Assessment of Brain Function in Sports
Concussion

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Concussions reported in NFL up 20 percent from 2010-2011 season

The Facts
- A concussion is a brain injury.
- All concussions are serious.
- Most concussions occur without loss of consciousness.
- Concussions can occur in any sport or recreation activity.
- Recognition and proper response to concussions when they first occur can help prevent further injury or even death.
Sports Neuropsychology

- New sub-field of neuropsychology
- Application to all levels/sports
- Consultation with trainers, coaches, physicians

Baseline vs postconcussion Evaluations

Standard protocols

- NHL
- NFL
- MLS

Sports Concussion Epidemiology

- CDC estimates 300,000 sports concussions / year
- 822 Sports Concussions / day
- 75% "Mild" but 9% require hospitalization
- Sports & recreation brain injuries cause 900 deaths / year

Collegiate Sports Concussion

- NCAA survey 1997-2000
- 40,547 physical injuries
- 6.2% (2,502) were concussion

Covassin et al., 2003, Applied Neuropsychology, 10, 12-22
**Sports Concussion Statistics:**

**NCAA Injury Surveillance System data**

- Concussion accounted for the following % of sports injuries during 2002-2003:
  - Ice Hockey: 12%
  - Football: 8%
  - Soccer: 5%

(Dick, 2003 National Collegiate Athletic Association)

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**High School Athletic Concussions**

**Boys**
- 1. Football
- 2. Wrestling
- 3. Soccer
- 4. Basketball
- 5. Baseball

**Girls**
- 1. Soccer
- 2. Basketball
- 3. Softball
- 4. Field Hockey
- 5. Volleyball

(Powell & Barbe-Fox, 1999, *JAMA*, 282, 908-913)

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**What happens to the brain?**
Assessment of the Concussed Athlete

- How are concussion symptoms determined?
  - Can be challenging for many reasons
- LOC in ≤ 10% of cases
- Normal CT/MRI in majority of cases
- Disruption in normal brain function
  - Demonstrated by behavior change
  - Assessed by neurobehavioral examination
  - Standardized Cognitive Screening
  - Role of Neuropsychology

Acute Signs of Concussion

- LOC not necessary for dx
- Confusion, Disorientation
- Motor/balance problems
- Nausea/vomiting
- Amnesia for recent information
- Visual problems (blurring, photosensitivity)
- Headache
- Behavior change*
  - Sxs may be subtle

Assessment of Concussion Severity

<table>
<thead>
<tr>
<th>Severity</th>
<th>Grade I</th>
<th>Grade II</th>
<th>Grade III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cantu</td>
<td>NO LOC</td>
<td>LOC &lt; 5 min</td>
<td>LOC ≥ 5 min</td>
</tr>
<tr>
<td></td>
<td>PTA &lt; 30 m</td>
<td>PTA &gt; 30 &lt;24 hr</td>
<td>PTA ≥ 24 hr</td>
</tr>
<tr>
<td>Colorado Med Society</td>
<td>Confusion</td>
<td>Confusion</td>
<td>LOC</td>
</tr>
<tr>
<td></td>
<td>NO LOC</td>
<td>NO LOC</td>
<td>NO LOC</td>
</tr>
<tr>
<td></td>
<td>NO Amnesia</td>
<td>Amnesia</td>
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</tr>
<tr>
<td>AAN</td>
<td>Confusion</td>
<td>Confusion</td>
<td>LOC</td>
</tr>
<tr>
<td></td>
<td>NO LOC</td>
<td>NO LOC</td>
<td>NO LOC</td>
</tr>
<tr>
<td></td>
<td>Sxs &lt; 15 m</td>
<td>Sxs &lt; 15 m</td>
<td>Sxs &gt; 15 min</td>
</tr>
</tbody>
</table>
**More Serious Signs**

- One pupil larger than the other
- Is drowsy or cannot be awakened
- A headache that not only does not diminish, but gets worse
- Weakness, numbness, or decreased coordination
- Repeated vomiting or nausea
- Slurred speech
- Convulsions or seizures
- Cannot recognize people or places
- Becomes increasingly confused, restless, or agitated
- Has unusual behavior
- Loses consciousness (a brief loss of consciousness should be taken seriously)

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**Late Potential Concussion Symptoms**

Most symptoms usually resolve within a week, but some may persist, e.g.

- Decreased processing speed/slowed thinking
- Feeling foggy
- Short term memory impairment
- Decreased frustration tolerance & irritability*
- Fatigue
- Sleep disturbance
- Depression

*Note: Some may be difficult to distinguish from other conditions such as being a teenager*

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**What is Neuropsychological Assessment?**

- Quantitative samples of cognition derived from carefully developed tests
- Measurement of cognitive abilities
- Involves principles of neurology & psychology, with influence of cognitive psychology & neuroscience
Neuropsychological Testing

- Standardized tests
- Documented validity & reliability
- Scores allow comparison × time
- Most sensitive means of assessing brain function
- Accepted neurodiagnostic procedure*

*Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology (1996)

Neurocognitive Testing Caveats

- Brief screening can be insensitive to cognitive impairment
- Cognitive deficits most reliably detected via detailed testing
- Pts may under- or over-report sx; thus, objective scores useful (though not infallible, as they depend on effort)

Interpretation of neurocognitive tests

- Issue of baseline assessment
- Test-retest ("practice") effects
- Preexisting and co-existing factors may influence test results
  - Situational factors (effort, medications, pain, fatigue)
  - Sociodemographic, linguistic, educational, ADD, I.D, intellectual
"Quarterbacks are not geniuses, a genius is some guy like Norman Einstein"

(Famous former NFL player)

**Neurocognitive Tests:**
*What are they like?*

- Pencil-paper, question-answer, and/or computerized tests requiring various cognitive skills.

