Development of a Decision Rule for Children at High Risk of Prolonged Post-Concussive Syndrome

Kara Seaton MD1, Robert Doss PsyD2,3, Joseph Petronio MD2, Henry Ortega MD1, and Anupam Kharbanda MD1
1Children’s Hospitals and Clinics of Minnesota Division of Emergency Medicine, 2Children’s Neuroscience Center, 3Minnesota Epilepsy Group

Background
• One out of every 220 Pediatric Emergency Department visits is for concussion.
• While many children have an uneventful recovery, some will go on to have prolonged symptoms lasting weeks to months.
• To date, there is no consensus on how to predict which patients will have a typical recovery, and which will develop prolonged post-concussive syndrome (PCS) at the time of injury.

Objective
• To identify clinical parameters associated with prolonged PCS in pediatric patients diagnosed with concussion.
• To develop a clinical decision rule to identify children at high risk for prolonged post-concussive symptoms.

Methods
• Study Design: Retrospective cohort study, with data collected from September 2011 through February 2013.
• Subjects: Children 8-18 years who were diagnosed with concussion and sought care at a multidisciplinary concussion clinic.
• Outcome: Prolonged recovery, with symptoms lasting > 14 days.
• Exclusion Criteria: Age < 8 years, neurosurgical intervention, abnormal findings on radiologic studies, or unknown time to recovery.
• Analysis: We used the Chi-square test for categorical variables, and t-test for continuous variables. Variables that were significantly associated with prolonged PCS were then analyzed using recursive partitioning (RP) to develop a high risk clinical decision tool. In model creation, we aimed for a sensitivity > 90% and a specificity of > 20%.

Key Results
• A total of 472 patients were enrolled over the 18 month study period, with 415 patients eligible for inclusion in the study.
• Gender was significantly associated with recovery, with females being more likely to have PCS (p = 0.004).
• The following parameters were not significantly associated with developing PCS: headache, loss of consciousness, wearing a helmet, problems with gait, or history of prior concussion, migraine, or depression.
• The RP model identified a) abnormal Romberg or b) normal Romberg with the presence of dizziness as key parameters associated with increased risk of PCS.
  - Sensitivity of 85.5% (95% CI 81.1-89.1)
  - Specificity of 37.8% (95% CI 28.0-48.7)

Conclusion
• Patients who present with concussion and have an abnormal Romberg or dizziness at the time of injury are at higher risk of PCS.
• This rule could easily be utilized in the ED to quickly assess patient risk.
• Early identification of patients at high risk for PCS could help to set reasonable expectations about recovery for families, including return to school and return to play.

Limitations
• Single center study.
• Our patient population was skewed towards a longer recovery, which may represent a selection bias of patients evaluated in the concussion clinic.
• Before clinical usage, it will be necessary to further assess the clinical decision tool. Ideally this would be done using a prospective, multicenter approach.

Results

Table 1. Demographics.

<table>
<thead>
<tr>
<th>Clinical Predictor</th>
<th>All patients</th>
<th>Normal recovery</th>
<th>Prolonged recovery</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>13.2 (SD = 2.5)</td>
<td>12.8 (SD = 2.8)</td>
<td>13.3 (SD = 2.4)</td>
<td>0.08</td>
</tr>
<tr>
<td>Male gender</td>
<td>255 (61%)</td>
<td>67 (74%)</td>
<td>188 (58%)</td>
<td>0.004</td>
</tr>
<tr>
<td>Recovery time (days)</td>
<td>28 (IQR = 16-52)</td>
<td>10 (IQR = 4-12)</td>
<td>36 (IQR = 22-62)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Table 2. Clinical predictors of prolonged recovery.

<table>
<thead>
<tr>
<th>Clinical Predictor</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>PPV, %</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vomiting</td>
<td>9.9</td>
<td>78.9</td>
<td>62.7</td>
<td>0.014</td>
</tr>
<tr>
<td>Dizziness</td>
<td>79.6</td>
<td>42.2</td>
<td>83.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Difficulty with balance</td>
<td>56.5</td>
<td>63.3</td>
<td>84.7</td>
<td>0.002</td>
</tr>
<tr>
<td>Romberg test</td>
<td>42.8</td>
<td>85.0</td>
<td>91.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Tandem gait test</td>
<td>24.2</td>
<td>93.4</td>
<td>93.0</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Figure 1. RP analysis model correctly identifies 278 of the 325 patients with prolonged recovery.