Reverse Shock Index and Glasgow Coma Scale: Early Predictors Of Mortality In Traumatic Brain Injury In A Rural Setup

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Abstract

Introduction: It is estimated that nearly 1.5 to 2 million persons are injured and 1 million succumb to death every year in India due to traumatic brain injury (TBI). Road traffic injuries are the leading cause (60%) of traumatic brain injuries followed by falls (20%-25%) and violence (10%).[1]

Half of those who die from TBI do so within the first two hours of injury. It is now known that only a portion of neurological damage occurs at the moment of impact (primary injury); damage progresses during the ensuing minutes, hours and days. The secondary brain injury can result in increased mortality and disability.

Consequently, the early and appropriate management of TBI is critical to the survival of these patients. This while being a critical factor in the overall prospects of a patient is yet to be fully appreciated.[2] Therefore, it is important to identify trauma patients with high mortality risk and commence aggressive resuscitation and proper medical intervention.

Aims and objective: The goal of this study was to create a simplified prediction model that might detect high death risk in severely head-injured patients early , leading to the development of an effective and efficient treatment strategy to decrease the mortality associated with traumatic brain injury.

Material and methods: This was a retrospective observational study at a tertiary care centre in a rural setup. Consecutive patients from 17 years to 80 years of age who presented to our institute's emergency department between January 2021 to December 2021 were included. A total of 178 patients were studied and detailed data collected which included age, sex, mode of head trauma, systolic blood pressure, heart rate and glass go coma scale.

Results: The ability to predict mortality risk using rSI, GCS, and rSIG among the examined variables is 93%, 96.5%, and 99.3%, respectively. The best cut off level rSI, GCS and rSIG to predict mortality in adult severe trauma patients with head injury is 0.921, 7.50 and 6.07, respectively.

Conclusion: Our analysis of the data on trauma patients revealed that rSIG, GCS, rSI, and SI are readily measurable indicators with equivalent ability to predict mortality, with rSIG being the most accurate among them. These are feasible methods for categorizing traumatised patients according to risk in overcrowded emergency rooms, and they may be especially valuable in low-resource regions like low and middle income countries(LMICs).

Keywords: Traumatic brain injury, Reverse shock index , Shock index, Glasgow coma scale, Trauma and Injury Severity Score, Injury severity score.

INTRODUCTION

In recent years, India's epidemiological and socio-demographic shift has led in the emergence of injuries as a serious public health hazard. Rapid urbanisation, unprecedented motorization, developing industrialisation, as well as people's changing life styles and values with regards to the lack of safety rules and programmes, have all contributed to this situation.

It is estimated that nearly 1.5 to 2 million persons are injured and 1 million succumb to death every year in India. Road traffic injuries are the leading cause (60%) of Traumatic brain injuries(TBIs) followed by falls (20%-25%) and violence (10%).[1]

Motor vehicle accidents represent 61.59% of total polytrauma cases which also includes brain injuries (62.2%) and orthopaedic injuries(62.5%).[2]

Half of those who die from TBI do so within the first two hours of injury. It is now known that only a portion of neurological damage occurs at the moment of impact (primary injury); damage progresses during the ensuing minutes, hours and days. The secondary brain injury can result in increased mortality and disability.

Consequently, the early and appropriate management of TBI is critical to the survival of these patients. This while being a critical factor in the overall prospects of a patient is yet to be fully appreciated.[3] Therefore, it is important to identify trauma patients with high mortality risk and commence aggressive resuscitation and proper medical intervention.

Background

When used individually, blood pressure and heart rate may fail to predict accurately the severity of hypovolemia and shock in major trauma. The shock index(SI) may be a more sensitive indicator of occult shock than heart rate or blood pressure alone, especially in patients with trauma or acute hemorrhage.

