Computerized Testing and Symptom Reporting In The Emergency Department For Concussed Athletes

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Disclosures
Disclosures

- None
Background
Background

- Concussions are a societal burden due to both the volume of injuries and risk of persistent neurocognitive sequelae.

- Many young athletes are evaluated in pediatric emergency departments (PED) and rely solely on the PED evaluation for guidance and management.

- Existing PED resources mostly depend on an athlete’s symptom report to guide recommendations.
Background

- Computerized neuropsychological testing can provide an objective assessment of impairments that would otherwise not be detected by symptom reporting or imaging studies.

- The identification of those likely to have prolonged symptoms can improve our discharge recommendations from the PED.

- This risk stratification can potentially prevent reinjury with more catastrophic consequences.
Background

- Iverson et al (2007) found that, when examined within 72 hours of injury, high school football players with prolonged symptoms (>10 days) performed worse on ImPACT and reported more initial symptoms

- Athletes that were slow to recover were 18 times more likely to have unusually low ImPACT scores

- Definition: 3 or more low domain scores (<10th percentile)
  - SP of 0.98
  - PPV of 0.94
Objectives
Objectives

- To determine if ImPACT in the PED can predict which young athletes are at risk of having persistent concussive symptoms

- To delineate the recovery patterns of young concussed athletes that present to the PED

**HYPOTHESIS:**
- Athletes with unusually low ImPACT scores would be more likely to have symptoms at 1 and 2 weeks post injury
Study Design
Study Design

- A prospective cohort study conducted in an urban and a community PED

**Inclusion Criteria**
- Athletes ages 11-18 years
- <24 hours after sustaining sports-related blunt trauma
- Participating in an organized sports team
- Presented with any concussive symptom, LOC, post-traumatic seizure, amnesia, disorientation, perseveration, and/or any change in mental status
Study Design

- **Exclusion Criteria**
  - Required acute surgical intervention or urgent admission
  - Multiple trauma or major trauma requiring prolonged immobilization
  - Upper extremity injury affecting the use of a computer or mouse
  - Recently received drugs or medications that could affect mental status
  - History of color blindness
  - Unfamiliar with use of a computer
Study Design

- Assessment Tools
  - ImPACT (version 2.0)
  - Post Concussion Symptom Scale (PCSS)
  - Telephone questionnaire

- ImPACT and the PCSS were administered in a standardized fashion in the PED

- Follow-up telephone questionnaires, including the PCSS, were completed at approximately 1 and 2 weeks post-injury
Nurse

Design Memory

Was this one of the designs displayed?

Yes  No
Click each of these buttons in BACKWORD ORDER.

Start with 25 and count down to 1 AS FAST AS YOU CAN.

If you make a mistake, use the 'Go Back' button to clear the buttons you have already clicked, one at a time.
<table>
<thead>
<tr>
<th>Symptom</th>
<th>None</th>
<th>Minor</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nausea</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Vomiting</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Balance problems</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Fatigue</td>
<td>0</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Trouble falling asleep</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sleeping more than usual</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sleeping less than usual</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Irritability</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sadness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nervousness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling more emotional</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Numbness or tingling</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling mentally “foggy”</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Visual problems</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Adapted from Lovell MR, Collins MW. Neuropsychological assessment of the college football player. J Head Trauma Rehab 1998;13:9–26; with permission.
Study Definitions

- Poor ImPACT performance
  - 3 or more unusually low domain scores (<10th percentile for age and gender), OR
  - Not able to complete ImPACT testing due to symptoms

- Prolonged recovery
  - Symptomatic at >1 week post-injury
    - PCSS total raw score
      - ≥6 in males
      - ≥8 in females
Sample Size

- Using data from previous studies, we estimated that approximately 50% of our patients would remain symptomatic with concussive symptoms at one week post injury.

