Shock Index and Injury Severity Score: Predictors of Mortality After Multi-System Trauma

Kate Moore, DNP, RN
To compare calculated pre-hospital shock index and calculated ED shock index with the Injury Severity Scores reported in the National Trauma Data Bank in their ability to predict death within 48 hours of sustaining traumatic injuries.
Death from Injury

- Injury: 90,000 deaths
- Non-Communicable Diseases: 50,000 deaths
- Infectious Diseases: 10,000 deaths
Unintentional injury is the 5\textsuperscript{th} leading cause of death in the US, at 38.4/100,000
MVC deaths, 11.2/100,000
All injury deaths 57.7/100,000
Leading cause of death ages 1-44
Leading cause of death in males, ages 1-44
Leading cause of death in females, ages 1-34
Assessing Injury Severity

- Multiple, complex injuries
- Often not fully manifested at time of initial examination
- Limits of time and resources pre-hospital
- Transport issues
Anatomic Scores
- Abbreviated Injury Scale (AIS): probability of threat to life based on individual injury, describes type, location and severity of injury
- Injury Severity Score (ISS): sum of the squares of the AIS for the 3 most severely injured regions

Physiologic Scores
- Revised Trauma Score (RTS): physiologic scoring system, includes GCS, SBP and RR, range 0 to 4

Combined Score
- Trauma Score-Injury Severity Score (TRISS): mathematic model of probability of survival
- Anatomical scoring system
- Provides a reasonably accurate ranking of injury severity
- Represents the 'threat to life' associated with an injury
- Not meant to represent a comprehensive measure of severity.

<table>
<thead>
<tr>
<th>AIS Score</th>
<th>Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minor</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
</tr>
<tr>
<td>3</td>
<td>Serious</td>
</tr>
<tr>
<td>4</td>
<td>Severe</td>
</tr>
<tr>
<td>5</td>
<td>Critical</td>
</tr>
<tr>
<td>6</td>
<td>Unsurvivable</td>
</tr>
</tbody>
</table>
ISS

- Anatomical scoring system that provides an overall score for patients with multiple injuries
- Each injury is assigned an AIS score allocated to one of six body regions (Head, Face, Chest, Abdomen, Extremities, External)
- Only the highest AIS score in each body region is used
- The 3 most severely injured body regions have their score squared and added together to produce the ISS score.
# RTS

- Physiologic scoring system
- High inter-rater reliability
- Demonstrated accuracy
- Scored from first set of data obtained
- Heavily weighted toward GCS
- Does not account for compensated shock

<table>
<thead>
<tr>
<th>GCS</th>
<th>SBP</th>
<th>RR</th>
<th>Coded Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-15</td>
<td>&gt;89</td>
<td>10-29</td>
<td>4</td>
</tr>
<tr>
<td>9-12</td>
<td>76-89</td>
<td>&gt;29</td>
<td>3</td>
</tr>
<tr>
<td>6-8</td>
<td>50-75</td>
<td>6-9</td>
<td>2</td>
</tr>
<tr>
<td>4-5</td>
<td>1-49</td>
<td>1-5</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
TRISS determines the probability of survival (Ps) of a patient from the ISS and RTS using a mathematical formula.

The TRISS calculator determines the probability of survival from the ISS, RTS and patient's age.
ISSLOC – reflects the patient injuries as calculated by the receiving hospital
ISSICD – derived by converting ICD-9 codes to an AIS then calculating ISS
ISSAIS – ISS calculated from the AIS by the receiving facility
The Problem

- These scores cannot be calculated on the scene by EMS personnel to make transport decisions
- These scores are not easily calculated in the ED
- ISSICD requires addition of ICD-9 codes to the score
Searching for a Solution

- Identify a major cause of early trauma death
- To determine a field expedient, accurate scoring system
- To use that system to ensure the right patient is taken to the right place in the right amount of time
- Goal: to improve outcomes in trauma care
- To provide the right care, right now
Clinical Outcome of Interest

- Shock
- Hemorrhagic Shock
- Hemorrhagic Shock in Trauma
Shock

- Inadequate tissue oxygenation to meet tissue oxygen requirements
- Condition of the inadequate delivery of oxygen and nutrients necessary for normal tissue and cellular function
- State of inadequate tissue perfusion in which delivery of oxygen to tissues and cells is insufficient to maintain normal aerobic metabolism
ANTICIPATION STAGE

- The disease has started but remains local.
- You should already suspect that shock could appear if the underlying disease is left undiagnosed and untreated.
- Parameters are stable and within normal limits.
- There is usually enough time to diagnose and treat the underlying condition.
Anticipation Stage

Parameters (SBP, Pulse, Bicarbonate, Lactic acid) stay within their normal limits.

