DOI: 10.7860/JCDR/2024/67886.19384

Original Article

Internal Medicine Section

Assessing Reverse Shock Index as a Survival Predictor for Trauma Patients in Emergency Settings: A Retrospective Observational Study

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ABSTRACT

Introduction: Identifying trauma patients with shock is crucial, as early intervention and prompt treatment improve patient prognosis and survival. To address this, the ratio of Systolic Blood Pressure (SBP) and Heart Rate (HR), known as the Reverse Shock Index (RSI), is measured.

Aim: To evaluate the effectiveness of RSI calculation in assessing prognosis.

Materials and Methods: This was a retrospective observational study in which data were retrospectively collected on trauma patients treated in the Emergency Room (ER) at Dhiraj Hospital, Sumandeep Vidyapeeth Deemed to be University, Vadodara, Gujarat, India, from January 2021 to December 2022. Patients involved in road traffic accidents, fall from a height of ≥6 m, assault, and machinery injuries were included. Upon arrival, vital signs such as HR, SBP, Respiratory Rate (RR), Glasgow Coma Scale (GCS), associated injuries, and in-hospital mortality were documented. Any resuscitative procedures required, such as Cardiopulmonary Resuscitation (CPR), intubation, oxygen therapy, chest tube insertion, and blood transfusion, were also recorded. The RSI was calculated for all trauma patients and divided into two groups (RSI <1 and RSI ≥1). The t-test was performed with a 95% Confidence Interval (CI).

Results: Out of 363 patients, data from 320 patients were included. Among them, 55 patients (17.2%) had RSI <1, and 265 patients (82.8%) had RSI ≥1. Patients with RSI <1 exhibited lower GCS scores, tachypnoea (RR >29), or bradypnoea (RR <10), along with higher mortality rates. These patients also required resuscitative interventions. Those with RSI <1 experienced more head injuries, thoracic trauma, and maxillofacial injuries (p<0.001).

Conclusion: The RSI <1 in trauma patients demonstrated significantly higher predictive accuracy for adverse outcomes, serving as a primary tool for early intervention and aggressive care in the ER.

Keywords: Emergency room, Mortality, Respiratory rate, Systolic blood pressure, Triage

INTRODUCTION

Trauma patients presenting to the ER exhibit a range of injuries and conditions [1]. The mortality risk among patients with severe traumatic injuries is 20% [2,3]. Trauma patients are promptly triaged to different zones: the red zone (threat to life - immediate resuscitation required), yellow zone (high-risk cases - urgent treatment required), and green zone (non critical cases).

Triage aims to rapidly identify the most injured or serious patients, ensuring timely and appropriate treatment based on clinical urgency and reducing resource wastage. Effective triage enhances the quality and prognosis of patient care, shortens patients' length of stay, and reduces the waiting time between medical assessment and intervention.

Hypovolemic shock is the most common type of shock in trauma patients. Isolated vital signs such as HR or SBP are not reliable factors for identifying hypovolemic shock because other compensatory mechanisms exist to increase cardiac output and maintain Blood Pressure (BP) [4]. Various diagnostic tools like the Shock Index (SI), GCS, Trauma and Injury Severity Score (TRISS), Abbreviated Injury Scale (AIS), Revised Trauma Score (RTS), and Injury Severity Score (ISS) have been utilised to assess injury severity and predict mortality. No single triage tool is universally considered the gold standard or most accurate for screening, especially in traumatic injuries [5]. Calculating these scores requires complex formulas, which may not be feasible in a busy ER.

The SI, a ratio of HR and SBP, has been developed to identify trauma patients in hypovolemic shock. The normal value of SI is 0.7, while an SI of ≥1 is highly indicative of haemodynamic instability, transfusion requirements, and mortality upon arrival at the ER [6,7]. The SI has been previously emphasised as a capable measure for assessing uncompensated shock and a valuable predictor of outcomes in trauma patients [8-12]. However, the calculation of the SI as the ratio of HR to SBP is peculiar and appears contradictory to the basic concept of shock [4].

The TRISS is calculated using age, ISS (an anatomical variable), RTS (a physiological variable), and the application of different coefficients for blunt and penetrating injuries. TRISS can only be computed using information from all injured organs, which is not available upon admission and can change after admission; thus, its utility at the Emergency Department (ED) upon arrival is limited [13-15]. RTS and ISS are reliant on various variables such as HR, BP, RR, and AIS. The calculation of these scores is highly complex and cumbersome for early prediction of injury severity and mortality.

The identification of trauma patients with shock is vital, as early intervention and prompt treatment improve patient prognosis and survival. RSI is easy to calculate and less time-consuming, and no studies are available in India and the geographical area of Gujarat. Therefore, the present study aimed to evaluate the survival of trauma patients in the ER. The primary objective was to correlate RSI <1 with poor GCS, more procedures performed, and more associated injuries throughout the body.

