Evaluation of shock index in prediction of mortality in pediatric polytrauma

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Received: 31 October 2021
Revised: 21 November 2021
Accepted: 30 November 2021
Published: 10 October 2022

The Egyptian Journal of Surgery 2022, 41:203–207

Background
Pediatric trauma has a significant effect on childhood mortality. Shock index (SI) is a physiological score that evaluates trauma severity and also predicts early shock. Few studies exist in the literature regarding the use of the SI on defining the severity of trauma mortality. This study aimed to evaluate the performance of SI for prediction of trauma-related mortality in pediatric population.

Patients and methods
A prospective study was conducted that included 200 patients with polytrauma aged less than 16 years admitted to Emergency University Hospitals within 24 h of trauma from January 2019 till January 2021. SI was evaluated for all patients regarding receiver operating characteristic curve, sensitivity, specificity, positive predictive value, negative predictive value, accuracy, and cutoff points for prediction of mortality.

Results
SI was superior to injury severity score in prediction of mortality. A cutoff more than or equal to 0.9 of SI to predict mortality has a sensitivity of 97.62% and a specificity of 85.71, and a cutoff more than or equal to 21 of injury severity score has a sensitivity of 75% and a specificity of 80.95%. Higher SI was associated with a higher rate of death.

Conclusions
SI is a reliable predictor of mortality but needs to be investigated in detail. It is an applicable easy method for predicting mortality in pediatric emergency. This would evaluate early invasive monitoring and decision of ideal treatment in an ICU.

Keywords:
emergency, mortality, pediatric trauma, shock index

Egyptian J Surgery 2022, 41:203–207

1110-1121

Background

Trauma is a major source of childhood morbidity, long-life disability, and death in early life in developed countries [1]. Pediatric trauma is considered a worldwide issue, leading to more than 10 000 child mortalities annually, and ~10% of pediatric hospital admissions [2,3]. The trauma sequelae must be controlled with punctual management before and after hospital admission [4,5].

Trauma triage assessment is in need for a quantitative scale especially in trauma centers [6–9]. These scores and indices have been crucial in advancement of trauma care in the past two decades [10].

Variable parameters and indices were described to determine preoperative evaluation, medications, and the prognosis of pediatric trauma. Shock index (SI) can be used in their assessment. There are few studies in the literature about using of these indices on defining the severity of trauma and mortality [11–13].

Vital signs such as heart rate (HR), systolic blood pressure (SBP), and respiratory rate have been used by different groups of trauma to detect early mortality [14]. SI is calculated using the ratio between HR and SBP. It evaluates trauma severity and detects an early hemorrhagic shock [15–17].

The purpose of study was evaluation of SI in comparison with other trauma scores as a predictor of pediatric trauma-related mortality.

Patients and methods

This observational, retrospective cohort study was approved by the ethical committee of our institutional review board after ensuring confidentiality of patients' data besides receiving an informed verbal consent from patients' relatives. It included 200 pediatric patients aged less than 16 years of both sexes, who were admitted within 24 h after blunt polytrauma to the Emergency Department in Tanta University Hospitals from January 2019 till January 2021.

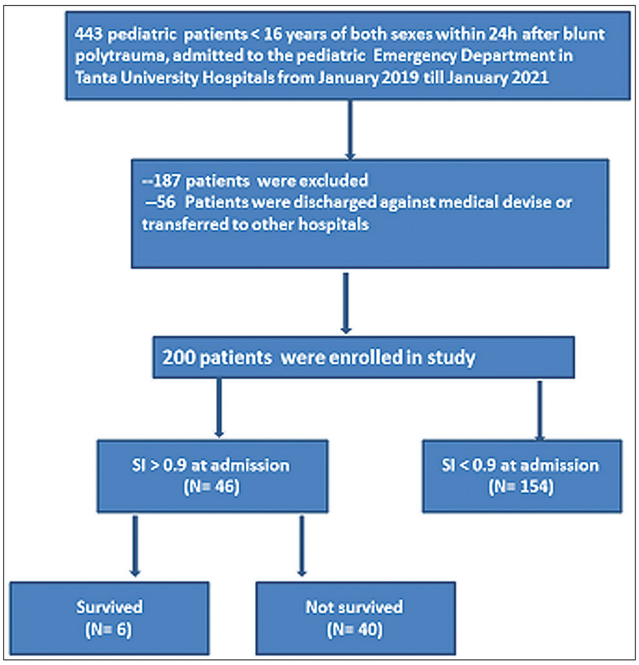
We excluded patients with major injuries, penetrating injuries, major burns, and chronic disabling diseases. Every patient's medical data were collected with respect to age, sex, onset and mechanism of trauma, prehospital drugs, past medical history, last meal, and events.

Additionally, SBP and HR were recorded considering their physiological differences in pediatric population. Blood gases and coagulation profile parameters were also recorded.

Injury severity score (ISS) criteria were noted in all six body regions and were calculated according to the abbreviated injury score, which was assigned to one of six different body regions. ISS was equal to the sum of squares of the highest abbreviated injury score code in each of the most severely affected three body regions. Admission details either in the ward or in ICU were taken (Fig. 1).