- **Systolic Blood Pressure**: 120-100 mmHg
- **Pulse**: 60-100 BPM
- **serum Bicarbonate**: 23-30 meq/liter
- **Lactic Acid**: 0.6-1.8 mmol/liter

 ![Graph showing stages of anticipation with parameters changing over time](image)
Pre-Shock

- The disease is now systemic.
- Parameters drift, slip and slide and start hugging the upper or lower limit of their normal range, but there is no shock yet!
- The absence of shock is due to the fact that compensatory mechanisms are at play.
- The condition of pre-shock is, sadly, completely missed by many clinicians.
Pre-Shock

Parameters still stay within their normal limits but drift toward their upper or normal limits. Things are changing.
Compensated Shock

- Compensated shock can start with low normal blood pressure.
- The proof that a patient is in shock with normal blood pressure is the appearance of metabolic acidosis due to some organ hypoperfusion.
- The reason for normotension is that blood pressure is maintained initially due to marked activation of many compensatory mechanisms (including the sympathetic nervous system).
- However, because organs suffer from inadequate perfusion, it is already a state of shock.
Compensated Shock

Parameters start to leave their normal limits. Systolic blood pressure can still be low normal, while acidosis appears. In those cases this is called "normotensive" shock... Things are moving faster and faster.

Stage 1  Stage 2  Stage 3  Stage 4  Stage 5

Systolic Blood Pressure
120-100 mmHg

Pulse
60-100 BPM

serum Bicarbonate
23-30 meq/liter

Lactic Acid
0.6-1.8 mmol/liter

Striped Giraffe Press © September 2005
• Everybody call this "SHOCK" because hypotension is always present at this stage.,
• Normotension can only be restored with intravenous fluid (if indicated) and/or vasopressors.
• If you have not diagnosed the cause of shock by now, it will be very difficult to treat your patient
• Organs now suffer MODS and acidosis is becoming rapidly more and more severe.
• This systemic suffering worsens shock itself (vicious cycles) and leads to catastrophic microvascular damage, DIC and SIRS.
Decompensated Shock, Reversible

All parameters are outside their normal limits. The deviations continue faster and faster. But things can still be reversed at this stage, using maximal efforts and all resources.
Microvascular and organ damage are now irreversible.

There is often a "last ditch" effort from the ischemic midbrain with an enormous discharge of endogenous catecholamines and this can create a last spike of sinus tachycardia.

This is the "whoops! stage" --- too late to be able to turn things around.
Decompensated Shock, Irreversible

Parameters change rapidly, in an exponential fashion.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
<th>Stage 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic Blood Pressure</td>
<td>120-100</td>
<td>100-120</td>
<td>90-100</td>
<td>80-90</td>
<td>70-80</td>
</tr>
<tr>
<td>Pulse</td>
<td>60-100</td>
<td>90-120</td>
<td>100-120</td>
<td>110-130</td>
<td>120-140</td>
</tr>
<tr>
<td>Lactic Acid</td>
<td>0.6-1.8 mmol/liter</td>
<td>1.1-1.5 mmol/liter</td>
<td>1.5-2.0 mmol/liter</td>
<td>2.0-2.5 mmol/liter</td>
<td>&gt;2.5 mmol/liter</td>
</tr>
</tbody>
</table>
Microvascular Changes in Shock

• The changes are mainly due to a "cytokine storm" induced by severe tissue ischemia
  • (1) the endothelium is activated (vasodilates, becomes pro-coagulant, expresses adhesion molecules)
  • (2) monocytes are activated (and discharge numerous cytokines)
  • (3) white blood cells obstruct some capillaries
  • (4) disseminated intra-vascular coagulation and platelet aggregation plug microcirculation as well
• With so much deterioration to the microcirculation, perfusion to organs worsens rapidly
• Systemic shock also worsens extremely rapidly
Microvascular Changes in Shock

- Activated endothelium
- Fibrin (intravascular coagulation)
- Plugging of capillaries by white blood cells
- Activated monocyte secreting cytokines
- Plugging of capillaries by aggregating platelets
- Leaky endothelium

Striped Giraffe Press © 2005
Shock as a Causative Factor

- Blunt injuries lead to organ damage with potential for hemorrhage
- Penetrating injuries damage and sever vessels with potential for hemorrhage
- Mixed type injuries include both organ damage and vessel damage with potential for hemorrhage
Shock Index

