Accuracy of Shock Index as A Predictor Tool for Differentiating Major from Minor Injuries in Adult Trauma Patients Attending to Emergency Department at Suez Canal University Hospital

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Abstract

**Background:** The importance of early recognition of hemorrhagic shock and its effects on outcome have long been recognized. Traditional vital signs are relatively insensitive as early diagnostic markers of hemorrhage. The Shock Index (SI); Heart Rate (HR) divided by Systolic Blood Pressure (SBP), has been suggested as such a marker. We tested the accuracy of the SI in differentiating major from minor injury in trauma patients.

**Aim:** To assess accuracy of shock index as a simple and early predictor marker in differentiating major from minor injuries in trauma patients in Emergency Department at Suez Canal University Hospital.

**Patients and Methods:** This cross sectional study was conducted on 106 trauma patients, both genders and all age groups above 18 years old, admitted to Emergency Department at Suez Canal University Hospital. Demographics, injury mechanism, HR, SBP, base deficit and lactate were recorded and Injury Severity Score were calculated. Major injury was defined as either death within 24 hours, Injury Severity Score (ISS) <=16, Intensive Care Unit (ICU) stay <=1 day or amount of Blood Transfused (BT) <=2 units.

**Results:** One hundred and six trauma patients were enrolled. There was 54.72% of patients has minor trauma and 45.28% of patients has major trauma. The area under the receiver operator characteristic curves for SI [0.98 95% Confidence Interval (CI) 0.92-0.99] was significantly more than that for base deficit (0.91, 95% CI: 0.84-0.95) or lactate (0.94, 95% CI: 0.87-0.97). Shock index was found to have higher sensitivity (95.83%) and specificity (96.55%) compared to either heart rate or systolic blood pressure alone.

**Conclusion:** The current study has shown that shock index is the most accurate parameter (with highest sensitivity and specificity) in differentiating major from minor trauma patients compared to base deficit and serum lactate. So, shock index can be conducted as a simple and early sensitive and specific predictor marker in differentiating major from minor injuries in trauma patients.

**Key Words:** Shock index – Trauma – Hemorrhagic shock – Mortality – Prediction.

Introduction

TRAUMA is an injury to the body that occurs when an uncontrolled force or acute source of energy makes contact with the body and the body cannot tolerate it [1].

Trauma accounts for 5 million deaths per year, of which 1 million are in Europe. It is estimated that in 2014 the annual trauma-related mortality worldwide increase to 8.4 million [2].

Regardless of the mechanism of injury, hemorrhage is a leading cause of death following trauma. Injury-induced hemorrhage accounts for the largest proportion of mortality within the first hour of trauma center care, causes 50% of injury-associated death within the first 24 hours of trauma care [1].

Although Blood Pressure (BP) is an easy and universal tool for monitoring patients developing shock, data are lacking that clarify the most specific phase in shock patients. A normal BP can be sustained despite loss of up to 30% of blood volume [3].

The importance of early recognition of hemorrhagic shock and its effects on outcome have long been recognized. Traditional vital signs are relatively insensitive as early diagnostic markers of hemorrhage [4].

The normal ratio of heart rate to systolic blood pressure (HR to SBP) is generally >0.7. This ratio is elevated in the setting of acute hypovolemia and circulatory failure and is referred to as the Shock Index (SI). It has been used as a marker for severity of injury and poor outcome in trauma patients [8].
Measurement of the shock index is more useful in predicting early shock than either the HR or the SBP alone and has been shown to correlate with other indices of end-organ perfusion such as central venous oxygen saturation and arterial lactic acid concentration [6].

Many studies suggested that the Shock Index (SI) may be a tool in predicting major injuries in trauma patients when it is abnormal even when other biochemical parameters are not (as serum lactate and base deficit) [4].

Base deficit is the amount of base, in millimoles, required to titrate 1 L of whole arterial blood to a pH of 7.40, it consider a sensitive measure of both the degree and the duration of inadequate perfusion [7]. Lactate is often considered a measure of tissue hypoxia. However, it can be elevated in nonhypoxic situations [8].

So the Shock Index (SI); Heart Rate (HR) divided by Systolic Blood Pressure (SBP) was suggested in our study as a simple and early predictor marker in differentiating major from minor injuries in trauma patients.