On arrival at the hospital, every patient was managed with the primary and then the secondary survey in the early 10–15 min according to Advanced Trauma Life

Figure 1



Algorithm of SI in evaluation of pediatric polytrauma. SI, shock index.

Support, including both the routine laboratory and radiological investigations. Bearing on severity, patients were managed by one or more of the following: bolus fluid therapy, blood or blood products transfusion, hyperosmolar therapy for intracranial hypertension, and operative interventions. SI was obtained from the HR to SBP ratio.

Statistical analysis

Statistical analysis was done using IBM SPSS statistics for windows, Version 23.0 (IBM Corp., Armonk, NY, USA). Quantitative variables were described in the form of mean and SD. Qualitative variables were described as number and percent using χ^2 test or Fisher's exact test when frequencies were less than five on comparison. Pearson correlation coefficients were used for association between two normally distributed variables. The receiver operating characteristic (ROC) curve was used for SI, HR, SBP, and ISS to predict mortality. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and cutoff points were also used. *P* value less than 0.05 was considered significant. The data sets used and analyzed during the current study are available from the corresponding author on reasonable request.

Results

Demographic data

A total of 200 child were divided into two groups: the first one of 40 nonsurvived cases and the second one was of 160 survived cases. Of all patients, 66% were male and 34% were female, with a mean age of 10.095 ± 3.562 years in the first group and 9.167 ± 4.572 years in the second one, with a range from 1 to 16 years among all patients. Road traffic accident (50%, *n*=100) and falling from height (37%, *n*=74) were the most common causes of injury, whereas run over and explosion constituted 12% (*n*=24) and 1% (*n*=2), respectively.

Outcome and clinical characteristics

Causes of mortality

Regarding mortality, brain damage (55%, *n*=22) and hemorrhagic shock (35%, *n*=14) were the most common causes of death, followed by rhabdomyolysis with hyperkalemia (5%, *n*=2) and severe respiratory distress with hypoxia (5%, *n*=2). There were 24 cases with compromised airway and six cases intubated in the nonsurvived group, rendering significant worsening in airway regarding nonsurvived group compared with survived group ($P \leq 0.001$). We observed hypotension, tachycardia, and tachypnea in nonsurvived group than survived one, which was statistically significant ($P<0.001$).

Correlation of shock index and injury severity score

Based on multivariate analysis, we studied the effect of multiple variables such as ISS, SBP, HR, and SI in correlation with each other and with mortality.

We observed 77% of our patients (154) had SI less than 0.9, and 23% of them (46) had SI more than 0.9. All dead cases had a high SI more than 0.9, and a higher SI was associated with higher odds of death, where the odds ratios were 2.255 and 95% confidence interval: 0.316–3.218, with a statistically significant difference (P<0.001) using logistic regression analysis. There was also a statistically significant increase in nonsurvived group regarding ISS, SBP, HR, and SI (P<0.001) (Table 1).

Using ROC curves, we analyzed the powers of SI, SBP, HR, and ISS for mortality prediction. Sensitivity, specificity, NPV, PPV, and accuracy of ISS, SBP, HR, and SI were calculated. They were independent predictors of mortality in pediatric polytrauma. We observed that ISS predicted mortality at a cutoff more than or equal to 21 and SI at a cutoff more than or equal to 0.9 (Table 2).

Discussion

Our study was conducted on 200 children aged less than 16 years with blunt polytrauma whose mean age was 9.352 years. Males represented 66% and females represented 34% of all cases, which can be explained by the fact that boys in our community are more active and prone to trauma than girls. Sultanoğlu *et al.* [18] conducted a study on 1510 patients whose mean age was 7.81 years, with male predominance of 59.5%. El-Gamasy *et al.* [19] conducted a study on 50 patients whose age ranged from 1 to 16 years, but 48% were males and 52% were females.

Regarding mortality, the mortality rate in our study was 20% (40 nonsurvived cases), which is more than that in the study by Grandjean-Blanchet *et al.* [20], where the mortality rate was 8.3% (28 nonsurvived cases) and the study by Davis *et al.* [21], where the mortality rate was 8% (50 died patients). However, the study by El-Gamasy *et al.* [19] revealed a higher mortality rate of 30% of the total cases (15 nonsurvived patients).

In our study, no significant difference regarding age was detected between nonsurvived and survived groups (P=0.388). This comes in agreement with the study by Nakayama *et al.* [22], which showed that pediatric survival is independent of the patients' age after injury control. Additionally, the study by Sarnaik *et al.* [23] showed no difference in mortality of children with different ages with severe traumatic brain injuries (P=0.58). In contrary, El-Gamasy *et al.* [19] found a decrease in the nonsurvivors' age in comparison with survivors' age, which was statistically significant (P=0.01).

