Examination of Concussion: Medical and Cognitive Considerations

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What is concussion?

- American Academy of Neurology (AAN):
  - Traumatically induced alteration in mental status that may or may not involve a loss of consciousness (LOC)
  - Emphasizes that concussions may occur w/o LOC
- Functional NOT Structural Injury

Concussion Rates (per 1,000 A-E) for High School Sports

<table>
<thead>
<tr>
<th>Sport</th>
<th>Powell 1999 Injury Rate (per 1000 AE)</th>
<th>Schultz 2004 (converted to per 1000 AE)</th>
<th>Gessel 2007 Injury Rate (per 1000 AE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseball</td>
<td>0.07</td>
<td>0.11</td>
<td>0.05</td>
</tr>
<tr>
<td>Softball</td>
<td>0.10</td>
<td>0.10</td>
<td>0.07</td>
</tr>
<tr>
<td>Boys' Basketball</td>
<td>0.11</td>
<td>0.10</td>
<td>0.07</td>
</tr>
<tr>
<td>Girls' Basketball</td>
<td>0.16</td>
<td>0.17</td>
<td>0.21</td>
</tr>
<tr>
<td>Boys' Soccer</td>
<td>0.18</td>
<td>0.23</td>
<td>0.22</td>
</tr>
<tr>
<td>Girls' Soccer</td>
<td>0.23</td>
<td>0.13</td>
<td>0.36</td>
</tr>
<tr>
<td>Football</td>
<td>0.59</td>
<td>0.33</td>
<td>0.47</td>
</tr>
<tr>
<td>Field Hockey</td>
<td>0.09</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Volleyball</td>
<td>0.02</td>
<td>NR</td>
<td>0.05</td>
</tr>
<tr>
<td>Wrestling</td>
<td>0.25</td>
<td>0.09</td>
<td>0.18</td>
</tr>
</tbody>
</table>

NR - Not reported

Objectives: Clinical Dilemmas

- How to objectively assess concussion
- Return to Play?
- Home care instructions
- How many is too many?
- Cumulative Effects?
- Grading Scales?
- To rest or not to rest?
- School and other ADLs?
- Rehabilitation?

Concussion as a predisposition to future injury

196 total injuries/ 4,251 NCAA FB players (4.2%)

Guskiewicz, McCrea et al, JAMA 2003

Fact or Fallacy: The FIRST WEEK is critical:

- Average of 7 days for full recovery
- 75% of repeat concussions within first 7 days
- 92% of repeat concussions within first 10 days
Cumulative risks for youth athletes

How should I refer to the injury?

- Concussions are injuries to the brain
- Should not be dismissed as “ding” injuries
  - “Ding”/Grade 1 injuries resulted in neurocognitive deficits 36 hours after injury (Lovell et al., 2004)
- The grading dilemma:
  - Grade the concussion at time of injury - NO!
  - Grade concussion after symptoms have resolved - Maybe
  - Always focus attention on recovery of S/S, NP testing, and balance

How do I evaluate a head injury?

- Baseline testing can be beneficial
- No different than any other injury:
  - Primary survey (Basic Life Support)
    - ABCs
    - Life threatening or Limb threatening
  - Secondary survey
    - Conduct normal injury evaluation
    - Focus on neurological deficits
- Don’t just assume it’s a typical concussion!

Recurrent Concussion

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Mild)</td>
<td>No LOC; PTA &lt; 30 minutes; PCSS &lt; 24 hours</td>
</tr>
<tr>
<td>2 (Moderate)</td>
<td>LOC 1 minute or PTA 1-24 minutes &lt; 24 hours or PCSS 2-4 hours &lt; 7 days</td>
</tr>
<tr>
<td>3 (Severe)</td>
<td>LOC 2-24 minutes or PTA 24-72 hours or PCSS &gt; 7 days</td>
</tr>
</tbody>
</table>

*Loss of Consciousness  †Post Traumatic amnesia (anterograde/retrograde) ‡Post Concussion signs/symptoms other than amnesia


Red Flags…

- S/S lasting longer than 7-10 days
- Extensive loss of consciousness or amnesia
- Deterioration over time instead of resolution
- Compounded by multiple concussions
- Personality changes
- Other neurological disorders present
Concerns