Allgower and Burri in 1967 developed the shock index (SI), which is the ratio of heart rate (HR) to systolic blood pressure (SBP). It has been used to identify trauma patients who are experiencing hypovolemic shock.[4]

SI is easily calculated at the bedside without the need for additional information or equipment, and it has been used to identify risk of mortality and the need for massive transfusion , even in the presence of severe traumatic brain injury.[5]
Normal shock index is 0.5-0.7, whereas higher values are more sensitive in the detection of occult shock, transfusion requirements, and post-intubation hypotension than either vital sign in isolation.
The reverse (or inverse) shock index (rSI), which measures the ratio of SBP to HR, is preferred over the shock index, according to a research team in Taiwan , because practitioners typically regard unstable hemodynamic condition as SBP lower than HR rather than HR greater than SBP as indicated by the SI.[6,7]
Practitioners believe that SBP is a more useful measure than heart rate, making the reverse shock index—a ratio of SBP to HR—a more reliable indicator of the severity of trauma and death.
rSI < 1 upon arrival at an ED is an alarming sign of an associated worse outcome, patients with RSI < 1 had worse outcomes than those with rSI ≥ 1[5]
A high association between mortality and low Glasgow Coma Scale (GCS), has been found in patients with traumatic brain injury. A Japanese research team has suggested a new scoring method called rSIG that takes into account these factors. It was created from a multicenter retrospective study and is determined by multiplying rSI by GCS score.[8]

OBJECTIVE:

The goal of this study was to create a simplified prediction model that might detect high death risk in severely head-injured patients early , leading to the development of an effective and efficient treatment strategy to decrease the mortality associated with traumatic brain injury.

Material and Methods

This was a retrospective observational study at a tertiary care centre in a rural setup. Consecutive patients of brain injury due to trauma, may be associated with other limb, abdominal or thoracic injury between 17 years to 80 years of age who presented to our institute's emergency department between January 2021 to December 2021 were included..
A total of 178 patients were studied and detailed data collected which included age, sex, mode of head trauma, systolic blood pressure, heart rate and Glasgow coma scale. Data was collected from ICU and ward and emeregency department registers.
Inclusion Criteria
All patients of brain injury due to trauma, may be associated with thoracic, abdominal and limb injuries were included.
Exclusion Criteria
Patients who did not survive for 12 hours or less than 12 hours after attending our ED , ICU or ward were excluded.

Measurements:

Shock Index= Heart rate(bpm)/Systolic blood pressure(mm of Hg)
Reverse Shock Index= Systolic blood pressure(mm of Hg)/Heart rate(bpm)
Reverse Shock Index* Glasgow Coma Scale (rSIG)
Glasgow Coma Scale reference no 16

Results:

Among the total 178 patients in the study, 82.5%(n=147) were male and 17.4%(n=31) were female. Mean age of head trauma was 42.5years.
Most common cause of head trauma was road traffic accident accounting for 83.14%(n=148), whereas assault and fall from height accounted for 8.42%(n=15) each .
The mean heart rate was higher and SBP was lower in mortality group (110.22 beats/ min and 96.28 mm of Hg,respectively) as compared to the survival group(90.76 beats/min and 125.84mm of Hg, respectively.
The mean SI for the mortality group was 1.177, compared to 0.739 for the survival group. Mean rSI in the mortality group was 0.934, while it was 1.39 in the survival group. In the death group, the mean GCS was 5.171, while in the survival group, it was 12.47. In the mortality group, the mean rSIG was 4.765; in the survival group, it was 17.843. (Table1)

Variables	Alive	Demised
Heart rate	90.76	110.22
Systolic blood pressure	125.8	96.2
GCS	12.47	5.171
Shock Index	0.739	1.177
Reverse shock index	1.39	0.934
rSIG	17.843	4.765

Table 1 Mean values of variables among alive and demised patients.