MATERIALS AND METHODS

This retrospective observational study was conducted at Dhiraj Hospital, Sumandeep Vidyapeeth Deemed to be University, Vadodara, Gujarat, India. The study collected and analysed data from a total of 363 trauma patients (aged ≥18 years) who visited the ER over a two-year period (from January 1, 2021, to December 31, 2022). Institutional Ethical Committee approval was obtained under SVIEC/ON/Medi/RP/Jan/23/21. Data collection took place from January 1, 2023, to June 30, 2023, with data analysis conducted over two months from July 1, 2023, to August 31, 2023.

Inclusion and Exclusion criteria: Trauma resulting from road traffic accidents, fall from a height of ≥6 m or two stories up, assault, and machinery injuries were included [1]. Patients with incomplete data regarding vital signs, GCS, or associated injuries were excluded. Minor injuries sustained at home or from falls were also excluded.

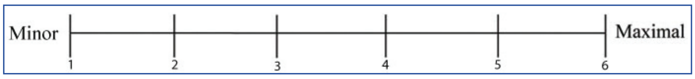
Study Procedure

After receiving permission from the Sumandeep Vidyapeeth Institutional Ethical Committee (approval number SVIEC/ON/Medi/RP/Jan/23/21), retrospective data from the hospital's record section in the form of case records were collected for all trauma patients presenting to the Department of Emergency Medicine using Microsoft excel 2010 software. The ethical committee waived the need for participant consent as the study involved reviewing medical records. Permission was obtained from the Medical Superintendent to access the record section. Demographic data including age, sex, and date of admission were collected. Upon arrival at the Department of Emergency Medicine, vital signs such as HR, BP, RR, GCS score, associated injuries, and in-hospital mortality were recorded. Any procedures required for patient resuscitation, such as CPR, intubation, oxygen therapy, chest tube insertion, and blood transfusion, were considered. The RSI for all trauma patients was calculated as SBP divided by HR [1-3].

$$RSI = \frac{SBP}{HR}$$

The authors divided patients according to RSI <1, indicating SBP less than the HR, and RSI ≥1, indicating SBP more than the HR [1]. They compared demographic data, vital signs, GCS score, associated injuries, in-hospital mortality, and any procedures performed. The t-test was calculated with a 95% confidence interval.

The AIS is an internationally accepted tool for ranking injury severity. AIS is an anatomically based, consensus-derived, global severity scoring system that classifies an individual injury by body region based on its relative severity on a 6-point scale [16].



The GCS is used to objectively describe the extent of impaired consciousness in all types of acute medical and trauma patients. The GCS is divided into three parameters: best eye response (E), best verbal response (V), and best motor response (M). The levels of response in the components of the GCS are 'scored' from 1 for no response, up to normal values of 4 (Eye-opening response), 5 (Verbal response), and 6 (Motor response) [17]. The total Glasgow Coma Score ranges from 3 to 15, with 3 being the worst and 15 being the highest.

STATISTICAL ANALYSIS

Data were analysed using Statistical Package for the Social Sciences (SPSS) version 20 statistical software (IBM Corporation, Armonk, NY, USA). The main outcome measure was in-hospital mortality. Univariate analysis was conducted to determine the socio-demographic profile of the trauma patients, and the Pearson's Chi-square test was used to understand the association of RSI with various variables such as mortality, RR, GCS score, procedures performed, and injuries. We also employed the independent Student's t-test where applicable. Results were presented as means±standard errors and t-test values. A p-value of <0.05 was considered statistically significant (95% confidence interval).

RESULTS

The authors reviewed data from 363 patients of either sex. Among these, 43 patients who were transferred from other hospitals, had incomplete data, or were in the paediatric age group were excluded from the study. A total of 320 patients' data were included based on the inclusion criteria. Out of these, 55 patients (17.2%) had RSI <1, and 265 patients (82.8%) had RSI ≥1 [Table/Fig-1].

Type of Injury	RSI <1 (n=55)	RSI ≥1 (n=265)	p-value	Significance if <0.05
Road traffic accident	46 (83.6%)	201 (75.8%)	0.21	NS
Fall from height	08 (14.5%)	40 (15.2%)	0.91	NS
Assault	01 (1.9%)	12 (4.5%)	0.35	NS
Machinery injury	00	12 (4.5%)	0.10	NS
Gender				
Male	45 (81.81%)	225 (84.9%)	0.56	NS
Female	10 (18.19%)	40 (15.1%)		

[Table/Fig-1]: Distribution of injury and demographic details.
*NS: Not significance. Test used-Univariate analysis

An equal distribution of injuries among all patients in both of these groups is demonstrated in [Table/Fig-1]. The p-value is more than 0.05 (not significant). There is no statistically significant difference regarding gender between patients with RSI <1 and RSI ≥1. The p-value is 0.56 (>0.05, not significant).