In our study, mortality showed correlation with SI more than 0.9. All dead cases had a high SI more than 0.9. A higher SI was associated with higher odds of death. SI appears as a mortality predictor within 24 h from trauma. Berger and colleagues, Choi and colleagues, and Bruijns and colleagues showed in different series that the use of SI is predictive of mortality [24–27].

Using ROC curves, we analyzed the power of different trauma scores (ISS, SBP, HR, and SI) for prediction of trauma-related mortality. Sensitivity, specificity, NPV, PPV, and accuracy were individually calculated. In the study by Grandjean-Blanchet *et al.* [20], the sensitivity of ISS components varied between 0.77 and 0.93 and also their specificity ranged from 0.66 to 0.74. El-Gamasy *et al.* [19] found a significant increase in SI in nonsurvivors versus survivors (P=0.039). Regarding INR, we found a significant increase in the nonsurvived

Table 1 Multivariate correlation analysis of injury severity score and shock index and its two items individually in prediction of mortality

Mortality	Odds ratio	95% CI	*P* value
ISS	0.890	0.740–1.070	0.214
HR	2.539	0.395–3.737	<0.001*
SBP	2.862	0.445–3.698	<0.001*
SI	2.255	0.316–3.218	<0.001*

CI, confidence interval; HR, heart rate; ISS, injury severity score; SBP, systolic blood pressure; SI, shock index. *0.001 indicates significant difference.

Table 2 Receiver operating characteristic curves of injury severity score, systolic blood pressure, heart rate, and shock index of all studied patients

	ROC curve between nonsurvived and survived groups					
	Cutoff	Sensitivity	Specificity	PPV	NPV	Accuracy (%)
ISS	>21	75.00	80.95	94.0	44.7	83.1
HR	>100	64.29	100.00	100.0	41.2	90.8
SBP	>90	95.24	76.19	94.1	80.0	89.3
SI	> 0.9	97.62	85.71	96.5	90.0	97.2

HR, heart rate; ISS, injury severity score; NPV, negative predictive value; OR, odds ratio; PPV, positive predictive value; ROC curve, receiver operating characteristic curve; SBP, systolic blood pressure; SI, shock index.

group than the survived group (*P*≤0.001). Additionally, INR showed a sensitivity of 80.95%, a specificity of 52.38%, a PPV of 87.2%, a NPV of 40.7%, and an accuracy of 70.5%. The study by Hess *et al.* [28] noticed abnormal coagulation tests frequently with increasing severity of injury. The study by Verma and Kole [29–31] confirmed that ISS has a high diagnostic accuracy and is a valuable predictor of trauma mortality.

Our study revealed a cutoff more than or equal to 21 of ISS to predict mortality with a sensitivity of 75%, a specificity of 80.95%, a PPV of 94%, a NPV of 44.7%, and an accuracy of 83.1%; *P* value was less than 0.001. Deng *et al.* [31] reported that the new injury severity score (NISS) and the ISS have similar abilities as predictors of mortality. Sullivan *et al.* [32] found that NISS is similar to ISS in prediction of trauma-related mortality in pediatric population whose ISS less than 24, indicating severe injuries. This was in agreement with El-Gamasy *et al.* [19], who stated that NISS more than or equal to 39.5 had a sensitivity of 53.3%, a specificity of 54.3%, a PPV of 33.3%, a NPV of 73.1%, and confidence interval of 0.48–0.79. Bharti *et al.* [33,34], who conducted their study in India on 5122 injured patients, found that the sensitivity of ISS in mortality prediction was 63% and its specificity was 68.3%.In this study, we verified that SI was superior to the ISS in prediction of mortality. Similarly, El-Gamasy *et al.* [19] reported that the ISS has a lower sensitivity and specificity in comparison with the BIG score, with a significant positive correlation between BIG score values and mortality rate. On the contrary, Sultanoğlu *et al.* [18] analyzed the power of trauma scores in mortality prediction with ROC curves. Accordingly, BIG score had an area under the curve value of 0.984 (0.976–0.990), a sensitivity of 92.4%, and a specificity of 96.6%, whereas ISS had an area under the curve of 0.992 (0.986–0.996), a sensitivity of 93.6%, and a specificity of 97.3%. Hence, ISS was better than the BIG score in prediction of trauma-related mortality. All scores studied in their study (BIG score, BD, INR, GCS, pediatric trauma score, revised trauma score, ISS, and NISS) showed the same predictive performances possibly owing to the province of their hospital as a trauma center of pediatric patients, where cases with a proposed mortality were referred.

Our study had less functional data to objectify the consequences of these results functionally. Another limitation was abdominal erect radiograph scan was not done for all patients owing to their inability to undergo it. Based on our findings, it seems wise in further research to address functional implications of the presented observations. Inability to perform a multicenter study owing to the variable triage system settings was another limiting factor.

Conclusion

We conclude that the SI is a reliable predictor of mortality but needs to be investigated in detail. Regarding pediatric trauma scores, SI is an applicable, easy method for prediction of mortality in pediatric emergency and is superior to ISS. This would also help in evaluation of early invasive monitoring and treatment decisions in the ICU.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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