The ability to predict survival using Shock Index is 91.9% accurate in our study with sensitivity of 94.3% at an optimum cut off of 0.874 as shown in Table 2

Test Result Variables	Area Under the Curve	P value	Optimum cut off	Sensitivity	Specificity

Shock Index	0.919	<0.001	0.874	94.3%	80.4%

Table 2 ROC curve for Shock Index predicting survival

The ability to predict mortality risk using rSI, GCS, and rSIG among the examined variables is 93%, 96.5%, and 99.3%, respectively (Table 3)

The best cut off level rSI, GCS and rSIG to predict mortality in adult severe trauma patients with head injury is 0.921, 7.50 and 6.07, respectively.(Table 3)

Test Result Variables	**Area Under the Curve**	**P value**	**Optimum cut off**	**Sensitivity**	**Specificity**
Reverse shock index	0.915	<0.001	0.92150	93.0%	88.6%
GCS	0.982	<0.001	7.50	96.5%	91.4%
rSIG	0.980	<0.001	6.07	99.3%	77.1%

Table 3: ROC curve for Indices predicting mortality

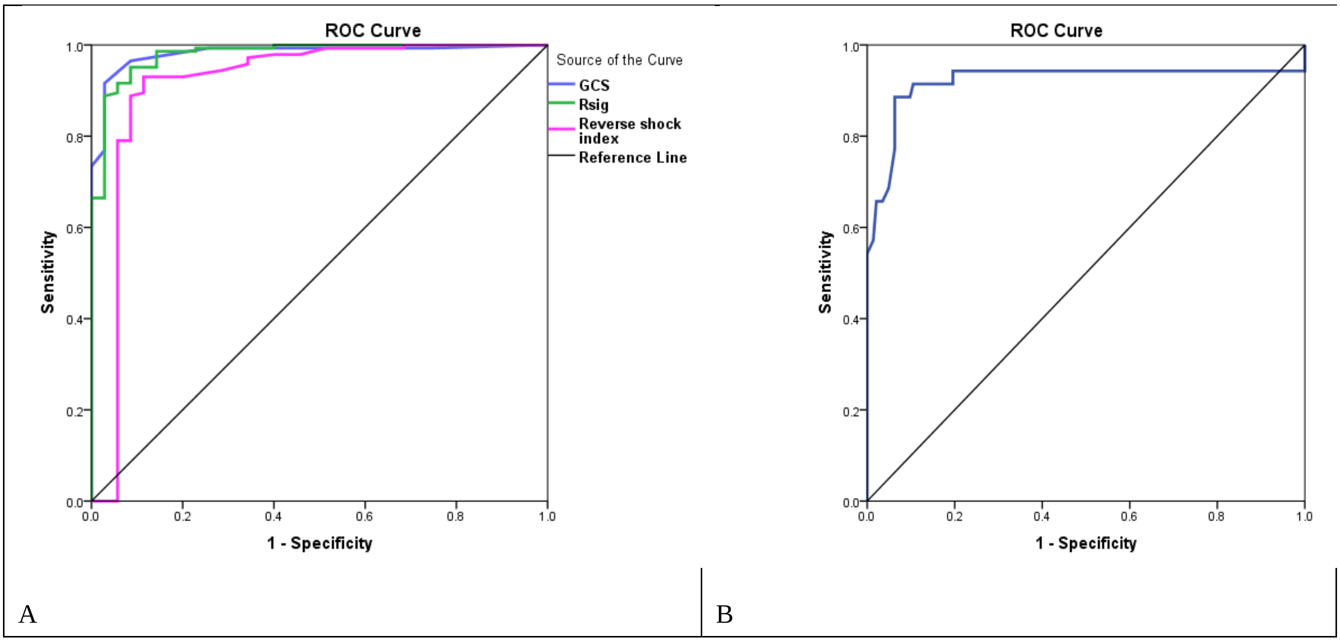

Fig 1.A ROC curve for rSI, GCS and Rsig 1.B ROC curve for Shock Index predicting survival

ROC curves for in-hospital mortality with rSI, GCS and rSIG is shown in Fig 1.A. Statistical differences (p <0.001) were seen among the AUROCs

AUROCs were comparable among rSI, GCS and rSIG with better mortality risk prediction in rSIG than GCS and rSI.