**Aim of the work:**

To assess accuracy of shock index as a simple and early predictor marker in differentiating major from minor injuries in trauma patients in Emergency Department at Suez Canal University Hospital.

**Material and Methods**

This study was conducted as cross sectional study in trauma patients in the Emergency Department at Suez Canal University Hospital. The study was conducted from March 2013 to February 2014. The calculated sample size was 106 patients.

**Inclusion criteria:**

Both genders, adult patients (more than 18 years old) and different patterns of trauma.

The following patients were excluded from the study: Patients discharge on his demand, transferred to other hospitals or escaped, patients with chronic diseases as hypertension, cardiac disease, chronic liver disease, diabetes mellitus or others and burn patients and patients on long term treatment as anticoagulants, antiarrhythmic or others.

The clinical data was collected by the researcher in a pre-organized data sheet for each patient, the following were studied: Socio-demographic data, Clinical evaluation regarding: Initial assessment of ABCDE (air way and cervical spine control, breathing, circulation, dysfunction of the central nervous system and exposure), regional examination, calculate the shock index for each patient, assess Injury Severity Score (ISS).

**Laboratory investigations, as:**

- Complete blood count, blood typing and cross matching and coagulation profile, arterial blood gas (base deficit) and serum lactate.

**Treatment and follow-up:**

- Major injury was defined as either death within 24 hours, injury severity score (ISS) ≤ 16, Intensive Care Unit (ICU) stay ≤1 day or amount of Blood Transfused (BT) ≤2 units.

**Results**

Table (1) shows that 54.72% of patients has minor trauma and 45.28% of patients has major trauma.

Table (2) shows that only one of minor trauma patients has heart rate >1 00 beat/min and systolic blood pressure >89mmHg.

Table (3) shows that 70.83% of major trauma patients have shock index >0.9 versus none of minor trauma patients with statistically significant difference.

Table (4) shows 37.50% of major trauma patients have serum lactate >4mmol/L versus none of minor trauma patients with statistically significant difference. 60.42% and 22.92 of major trauma patients have base deficit -6 - -10mmol/L and >-10 mmol/L respectively versus 5.17% and none of minor trauma patients respectively with statistically significant difference.

**Table (1): Distribution of major and minor injuries among the studied patients (n= 106).**

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major injuries</td>
<td>48</td>
<td>45.28%</td>
</tr>
<tr>
<td>Minor injuries</td>
<td>58</td>
<td>54.72%</td>
</tr>
</tbody>
</table>

**Table (2): Comparison between patients with major and minor outcomes regarding blood pressure and heart rate (n=106).**

<table>
<thead>
<tr>
<th></th>
<th>Major outcome</th>
<th>Minor outcome</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;100b/min</td>
<td>17</td>
<td>57</td>
<td>0.001*</td>
</tr>
<tr>
<td>&gt;100b/min</td>
<td>31</td>
<td>1</td>
<td>1.72%</td>
</tr>
<tr>
<td>Blood pressure:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systole &gt;89mmHg</td>
<td>21</td>
<td>57</td>
<td>0.001*</td>
</tr>
<tr>
<td>Systole ≤89mmHg</td>
<td>27</td>
<td>57</td>
<td>1.72%</td>
</tr>
</tbody>
</table>

*: Statistically significant difference.
Table (3): Comparison between patients with major and minor outcomes regarding shock index.

<table>
<thead>
<tr>
<th>Shock index</th>
<th>Major outcome</th>
<th>Minor outcome</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5-&lt;0.7</td>
<td>8</td>
<td>56</td>
<td>0.001*</td>
</tr>
<tr>
<td>0.7-0.9</td>
<td>6</td>
<td>2</td>
<td>3.45%</td>
</tr>
<tr>
<td>&gt;0.9</td>
<td>34</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

*: Statistically significant difference.

Table (4): Comparison between patients with major and minor outcomes regarding serum lactate and base deficit.