- Epidural Hematoma - Arterial Bleed and Fast
- Subdural Hematoma - Usually Venous and Slower
- Subarachnoid Hematoma
- Second Impact Syndrome

Second Impact Syndrome

- Occurs when an athlete sustains a second head injury before symptoms from first have resolved (Cantu & Voy, 1995)
  - Loss of autoregulation of blood flow throughout the brain
- Different professionals discuss the condition in different ways
- 100% Morbidity, 50% mortality
Prevention of Catastrophic Brain Injury

- Proper preparedness for on-field & sideline medical management of head injury becomes paramount when dealing with a more serious and quickly deteriorating condition.
- If GCS <8, posturing, or not oxygenating well - be prepared to perform manual ventilations (endotracheal intubation, bag-valve-mouth resuscitation).
- Reduce ICP by elevating head to 30 deg and ensuring that the head and neck are maintained in a midline position to optimize venous outflow from the brain.
- Hyperventilation and intravenous diuretics such as mannitol (0.5-1.0 g/kg.) may also be used to decrease ICP.
- Being prepared for immediate transfer to a medical facility is extremely important under these conditions.

Concussion Assessment Protocol

- History
- Observation
- Palpation
- AROM/ PROM
- Strength Tests
- Stress Tests
- Functional Tests

Sports as a Laboratory Assessment Model (SLAM*)

- General History
- Determine level of consciousness:
  - alert
  - semicomatose
  - lethargic
  - comatose
  - stuporous
- Determine symptoms:
  - headache
  - blurred vision
  - tinnitus
  - tenderness
  - nausea
  - numbness or weakness
  - dizziness
  - photophobia

*Barth et al., 2002
Symptomatology

- Most important guideline:
  - No athlete returns to participation while still symptomatic

- Using a graded symptom checklist allows for objective assessment of...
  - variety of symptoms
  - severity of symptoms
  - duration of symptoms (i.e. “resolution pattern”)

- Important - Symptoms are Subjective
  - ~38% of athletes reporting no symptoms may still demonstrate neurocognitive deficits (Broglio, 2008)

Observation

- Watch athlete closely throughout evaluation
  - Aphasia - difficulty finding or saying the right words
  - Obvious deformities/abnormal positions of body parts
  - Coordination (how they walk off the field, etc)
  - Pupillary signs: (PEARL)
    - size
    - response to light
    - eye movement and tracking
  - Respirations
  - Overall demeanor

Palpation

- Additional info, can be gained through palpation once a baseline is established
  - Pulse
  - Blood Pressure
  - Palpate for signs of trauma:
    - Painful areas
    - Deformities
    - Swelling
    - Crepitus

ROM and Strength

- AROM and PROM
  - Check neck ROM
  - Any other ROM you think may be affected

- Strength
  - Assess neck strength
  - Any other strength deficits you think you might observe

- Dermatomes and Myotomes
Stress Tests: Cognition

Cognitive functioning:
- 3 word recall
- Serial 7’s
- Recite months of year in reverse order
- Recite days of week in reverse order
- Mental Status Assessment
- Neuropsychological Testing

Sideline mental status tests: SAC

- Orientation
- Immediate memory
- Exertional maneuvers
- Neurological screening
- Concentration
- Delayed recall
- Total score is computed (McCrea)

SCAT2 - Serial evaluations

<table>
<thead>
<tr>
<th>Test</th>
<th>Maximum</th>
<th>Score</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAC2</td>
<td>100</td>
<td>100</td>
<td>60</td>
</tr>
</tbody>
</table>

SCAT2 - Concussion injury advice

**Concussion injury advice** (to be given to concussed athletes)

If you notice any change in behavior, vision, dizziness, persistent headache, double vision or nausea:
- Converse telephone to the clinic or the nearest hospital emergency department immediately.