- With a CI of 0.95, an expected Sp of 0.95, and a lower acceptable confidence limit of 0.80, the target sample size was approximately 50 subjects in each outcome group.
Data Analysis

- Demographic and follow up data were compiled and analyzed using the Statistical Package for Social Sciences (SPSS, Inc., Release 17.0.0, 2008)

- Chi square analysis and student’s t-test were used to compare variables between outcome groups

- Univariate and multivariable logistic regression were used to compare the associations between PCSS items and the duration of symptoms
Results
Enrollment

Total Enrolled
n=109

- Withdrew - 7
- Excluded - 1*

Completed 1 Week F/U
n=93

Completed 2 Week F/U
n=84

Loss To Follow-up
n=8

Loss To Follow-Up
n=9

*Patient excluded for possible intracranial hemorrhage on head CT.

• 85% of the athletes that enrolled in the study were symptomatic based on PCSS reporting in the PED
## Description of Cohort

<table>
<thead>
<tr>
<th></th>
<th>Overall n=93</th>
<th>Prolonged Recovery n=56</th>
<th>Short Recovery n=37</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age - yrs (SD)</strong></td>
<td>15.0 (1.8)</td>
<td>14.8 (1.6)</td>
<td>15.2 (2.1)</td>
<td>0.87 (0.69-1.10)</td>
</tr>
<tr>
<td><strong>Gender: % Female (n)</strong></td>
<td>22% (20)</td>
<td>23% (13)</td>
<td>19% (7)</td>
<td>1.30 (0.46-3.63)</td>
</tr>
<tr>
<td><strong>Hx of Headache (n)</strong></td>
<td>12% (10)</td>
<td>13% (7)</td>
<td>8% (3)</td>
<td>1.79 (0.43-7.46)</td>
</tr>
<tr>
<td><strong>Hx of Cognitive Disorder (n)</strong></td>
<td>35% (30)</td>
<td>39% (19)</td>
<td>30% (11)</td>
<td>1.35 (0.54-3.35)</td>
</tr>
<tr>
<td><strong>Concussion Hx (n)</strong></td>
<td>None=73% (63)</td>
<td>None=57% (32)</td>
<td>None=84% (31)</td>
<td>3.49 (1.15-10.55)</td>
</tr>
</tbody>
</table>
# ImPACT Test Performance

<table>
<thead>
<tr>
<th></th>
<th>Overall n=93</th>
<th>Prolonged Recovery n=56</th>
<th>Short Recovery n=37</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor ImPACT Performance</td>
<td>26% (n=24)</td>
<td>30% (n=17)</td>
<td>19% (n=7)</td>
<td>1.87 (0.69-5.08)</td>
</tr>
<tr>
<td>Verbal Memory (%-ile)</td>
<td>33.7%</td>
<td>32.0</td>
<td>36.1</td>
<td>1.00 (0.98-1.01)</td>
</tr>
<tr>
<td>Visual Memory (%-ile)</td>
<td>24.9%</td>
<td>26.6%</td>
<td>22.5%</td>
<td>1.01 (0.99-1.03)</td>
</tr>
<tr>
<td>Reaction Time (%-ile)</td>
<td>34.9%</td>
<td>33.6%</td>
<td>36.8%</td>
<td>1.00 (0.98-1.01)</td>
</tr>
<tr>
<td>Processing Speed (%-ile)</td>
<td>30.4%</td>
<td>30.5%</td>
<td>30.3%</td>
<td>1.00 (0.99-1.02)</td>
</tr>
<tr>
<td>PCSS Total (in PED)</td>
<td>25</td>
<td>30</td>
<td>18</td>
<td>1.05 (1.02-1.09)</td>
</tr>
</tbody>
</table>
ImPACT in Predicting Recovery

<table>
<thead>
<tr>
<th></th>
<th>Prolonged Recovery</th>
<th>Short Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor Performance</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>Good Performance</td>
<td>39</td>
<td>30</td>
</tr>
</tbody>
</table>

