Neurocognitive Assessment of Sports Concussion and CTE: From Dings to Dementia

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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>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>
University of Virginia TBI Study (1981)

3 months post injury – 34% of mild head injured patients who were previously employed had not returned to work (n=310)
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
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: Baseline and Post Concussion Neurocognitive Assessment

SLAM

Sports as a Laboratory Assessment Model

[1989]
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
University of Virginia Football Study
(Barth, 1989; Macciocchi, 1996)

Evidence Level 1

<table>
<thead>
<tr>
<th>TOTAL</th>
<th>2350 Players</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-injury Protocol:</td>
<td></td>
</tr>
<tr>
<td>Head Injuries</td>
<td>195</td>
</tr>
<tr>
<td>Orthopedic Injuries</td>
<td>59</td>
</tr>
<tr>
<td>Student Controls</td>
<td>48</td>
</tr>
</tbody>
</table>
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]
Acceleration-Deceleration Mild Head Injury and Concussion Assessment

Sideline and In-Theater Screening:

• Standardized Assessment of Concussions (SAC)  
  (McCrea, Kelly, Kluge, Ackley, and Randolph, 1997)

• Military Acute Concussion Evaluation (MACE)
Computerized Assessment in Acceleration Deceleration Concussion

- **ANAM**: Automated Neuropsychological Assessment Metric – Bleiberg (DoD)
- **ImPACT**: Immediate Post Concussion Assessment and Cognitive Testing - Lovell (U of Pittsburgh)
- **CRI**: Concussion Resolution Index – Erlanger (HeadMinder)
Critical Issues in Sports Mild Head Injury

- Severity of concussion

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

- What are the effects of multiple concussions? Timing of concussions? Latency effects?
In this era of evidence based medicine, those who must make critical return-to-play decisions are left in the unenviable position of choosing between scientism or potential charlatanism.

Do we ignore a potential problem because we have little scientific data, or do we over-react to sensational headlines based upon single case observations?
To avoid decisional paralysis and harm to the athlete, we must **strike a balance** between what we know with reasonable certainty and what we observe and hope to better understand.
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
    - Chronic Traumatic Encephalopathy
    - Severe Emotional Problems
    - Acute and Chronic Cognitive Deficits

- Carry out the mission/goal
  - Return to game and play well
  - Not be 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:

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, 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
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:

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
Mild Head Injury Outcome

• Most mild head injured patients recover fully and quickly (within 3 months).

• Many mild head injury patients experience significant neurocognitive deficits which can last several weeks or months.

• Longer periods of disability are related to individual recovery curves and individual vulnerability.
Lessons Learned From Clinical Experience Outside of Sports: Individual Vulnerability Factors and Outcome

- More severe concussion
- Multiple concussions
- Age
- Pain
- Premorbid health/conditioning
- Premorbid intellectual/cognitive functioning/LD/ADD
Lessons Learned From Clinical Experience
Outside of Sports: Individual Vulnerability
Factors and Outcome

- Alcohol/substance use/abuse
- Depression
- Sleep disturbance
- Support systems to allow rest and recovery
- Information provision and positive expectations
- Genetics?
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
Evidence Level 5 [Expert Opinion]

- American Academy of Neurology Practice Parameters (1997)
  - Severity grading; no symptom return to play (presently being revised)
  - Importance of neurocognitive assessment
  - Simple vs. complex concussion
- Zurich Conference on Sports Concussion (2009)
  - Neurocognitive assessment important (verify athlete self report)
  - Individually based decisions (one size does not fit all)
  - Diagnosis of concussion = remove from game no matter how fast symptoms clear
Conservative Approach to Return to Play and Practice

- Every player is different and decisions should be made by the medical/athletic training staff (and the player), taking individual history into account.

- If concussion is diagnosed, the player should be removed from play for that game/practice and until symptom free with exertion. Rest is recommended.

- When symptom free, neurocognitive retesting should be implemented to check against baseline test scores to mitigate inaccurate player symptom report.
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.

• Consideration should be given to a full neurological and neurocognitive examination when considered necessary by the team physician following multiple concussions. Any significant neurologic symptoms should trigger such an evaluation.
Improvised Explosive Device Blast Injuries

- **Primary Blast Injury**: Wave induced changes in atmospheric pressure [hollow organs most effected].

- **Secondary Blast Injury**: Objects placed in motion by the blast and hitting soldiers.

- **Tertiary Blast Injury**: Soldiers being put in motion by the blast and hitting other objects.

- **Quaternary Blast Injury**: Burns, toxic fumes, crush injuries, hypertension.
Blast Injuries: Comparison to Sports Concussions

- Blast injuries are more complicated than sports concussions, yet have some similarities, particularly in the tertiary phase of acceleration-deceleration.

- Complications include:
  - Primary over pressure dynamics
  - Secondary blunt injury
  - PTSD
RECOMMENDATIONS FOR ASSESSMENT AND TREATMENT OF CONCUSSION BLAST INJURY IN THE FIELD OF OPERATION

LEVEL I [Line Medic Care]:
- Rest, observation (establishment of “Battle Buddy”), information, and positive expectations, (up to 2 days).

LEVEL I or II [FOB or BAMF Care]:
- Continue rest, observation, and positive expectations up to 14 days if improvement is noted. Referral to Level III if symptoms persist or deteriorate.

LEVEL III [Combat Support Hospital (CSH) Care]:
- Repeat ANAM or RBANS, or Comprehensive Neuropsychological Assessment. Possible referral to Level IV or V hospital care.

LEVEL IV or V [Military Hospital or in CONUS Care]:
- Comprehensive Neuropsychological Assessment.
Concussion Controversies

- We are uncomfortable with our lack of knowledge and the complexity of the concussion issue.

- When faced with this lack of comfort and complexity, we tend to become reductionists in order to increase our comfort by reducing our uncertainty.

- Reductionism leads us to simple extremes (all concussions are devastating or they are inconsequential).

- These simple extremes breed scientism or charlatanism.
Concussion Controversies

• Get comfortable with ambiguity

• Recognize and embrace the complexity of the concussion issue and treat it as a challenge to your scientific and clinical/medical skills.

• Take individual vulnerability into account when treating/managing your patient/athlete.
University of Virginia

BISC Institute

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