<table>
<thead>
<tr>
<th>Serum lactate</th>
<th>Major outcome</th>
<th>Minor outcome</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2mmol/L</td>
<td>7</td>
<td>51</td>
<td>0.001*</td>
</tr>
<tr>
<td>2-4mmol/L</td>
<td>23</td>
<td>7</td>
<td>12.07%</td>
</tr>
<tr>
<td>&gt;4mmol/L</td>
<td>18</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

| Base deficit | Class I (<-2mmol/L) | 4 | 8.33% | 51 | 87.93% | 0.001* |
|              | Class II (-2-/-6 mmol/L) | 4 | 8.33% | 4 | 6.90%  |
|              | Class III (-6-/-10mmol/L) | 29 | 60.42% | 3 | 5.17%  |
|              | Class IV (>10mmol/L)    | 11 | 22.92% | 0 | 0%     |

Graph (1): ROC curve characteristics of shock index for differentiating major trauma from minor trauma.

Graph (2): ROC curve characteristics of serum lactate for differentiating major trauma from minor trauma.

Graph (3): ROC curve characteristics of base deficit for differentiating major trauma from minor trauma.
Discussion

As regards the hemodynamics of major and minor trauma patients, the current study showed that only one of minor trauma patients has heart rate >100 beat/min and systolic blood pressure ≥89 mmHg. 64.58% of major trauma patients have heart rate >100 beat/min while 56.25% of them have systolic blood pressure ≥89mmHg with statistically significant differences. Evaluation of critically ill patients based on vital signs can be misleading and may underestimate the severity of shock. BP and pulse are known to have poor correlation with cardiac index [9].

In a recent study by Bruijns et al., [10] have found that shock index is better than heart rate and systolic blood pressure for detecting 48 hours mortality among trauma patients. Area under the curve was 79% for shock index while it was only 69% and 66% for heart rate and systolic blood pressure respectively [10].

Consistently, Birkhahn et al., [11] showed that the SI was a better marker than heart rate or systolic blood pressure in identifying blood loss.

Shock index was found to have higher sensitivity, specificity and predictive values compared to either heart rate or systolic blood pressure alone. This is consistent with Durukan et al., (2009) [12] who have found that after a small amount of acute blood loss, the shock index is better indicators of acute blood loss than heart rate and systolic blood pressure.

Shock index has been evaluated as a marker for significant injury in trauma patients as early as mid-90s. King et al., [13] has found that the optimal shock index values (by ROC analysis) for predicting the severity measures were 1.10 for death <24 hours, 0.71 for ISS ≥16, 0.77 for ICU ≥1 day, and 0.85 for BT ≥2 units. The optimal SI value (by ROC analysis) for any of the above measures was 0.83; use of this shock index cutoff provided a specificity of 83% (95% CI 80-87%). These findings are inconsistent with the current study as we have found that shock index is highly sensitive and highly specific for prediction of any of major trauma outcome (mortality, ICU admission or blood transfusion ≥2 units).

Clinically, Rady and coworkers have reported in 275 patients who presented to the ED for urgent medical care that SI >0.9 was associated with the need for immediate treatment and admission of the patient [14]. These findings support the findings of current study that has shown that shock index >0.6 is 95.83% sensitive and 96.55% specific in differentiating major from minor trauma patients.
Consistently, Mutschler and colleagues [15] have found that worsening of shock index was associated with increasing injury severity scores, increasing incidence of mortality and number of blood units transfused.

The current study has shown that serum lactate >1.9 is 85.42% sensitive and 87.93% specific in differentiating major from minor trauma patients while base deficit ≤–2 is 91.67% sensitive and 87.93% specific in differentiating major from minor trauma patients. Paladino et al., had recently assessed the additional use of Base Deficit (BD), as a sensitive indicator of blood loss. The principle was associating traditional triage vital signs with measuring tissue perfusion to distinguish major from minor trauma. In their retrospective single-center analysis, abnormal vital signs alone had 40.9% sensitivity in identifying major injury. When abnormal metabolic parameters were added, the detection of major trauma increased significantly to a sensitivity of 76.4% [16].

Conclusion:

Shock index is the most accurate parameter (with highest sensitivity and specificity) in differentiating major from minor trauma patients compared to base deficit and serum lactate or even heart rate and blood pressure alone, so, shock index can be conducted as a simple and early sensitive and specific predictor marker in differentiating major from minor injuries in trauma patients.

References

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