- Measures of Shock
- Heart rate divided by systolic blood pressure, normal range 0.5 to 0.7
- Since HR and SBP alone are insensitive indicators in instability due to compensatory mechanisms of the body shock index provides a more sensitive indicator of the hemodynamic instability
- Shock index is a marker of hemodynamic instability not influenced by compensation.
Specific Aims

- To determine if SI recorded by EMS at the scene and reported injury severity scores are independent predictors of mortality
- To determine if SI recorded in the ED and reported injury severity scores are independent predictors of mortality
- To determine the best predictive model of the probability of mortality
Methods

- Secondary data analysis of 2009 National Trauma Data Bank
- Logistic regression applied to evaluate the predictive ability of the variables of interest
Demographics of Sample

- $n = 516,156$
- Mean age: 43 years (16-80)
- Gender: 68% male
- Ethnicity: 70% white
Results Specific Aim 1

- To determine if SI recorded by EMS at the scene and reported injury severity scores are independent predictors of mortality
- EMS SI, ISSAIS and ISSICD were significant predictors of the probability of death within 48 hours
- ISSAIS produced the strongest likelihood of predicting death within 48 hours
## EMS SI and ISS (n= 516,156)

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>p value</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMS SI</td>
<td>1.03</td>
<td>&lt;0.001</td>
<td>1.028</td>
<td>1.032</td>
</tr>
<tr>
<td>ISSLOC</td>
<td>1.02</td>
<td>0.08</td>
<td>0.998</td>
<td>1.047</td>
</tr>
<tr>
<td>ISSAIS</td>
<td>1.07</td>
<td>&lt;0.001</td>
<td>1.043</td>
<td>1.094</td>
</tr>
<tr>
<td>ISSICD</td>
<td>1.01</td>
<td>&lt;0.001</td>
<td>1.010</td>
<td>1.018</td>
</tr>
</tbody>
</table>
Results Specific Aim 2

- To determine if SI recorded in the ED and reported injury severity scores are independent predictors of mortality.
- ED SI, ISSAIS, and ISSICD were significant predictors of the probability of death within 48 hours.
- ISSAIS produced the strongest likelihood of predicting death within 48 hours.
### ED SI and ISS (n= 516,156)

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>p value</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED SI</td>
<td>1.103</td>
<td>&lt;0.001</td>
<td>1.071</td>
<td>1.135</td>
</tr>
<tr>
<td>ISSLOC</td>
<td>1.015</td>
<td>0.20</td>
<td>0.994</td>
<td>1.036</td>
</tr>
<tr>
<td>ISSAIS</td>
<td>1.077</td>
<td>&lt;0.001</td>
<td>1.056</td>
<td>1.099</td>
</tr>
<tr>
<td>ISSICD</td>
<td>1.018</td>
<td>&lt;0.001</td>
<td>1.015</td>
<td>1.021</td>
</tr>
</tbody>
</table>
Results Specific Aim 3

- To determine the best predictive model of the probability of mortality
- EMS SI, ED SI, ISSAIS and ISSICD were significant predictors of the probability of death within 48 hours
- ED SI produced the strongest likelihood of predicting death within 48 hours
### EMS SI, ED SI and ISS (n= 516,156)

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>p value</th>
<th>Lower CI</th>
<th>Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMS SI</td>
<td>1.019</td>
<td>&lt;0.001</td>
<td>1.016</td>
<td>1.022</td>
</tr>
<tr>
<td>ED SI</td>
<td>1.168</td>
<td>&lt;0.001</td>
<td>1.125</td>
<td>1.212</td>
</tr>
<tr>
<td>ISSLOC</td>
<td>1.008</td>
<td>0.558</td>
<td>0.982</td>
<td>1.034</td>
</tr>
<tr>
<td>ISSAIS</td>
<td>1.082</td>
<td>&lt;0.001</td>
<td>1.054</td>
<td>1.110</td>
</tr>
<tr>
<td>ISSICD</td>
<td>1.016</td>
<td>&lt;0.001</td>
<td>1.011</td>
<td>1.020</td>
</tr>
</tbody>
</table>
ED Shock Index was the strongest predictor of death within 48 hours of admission.
For each unit increase in calculated ED Shock Index, the odds of death within 48 hours increased by 17%.
While ISSAIS and ISSICD are significant predictors of the probability of death within 48 hours, they are not easily calculated in the field or in the ED.

Shock Index is easily calculated any time clinicians have access to heart rate and systolic blood pressure.
Future Steps

- To identify a group of measures, available on admission to the Emergency Department, that are early markers of morbidity and mortality in a population of patients with multiple trauma injuries.
- To develop a clinical instrument using those markers to identify high-risk patients earlier in the course of treatment and evaluation.
Questions