Other important points:
- Rest and avoid strenuous activity for at least 24 hours
- No alcohol
- Use nonaspirin or mild analgesic
- Use non-narcotic pain medication
- Avoid activity and mentally demanding
- Do not turn or jump until medically cleared

Clinic phone number

Managing Functional Academic Deficits

**Neuropsychological Testing**

- Assess cognitive factors such as memory, concentration, impulse control, and reaction time
- Paper and pencil tests:
  - Good: a lot of normative data exists
  - Bad: time-consuming (manpower and actual testing); and inability to assess reaction time
- Computerized NP tests:
  - Good:
    - Neuropsychologists not needed for test administration
    - Test multiple subjects at once
    - Reaction time can be assessed
  - Bad: reliability, sensitivity, and validity have been questioned (Randolph et al. 2005; Broglio et al. 2009)

**Neuropsychological Deficit**

<table>
<thead>
<tr>
<th>Neuropsychological Deficit</th>
<th>Functional School Problem</th>
<th>Management Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention/Concentration</td>
<td>Short focus on lecture,</td>
<td>Shorter assignments, break</td>
</tr>
<tr>
<td></td>
<td>classwork, homework</td>
<td>down tasks, lighten work load</td>
</tr>
<tr>
<td>&quot;Working&quot; Memory</td>
<td>Holding instructions in mind, reading comprehension, math calculation, writing</td>
<td>Repetition, written instructions, use of calculator, short reading passages</td>
</tr>
<tr>
<td>Memory Consolidation/Retrieval</td>
<td>Retaining new information, accessing learned info when needed</td>
<td>Additional time, slow down verbal info, comprehension-checking</td>
</tr>
<tr>
<td>Processing Speed</td>
<td>Keep pace with work demand, process verbal information effectively</td>
<td></td>
</tr>
<tr>
<td>Fatigue</td>
<td>Decreased arousal/ activation to engage basic attention, working memory</td>
<td>Rest breaks</td>
</tr>
</tbody>
</table>
Stress Tests: Balance/Coordination

Balance Error Scoring System (BESS)

- Clinical test battery:
  - 6 20-second trials
  - Uses 3 different stances (double, single, tandem)
  - 2 different surfaces (firm, foam)
  - All performed with eyes closed
- Recorded errors:
  - Hands lifting off iliac crests
  - Opening eyes
  - Step, stumble, or fall
  - Moving into >30° of hip flexion or abduction
  - Remaining out of test position for >5 sec.
  - Lifts toes or heel off the floor or foam

Balance Error Scoring System (BESS)

Clinical Recovery

Amnesia
LOC
Concussion Hx
Sex

Concussion treatment: Key factors

- Symptom exacerbation following physical or cognitive activity is a sign that the brain’s dysfunctional neurometabolism is being pushed beyond tolerable limits.
- In guiding recovery, management of neurometabolic demands on the brain is central.
- Not allowing physiologic threshold to be exceeded.
  Pay attention to over-exertion
- Physical
- Cognitive! (concentration, learning, memory)

What is cognitive “rest”?

- The concept of cognitive exertional activity (and rest) viewed along a continuum of activity
  No activity/full rest ↔ Full activity/no rest
- In reality, full cognitive rest is neither practical nor likely (unless asleep or comatose)
  Therapeutic goal is to limit cognitive activity to a level that is tolerable, and does not exacerbate or cause the re-emergence of symptoms
- Cognitive management = Academic management
Serial Evaluations

TOI: clinical eval & symptom checklist
1-3 hrs: symptom checklist
24 hrs: follow-up clinical eval & symptom checklist

### Symptomatic
1. Continued rest
2. Monitoring of s/s
3. If deteriorating – consider imaging

### Asymptomatic
1. Neuropsychological testing
2. Postural stability testing
3. Monitoring of s/s

Serial Evaluations (con’t)

Once athlete has been asymptomatic for 24 hrs:
- Reassess on clinical measures and compare to baseline scores.
- Continue to monitor symptoms for 24 hrs after assessment.
- If remain asymptomatic, reassess on clinical measures to see where they are relative to baseline and to previous day.
- Start Graduated RTP Progression if:
  * 95% baseline achieved
  * no deterioration from previous day

5 Step Graduated Return to Play

- **Exertion Step 1**: 20 minute stationary bike ride (10-14 MPH)
- **Exertion Step 2**: Interval bike ride: 30 sec sprint (18-20 MPH/10-14 MPH)/ 30 sec recovery x 10; and BW circuit: Squats/Push Ups/Situps x 20 sec x 3
- **Exertion Step 3**: 60 yard shuttle run x 10 (40 sec rest); and plyometric workout: 10 yard bounding/10 medicine ball throws/10 vertical jumps x 3; and non-contact, sport-specific drills for approximately 15 minutes
- **Exertion Step 4**: Limited, controlled return to non-contact practice
- **Exertion 5**: Full sport participation in a practice

Working through the RTP Progression

- The 5 steps do not necessarily require 5 days.

