Validation of Shock Index Pediatric-Adjusted (SIPA) for Children Injured in Warzones

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BACKGROUND

- Challenges in warzone pediatric trauma

- Staff
  - Surgeons
  - Technicians

- Resources
  - Blood Products
  - Consumables
Pediatric trauma in an austere combat environment

Philip C. Spinella, MD; Mathew A. Borgman, MD; Kenneth S. Azarow, MD

- Admissions to combat support hospitals 2001-2007
BACKGROUND

• What is SIPA?

\[
SI = \frac{Heart \ Rate \ (HR)}{Systolic \ Blood \ Pressure \ (SBP)}
\]

• Advantages
  • Rapidly calculated
  • Objective
  • Noninvasive
  • Reproducible
Pediatric specific shock index accurately identifies severely injured children

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Validation of the age-adjusted shock index using pediatric trauma quality improvement program data

Andrew Nordin a,b, Alan Coleman a, Junxin Shi c,d, Krista Wheeler c,d, Henry Xiang d,e, Shannon Acker f, Denis Bensard g, Brian Kenney a,c,*
The purpose of this study was to determine the utility of SIPA for the evaluation of pediatric patients injured in warzones.
METHODS

• Retrospective review
  • Pediatric trauma patients
• Department of Defense Trauma Registry (DoDTR)
• 2008 to 2015
METHODS

• Inclusion Criteria
  • Age < 18 years
  • Traumatic injury

• Exclusion Criteria
  • Age/Vital signs missing (HR or SBP)
  • First record of care at tertiary center
• Stratification
• Age Category
• Normal v. Elevated SIPA

<table>
<thead>
<tr>
<th>Age Category (years)</th>
<th>Heart Rate Range</th>
<th>Systolic Blood Pressure Range</th>
<th>SIPA Threshold Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>70-110</td>
<td>90-110</td>
<td>&gt;1.2</td>
</tr>
<tr>
<td>4-6</td>
<td>65-110</td>
<td>90-110</td>
<td>&gt;1.2</td>
</tr>
<tr>
<td>7-12</td>
<td>60-100</td>
<td>100-120</td>
<td>&gt;0.9</td>
</tr>
<tr>
<td>13-17</td>
<td>55-95</td>
<td>100-135</td>
<td>&gt;0.9</td>
</tr>
</tbody>
</table>
### Methods

#### Primary Outcomes

<table>
<thead>
<tr>
<th>Blood Product Transfusion (BPT)</th>
<th>Emergent Surgical Procedure (ESP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• PRBCs</td>
<td>• Craniotomy</td>
</tr>
<tr>
<td>• Whole Blood</td>
<td>• Thoracotomy</td>
</tr>
<tr>
<td>• FFP</td>
<td>• Exploratory Laparotomy</td>
</tr>
<tr>
<td>• Platelets</td>
<td>• Fasciotomy</td>
</tr>
<tr>
<td>• Cryoprecipitate</td>
<td></td>
</tr>
</tbody>
</table>
### METHODS

- **Secondary Outcomes**
  - ICU admission
  - ISS
  - Severe injury
  - Mechanical ventilation
  - Advanced imaging

- **Mortality**
  - Patient demographics
  - Injury mechanism
  - Injury pattern
• Descriptive statistics
• Univariate analysis
• Binary logistic regression analysis
  • Age category, gender, ISS, and GCS
• Testing characteristics
  • Sensitivity, specificity, PPV, NPV, Youden Index (YI)
RESULTS

Total Patients: 28,163

Met Criteria: 2,121

Elevated SIPA: 921 (43.4%)

Elevated SI: 1,613 (76.0%)
MECHANISM OF INJURY

- Blast: 44.8%
- GSW: 19.1%
- MVA: 12.4%
SUMMARY OF OVERALL OUTCOMES

- Blood Product Transfusion: 35.5%
- Emergent Surgical Procedure: 19.0%
- ICU Admission: 42.1%
- Severely Injured (ISS > 15): 31.8%
- Mechanical Ventilation: 9.8%
- Mortality: 7.2%
COMPARISON OF PRIMARY OUTCOMES BY SIPA CLASSIFICATION

**RESULTS**

<table>
<thead>
<tr>
<th>PRIMARY OUTCOMES</th>
<th>Normal SIPA</th>
<th>Elevated SIPA</th>
<th>Normal SI (SI&lt;0.8)</th>
<th>Elevated SI (SI≥0.8)</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Product Transfusion</td>
<td>25.0%</td>
<td>49.2%</td>
<td>26.2%</td>
<td>38.4%</td>
<td>*p&lt;0.001</td>
</tr>
<tr>
<td>Emergent Surgical Procedure</td>
<td>16.0%</td>
<td>22.9%</td>
<td>17.5%</td>
<td>19.5%</td>
<td>†p=0.364</td>
</tr>
</tbody>
</table>
RESULTS

COMPARISON OF SECONDARY OUTCOMES BY SIPA CLASSIFICATION

ICU Admission
- Normal SIPA: 36.1%
- Elevated SIPA: 49.9%

Severely Injured (ISS>15)
- Normal SIPA: 23.9%
- Elevated SIPA: 42.1%

Mechanical Ventilation
- Normal SIPA: 5.9%
- Elevated SIPA: 14.9%

Mortality
- Normal SIPA: 4.8%
- Elevated SIPA: 10.3%

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*p<0.001  ‡p=0.017  †p=0.014
• Binary logistic regression analysis

**RESULTS**

**ODDS RATIOS FOR BLOOD PRODUCT TRANSFUSION**
- Elevated SI
  - Odds Ratio: 1.62*
- Elevated SIPA
  - Odds Ratio: 2.36*

**ODDS RATIOS FOR EMERGENT SURGERY**
- Elevated SI
  - Odds Ratio: 1.04†
- Elevated SIPA
  - Odds Ratio: 1.29‡

* p<0.001  †p=0.044  ‡p=0.778
### TESTING CHARACTERISTICS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Elevated SIPA</th>
<th>Elevated SI (SI≥0.8)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blood Product Transfusion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>60.6</td>
<td>82.3</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>65.8</td>
<td>27.4</td>
</tr>
<tr>
<td>PPV (%)</td>
<td>49.2</td>
<td>38.4</td>
</tr>
<tr>
<td>NPV (%)</td>
<td>75.0</td>
<td>73.8</td>
</tr>
<tr>
<td>Youden Index</td>
<td>0.264</td>
<td>0.097</td>
</tr>
<tr>
<td><strong>Emergent Surgical Procedure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>52.4</td>
<td>77.9</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>58.7</td>
<td>24.4</td>
</tr>
<tr>
<td>PPV (%)</td>
<td>22.9</td>
<td>19.5</td>
</tr>
<tr>
<td>NPV (%)</td>
<td>84.0</td>
<td>82.5</td>
</tr>
<tr>
<td>Youden Index</td>
<td>0.111</td>
<td>0.023</td>
</tr>
</tbody>
</table>
DISCUSSION

• Limitations
  • Retrospective study
  • Exclusion of patients with absent vitals
  • Humanitarian care
  • Generalizability of findings
CONCLUSION

• Conclusions
  • Elevated SIPA was associated with increased need for blood product transfusion and emergent surgery
  • Comparing SIPA to “unadjusted” SI
  • Role in the initial evaluation of pediatric warzone trauma
Questions

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