@1 week

<table>
<thead>
<tr>
<th></th>
<th>Prolonged Recovery</th>
<th>Short Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor Performance</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Good Performance</td>
<td>19</td>
<td>42</td>
</tr>
</tbody>
</table>

@2 weeks

SN = 30 PPV = 71 SP = 81 NPV = 43
OR = 1.9 (0.6 - 5.7) p = 0.238
SN = 37 PPV = 48 SP = 78 NPV = 69
OR = 2.0 (0.7 - 6.1) p = 0.200
## PCSS in Predicting Recovery

<table>
<thead>
<tr>
<th></th>
<th>@1 week</th>
<th></th>
<th>@2 weeks</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prolonged Recovery</td>
<td>Short Recovery</td>
<td>Prolonged Recovery</td>
<td>Short Recovery</td>
</tr>
<tr>
<td>PCSS ≥40 in PED</td>
<td>18</td>
<td>4</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>PCSS &lt;40 in PED</td>
<td>38</td>
<td>33</td>
<td>18</td>
<td>45</td>
</tr>
</tbody>
</table>

SN = 32
SP = 89
PPV = 82
NPV = 47

OR = 3.9
(1.1 - 15.3)
p = 0.024

SN = 40
SP = 83
PPV = 57
NPV = 71

OR = 3.3
(1.1 - 10.5)
p = 0.020
Sub-analysis with Different PCSS Cut Off Scores

<table>
<thead>
<tr>
<th>PCSS Cut Off Value</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥29</td>
<td>48</td>
<td>78</td>
<td>77</td>
<td>50</td>
</tr>
<tr>
<td>≥33</td>
<td>39</td>
<td>89</td>
<td>85</td>
<td>49</td>
</tr>
<tr>
<td>≥40</td>
<td>32</td>
<td>89</td>
<td>82</td>
<td>47</td>
</tr>
<tr>
<td>≥45</td>
<td>20</td>
<td>97</td>
<td>92</td>
<td>44</td>
</tr>
</tbody>
</table>
Young athletes that remained symptomatic at 1 week were more likely to report in the PED

- Headache  OR 5.4  (1.7-17.0), p<0.05
- Fatigue  OR 3.4  (1.4-8.5), p<0.05
- Difficulty concentrating  OR 2.4  (1.0-5.8), p<0.05
Conclusions
Conclusions

- The majority of young athletes that presented to a PED with concussions remained symptomatic at 1 week post injury
  - Almost half had returned to athletic activities despite complaining of symptoms at 1 week
- A history of one or more prior concussions may be a risk factor for prolonged symptoms in subsequent concussions
- Poor ImPACT performance acutely after injury in the PED did not predict persistence of concussive symptoms
Conclusions

- Young athletes with a high **PCSS** raw score of 40 or more in the PED are about 4 and 3 times more likely to remain symptomatic at 1 and 2 weeks post injury, respectively
  - Using a cutoff score of 33 provided similar specificity and slightly improved sensitivity

- Young athletes that remained symptomatic at 1 and 2 weeks were more likely to report headache, fatigue, and difficulty concentrating in the PED
Limitations of Study

- The timing of ImPACT testing for a number of the athletes also coincided with late-night hours and bedtime which may have affected performance.

- We powered our study with a goal of obtaining at least 50 patients in each outcome group.
  - We did not achieve this.
Take Home Message

- A simple, quick symptom inventory conducted in the PED for young concussed athletes was helpful in predicting prolonged recovery, yet a time consuming computerized neurocognitive test does not appear to be helpful.
Acknowledgements

- Lynn Babcock MD, Co-Investigator
- Wendy Pomerantz MD, Co-Investigator
- Jarrod Peebles, Lead Research Coordinator
- Lynn Mullins, Data Management
- Mona Ho, CCHMC, Division of PEM, for statistical support
- Richard Ruddy MD, CCHMC, for mentorship
Questions??????