A highly statistically significant difference in mean SBP, mean HR, mean RSI, and mean GCS (p<0.0001) between patients with RSI <1 and RSI ≥1 is indicated in [Table/Fig-2]. This suggests that patients with RSI <1 have significantly lower GCS scores (7.5±4.62) compared to patients with RSI ≥1 (13.5±3).

Variables	RSI <1 (n=55)	RSI ≥1 (n=265)	t-test (95% CI)	p-value
SBP (mmHg)	101.27±14.14	122.3±15.17	-9.46	<0.0001 (HS)
HR (beats/min)	125.36±21.98	84.84±14.87	16.77	<0.0001 (HS)
RSI	0.81±0.11	1.48±0.29	-16.86	<0.0001 (HS)
GCS	7.5±4.62	13.5±3	-12.1	<0.0001 (HS)

[Table/Fig-2]: Haemodynamic responses.
RS values presented as mean±SD; *HS: Highly significant; Test used-Independent student's t-test

A highly statistically significant difference in RRs between both groups is revealed in [Table/Fig-3]. Additionally, the number of patients with poor GCS scores ≤8 was higher in the RSI <1 group, while the number of patients with higher GCS scores ≥13 was greater in the RSI ≥1 group. A high mortality rate was found in the RSI <1 group (65.5%) (p<0.0001).

Variables	RSI <1 (n=55)	RSI ≥1 (n=265)	p-value
Respiratory Rate (RR)			
>10 or <29	14 (25.5%)	237 (89.5%)	<0.0000001 (HS)
<10	18 (32.72%)	09 (3.4%)	<0.0000001 (HS)
>29	23 (41.81%)	19 (7.1%)	<0.0000001 (HS)
GCS score			
≤8	35 (63.6%)	28 (10.5%)	<0.0000001 (HS)
9-12	8 (14.6%)	29 (11.0%)	0.44 (NS)
≥13	12 (21.8%)	208 (78.5%)	<0.0000001 (HS)
Mortality			
Yes	36 (65.5%)	20 (7.54%)	<0.0000001 (HS)
No	19 (34.5%)	245 (92.46%)	

[Table/Fig-3]: Physiological responses.
*HS: Highly Significant; NS: Not Significant. Test used-Chi-square test

In [Table/Fig-4], the authors calculated the number of patients requiring oxygen, intubation, CPR, chest tube insertion, and blood transfusion. It demonstrated statistically significant differences in the need for oxygen, intubation, CPR, and blood transfusion between both groups. The group with RSI <1 patients required more lifesaving interventions (p<0.0001).

Procedure	RSI <1 (n=55)	RSI ≥1 (n=265)	p-value
Need for oxygenation	47 (85.4%)	55 (20.7%)	<0.0000001 (HS)
Intubation	42 (76.3%)	33 (12.4%)	<0.0000001 (HS)
Cardiopulmonary Resuscitation (CPR)	22 (3.63%)	03 (1.13%)	<0.0000001 (HS)
Chest tube insertion	03 (5.45%)	07 (2.64%)	0.27 (NS)
Blood transfusion	18 (32.72%)	27 (10.18%)	0.00001 (HS)

[Table/Fig-4]: Procedures performed.
*HS: Highly Significant; NS: Not Significant. Test used-Chi-square test

The patients with RSI <1 had significantly higher injuries involving the head, maxillofacial region, and thoracic region (p<0.001) as shown in [Table/Fig-5]. Patients with RSI ≥1 had a higher incidence of injuries in the extremities. The p-value was <0.05.

Injuries	RSI <1 (n=55)	RSI ≥1 (n=265)	p-value
Head trauma	78.18%	52.83%	0.00016 (HS)
Maxillofacial trauma	37.73%	16.36%	0.00066 (HS)
Thoracic trauma	29.00%	9.81%	0.0006 (HS)
Abdominal trauma	18.18%	8.77%	0.051 (NS)
Extremity trauma	15%	29.00%	0.016 (S)

[Table/Fig-5]: Associated injuries of trauma patients.
*HS: Highly Significant; NS: Not Significant; S: Significant. Test used-Chi-square test

DISCUSSION

Injuries, especially road traffic accidents, are increasing day by day. The identification of patients with higher chances of early mortality compared to those with lower chances of death is crucial in the crowded Department of Emergency Medicine. Effective triage can lead to improvement in the healthcare system [18].