  - No more than 2 steps should be performed on the same day, which allows for monitoring of both acute symptoms (during the activity) and delayed symptoms (within 24 hrs after the activity).
  - In general, if the exertional activities do not produce acute symptoms, the athlete may progress to the next step.
  - The athlete may advance to Step 5 and return to full participation once they have remained asymptomatic for 24 hrs following Step 4 of the protocol.
  - Always document the process, day by day, step by step!

Impact Biomechanics:

**Acceleration/ Deceleration**

*Biggest challenge:* How do we manage the energy to prevent both concussion and severe TBI?

The Concussion Equation

- Acute Dx
  - Biomarkers
- Acute Tx
  - Omega 3 Fatty Acids
  - Hyperbarics
  - Progesterone
By ALAN SCHWARZ Published: November 5, 2010 New York Times

CHAPEL HILL, N.C. — Alan Pelc has been taught how to block since his Houston boyhood, how to push and pulverize and punish oncoming defenders on the football field. This was different. He was learning how not to punish himself.

“Right there,” Dr. Kevin Guskiewicz said, pointing at a presentation screen showing more than a dozen arrows pointed straight into the top of a mannequin head. “These are all your recorded hits to the top of your helmet against L.S.U. Every time you dropped your head. These are the ones we’re concerned about.”

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Role of the cervical muscles?

Vianno, 2007

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The Center for the Study of Retired Athletes

The University of North Carolina at Chapel Hill

The Center conducts clinical and epidemiological research with the purpose of improving quality of life for retired athletes. Through these endeavors, the Center provides medical screenings to educate retired athletes about their potential health risks and needs.

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Mild Cognitive Impairment & Prior Concussion History

(Retired NFL Players)

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Safer Football, Taught From Inside the Helmet

UNC athletic trainer Scott Trulock and Dr. Kevin Guskiewicz talking with Offensive Linemen Alan Pelc.
Prevalence of Alzheimer’s Disease (Retired NFL Players)

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>US male population</th>
<th>Retired NFL players</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;69</td>
<td>0.1</td>
<td>0.5</td>
</tr>
<tr>
<td>70-74</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>≥75</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

Center for the Study of Retired Athletes

- 11% of all respondents (n=319) have been diagnosed with a bout with depression.
  - When analyzed by # previous concussions:
    - 0 concussions: 6.4%
    - 1-2 concussions: 9.8%
    - 3+ concussions: 21.2% \( \chi^2 = 71.51, df=2, p<.001 \)
- 87% of these players still suffer from depression & 46% are currently being treated with anti-depressant medications.
  - “Does depression limit your activities of daily living?”
    - 22% = NEVER
    - 65% = SOME
    - 12% = OFTEN

**WHEN IN DOUBT - SIT THEM OUT!**
No same day RTP
- Youth sports
- HS sports (NFSHSAA)
- College sports (NCAA)
- Pro sports (NFL, NHL)
- Elite/Olympic sports (Zurich Consensus/IOC)

**Conclusion: Research Drives Change - Fact!**
- Forcing clinicians to re-think how concussion is managed
  - defining the recovery curves
  - guiding policy change: NFL, NCAA, NFSHSAA, Youth Sports
- Providing a better understanding of injury biomechanics
  - determining the concussion threshold & influence of repetitive sub-concussive impacts
  - Helmet design, rules change, player/coaching education
- Providing an understanding of long-term effects of TBI
  - Slowed recovery & influencing academic performance/quality of life
  - Early detection of neurodegenerative processes (neuropsych tests and advanced neuroimaging)
  - Introducing interventions (concussion education, cognitive rehab, Omega-3 fatty acid, virtual reality)

Thank You

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