guidelines is straight-forward in most cases.

• Parental tolerance for risk for their child is less straight-forward and we must assist parents with our understanding of the risk of injury and the risk of non-participation in sports...the search for balance.
PREVENTION AND REDUCTION OF RISK IN SPORTS

• Education of the athlete and public
• Reduction of contact in practice
  o Number of contacts is more critical than severity
  o NFL 10 year career = 75,000 collisions/sub-concussive blows
• Rules to protect the brain
• Equipment to protect the brain
Xenith Sports Helmet

Flexible bonnet
Serves as an anchoring point for the 18 shock absorbers, drawstring and strap. The drawstring and straps ensure a snug fit.

Shock absorbers

Drawstring

Faceguard

Strap

Chin piece
PREVENTION AND REDUCTION OF RISK IN THE CLINICAL POPULATION

• Equipment to protect the brain