Timely recognition and rapid treatment of shock can be a challenging task. Therefore, the RSI (ratio of SBP and HR) may serve as an alert for early intervention for trauma patients arriving at the ER [19].

Measurement of RSI is very useful in directing resources to more severely injured patients who require immediate intervention. Patients with RSI ≥1 can potentially wait for some time in case of a crowded ED. Chuang JF et al., concluded that RSI <1 indicated greater injury severity, a higher incidence of commonly associated injuries, lower GCS scores, greater deterioration of vital signs, and a higher incidence of procedures compared to those with RSI ≥1, which aligns with the present study [4]. In their study, patients with RSI <1 also experienced worse outcomes, including prolonged hospital and ICU stays, a higher frequency of ICU admission, and higher in-hospital mortality. Prompt treatment of trauma patients with RSI <1 can improve survival prognosis.

Patients with RSI <1 also exhibited tachypnoea or bradypnoea and required oxygen, intubation, and mechanical ventilator support. Some patients had pneumothorax or hemothorax, necessitating chest tube insertion and blood transfusion. Wu SC et al., have concluded that patients with RSI <1 and very low or high RR require more procedures in the ER, including CPR, intubation, chest tube insertion, and blood transfusion [2,4,6].

Calculating RSI is straightforward and highly beneficial for quickly evaluating the haemodynamic stability of trauma patients without the need for additional equipment or costs. Mortality among trauma patients with RSI <1 (65.5%) was 9 times higher than that of patients with RSI ≥1 (7.54%). RSI helps identify patients with serious injuries and the need for early intervention to reduce early morbidity and mortality, which aligns with the study conducted by Lai WH et al., [19]. They concluded that specific attention and additional resources should be allocated to patients with an Emergency Medical Service (EMS) RSI ≥1 that deteriorates to an RSI <1 upon arrival at the ED, as these patients have higher odds of mortality. Lammers DT et al., also demonstrated that using RSI more accurately identifies paediatric patients at the highest risk of death following paediatric war zone injuries [20].

According to a recent study, patients with RSI <1 had trauma such as head injuries, including cranial fractures, subdural haematomas, epidural haematomas, and subarachnoid haemorrhages; maxillofacial trauma including orbital, nasal, maxillary, and mandibular fractures; and thoracic trauma including rib fractures, hemothorax, pneumothorax, lung contusions, and sternal fractures (p<0.05). Patients in both groups also experienced abdominal trauma such as hepatic injuries, splenic injuries, renal injuries, retroperitoneal injuries, urinary bladder injuries, and lumbar and sacral vertebral fractures. Patients with RSI ≥1 had the most injuries involving the extremities, including fractures of the humerus, ulna, radius, femur, tibia, fibula, scapula, etc. (p<0.05). This indicates that patients with severe injuries are more haemodynamically unstable and should be attended to as early as possible. This finding was also supported by Kuo SCH et al., in their study [1].

Studies have indicated that in addition to RSI, multiplying GCS by RSI also provides accurate information regarding a patient's haemodynamic status. The RSI×GCS (rSIG) value has a higher predictive value for mortality than SI, SBP, or HR alone. Therefore, measuring rSIG could be considered in future studies [3,6,18].

In patients with head injuries, the classic Cushing's triad of respiratory irregularity, hypertension, and bradycardia, which is a sign of intracranial hypertension, is commonly observed. In such patients, the ratio of SBP and HR might be ≥1. In the present study, three patients with head injuries, despite having RSI ≥1, were found to have poor GCS scores and mortality.

Limitation(s)

It was a retrospective study, and limitations of retrospective studies might include an inferior level of evidence compared to prospective studies, chances of selection bias, susceptibility to confounding, and the inability to measure certain key statistics. Secondly, severely injured trauma patients who died before reaching the ER could not be included in the study, potentially leading to bias. Thirdly, the effect of co-morbidities on the course of hospitalisation and mortality is unclear. Factors such as treatment cost, resource availability, treatment delays, and complications were not evaluated. Since this is a hospital-based study, its generalisability is limited.

CONCLUSION(S)

The authors analysis of data on trauma patients indicates that an RSI <1 is associated with higher mortality, a poorer GCS, increased procedure requirements, and a worse prognosis. The measurement of RSI is a very useful and effective tool for assessing the severity of injury and predicting the survival prognosis of trauma patients in crowded ERs or during mass casualties.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Oct 06, 2023
- Manual Googling: Mar 01, 2024
- iThenticate Software: Mar 04, 2024 (17%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Oct 05, 2023**
Date of Peer Review: **Dec 18, 2023**
Date of Acceptance: **Mar 06, 2024**
Date of Publishing: **May 01, 2024**