**Neurocognitive Domains**

- Global Functioning / IQ
- Language
- Visuospatial
- Attention/ Concentration*
- Learning & Memory*
- Executive Functioning
- Perceptual Motor

*most sensitive to concussion*
Examples of Neurocognitive Screening Tests used in Assessment of Concussion

- Sideline Assessment of Concussion (SAC, McCrea et al.)*
- Sport Concussion Assessment Tool-2 (SCAT-2)
- IMPACT: Immediate Post-Concussion Assessment and Cognitive Testing
- CNS Concussion Signs
- Headminder Concussion Resolution Index
- CogSport
- ANAM: Automated Neuropsychological Assessment Metrics Sports Medicine Battery
- NHL & NFL Neuropsychological Test batteries (standard tests)

Assessment of Concussion

SCAT2

- Standardized clinician-administered, downloadable tool
- Physical signs, GCS, balance testing, symptom ratings, cognitive screen

SCAT-2 Cognitive Screener

- Standardized performance-based testing
- Includes Standardized Assessment of Concussion (SAC; McCrea):
  - Orientation (Maddocks score)
  - Working memory (digits backward)
  - Recent memory (5-item word list x 3 trials + delay)*
  - Months reverse

Typical Testing Scheme for Sports Neuropsychology Programs

Baseline | Injury | 24/48 Hrs | 3/5/7 Days | 14 Days

Computerized Neurocognitive Testing Advantages:
- Widely used across age levels
- Only way to screen large #s of players
- Can be group-administered*
- Widely available & Cost efficient
- Available in multiple languages
- Results databased*
- Quick scoring/feedback

Computerized Neurocognitive Testing Caveats:
- Subject effort may be suboptimal
- Preexisting cognitive +/- not factored in
- Comorbid or situational factors may affect results
- Limited range of cognitive skills tested
- Individual scores may be unreliable
- Results may be misinterpreted
Computerized Neurocognitive Testing Caveats
- Group testing limitations
- Where's testing taking place?
- Who's monitoring? (parents? coaches?)
- Quality assurance of results (validity?)
- Where are data stored? How accessed?
- Who's interpreting?
- Sometimes results don't make sense!

ImpACT Composite Scores
- Verbal Memory
- Visual Memory
- Visuomotor Speed
- Reaction Time
- Impulse Control
- Symptom Checklist

Critical Factors in use of Computerized Cognitive Testing
- Emphasize purpose & importance
- Encourage good effort & attention
  - (eg. read all instructions!)*
- Ok for groups <5 (fewer = better)
- Quiet environment*
- Requires proctoring*
Practical Issues in Computerized Neurocognitive Testing in Sports

- Who should/can interpret computerized screening test results?

- Is “workshop training” for interpretation adequate?

- When to seek consultation?

Practical Issues

- Whomever is interpreting computer screening results must be familiar with:

  - Psychometric issues (reliability, validity, sensitivity / specificity) & limitations of tests

  - Identification of poor effort/invalid profiles
    - May not be reflected in “warning” scores
    - Need to examine subtests as well as global scores

Practical Issues

- Whomever is interpreting computer cognitive screening results must be familiar with:

  - Do results make sense vis a vis injury?

  - Awareness that “normal” scores can = impairment

  - Not all “impaired” scores = a deficit
Practical Issues

- Whomever is interpreting computer cognitive screening results must be aware of:

  - Relevant clinical comorbidities
    - What else could explain / influence results?

  - When to request consultation in interpretation*
  - When to recommend further evaluation*

*Neuropsychology should be part of the Concussion Team

Practical Issues in Computerized Neurocognitive Testing in Sports

- How to interpret test results?

- What if:
  - Results not back to baseline? What if they are?
  - There is no baseline?
  - There are many retest scores?
  - Only one subtest score declines or is abnormal?
  - Everything else is normal but computer results remain abnormal?

Neuropsychological Evaluation

- Assist with return to play
- May be particularly useful in cases that remain symptomatic beyond expected recovery period
- May help explain questionable computerized cognitive screening results
- Assist with return to school/work planning
How to decrease concussions?

- Awareness & information
- Protection (equipment, rules)
- Policy

Sports Neuropsychology

NFL urging states to pass youth football concussion laws.

Texas bill passed in 2011

- Baseline vs postconcussion Evaluations
- Recovery
- Return to Play
- Retirement
- Future risks?
- Research Needed

Practical Issues:

Identifying a consulting neuropsychologist:

- Licensed psychologist with specialized training and experience in evaluating brain-behavior issues.
- Local referrals/reputation in sports-related evals
- General neuropsychologist listings at
  - www.theAACN.org
  - www.rutonline.org
  - Sports Neuropsychology Society

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