Discussion:

Over 1 million Indians suffer from severe head injuries each year, with over 100,000 lives lost. In India, one in six trauma patients passes away, compared to one in 200 in the US.[9]

When mass casualty events occur and there are packed emergency rooms, it's critical to separate injured individuals who are at a higher risk of death from those who are at a lower risk. Additionally, strengthening LMIC health care systems through quality improvement (QI) in trauma treatment systems is crucial, and QI requires an objective comparison of outcomes with risk adjustment. For this reason, numerous prediction models have been developed, like Trauma and Injury Severity Score(TRISS) and Injury Severity Score (ISS). TRISS is the most popular logistic regression model, which predicts survival probabilities comprises of the Revised Trauma Score(RTS), ISS, age and mechanism of injury[10]. However, it requires complex equations and calculations since the RTS is a physiological score that is generated using the formula RTS=0.9368. It is made up of the weighted total of the coded GCS score, RR, and SBP.GCS+0.7326 SBP+0.2908 RR, which makes it difficult to manage trauma patients in the ED in real-time[11]. Similarly, the ISS score utilises anatomical variables to rank the severity of trauma victims using the sum of squares of the AIS score in the three body regions of the six predetermined body territories that were harmed the most severely[12]. All of these models call for difficult-to-remember coded scoring systems.

SI was first introduced by Allgower and Burri in 1967[13] and is said to be a more accurate indicator of shock and the likelihood that resuscitation efforts will be successful than traditional vital signs alone. SI can be quickly determined at the bedside without the use of additional data or tools. SI, is therefore feasible in LMICs for outcome prediction as well as real-time evaluation of trauma patients in hospitals. According to a retrospective study that used multivariate logistic regression and found that SI > 1 is an independent predictor of mortality[13]. In our study the shock index predicted survival at an accuracy of 91.9% and at an optimum cut off value of 0.874 has a sensitivity of 94.3%. (Table2)

Since systolic blood pressure is a more steady variable than heart rate, a ratio of SBP to HR, Reverse Shock Index(rSI) is considered to be a better predictor of mortality than HR to SBP. Poorer outcomes are correlated with lower rSI values, and rSI values below 1 point to a higher chance of mortality. In our study, we discovered that the deceased group's mean rSI was 0.934.

Score on the Glasgow Coma Scale (GCS), is used to measure consciousness level at almost all emergency centres across the world. Doctors and nurses measure it at the patient's bedside without the use of any special equipment and in a short amount of time. It is found to be a more accurate predictor of mortality than SBP, RR, age, and even injury severity. It is a better in hospital mortality predictor in acute head injury cases[14].

Reverse shock index multiplied by GCS (rSIG) is easily calculated using SBP, HR and GCS. rSIG on admission is very easy to calculate in emergency departments without the need for additional imaging, blood tests, or hard-to-remember coding systems. In addition, among the calculated values used in this study the AUROC was highest for rSIG for predicting mortality in our study. A higher rSIG means better survival (or lower in-hospital mortality).

The best cut-off level of rSIG score to predict mortality in adult severe trauma patients with head injury was 14, analyzed via the Youden Index. The mortality predictive ability of rSIG < 14 was further assessed via logistic regression and compared with SI > 0.9, rSI < 1, and GCS < 13 (cut-off point calculated via Youden index). The results showed that severe trauma patients with rSIG < 14 had the highest risk of mortality for 7.64-fold, while GCS < 13 was 6.16-fold.[7] As compared to this study the mortality predictive ability of rSIG<6.07, GCS<7.50 , rSI <0.921.[15]

The sensitivity for predicting mortality for rSIG, GCS and rSI is 99.3%, 96.5% and 93%, respectively. In addition, among the calculated values in our study the Area under ROC was highest for rSIG followed by GCS and rSI as shown in Fig 3

Conclusion

Our analysis of the data on trauma patients revealed that rSIG, GCS, rSI and SI are readily measurable indicators with equivalent ability to predict mortality, with rSIG being the most accurate among them. These are feasible methods for categorizing traumatised patients according to risk in overcrowded emergency rooms, and they may be especially valuable in low-resource regions like LMICs.

Limitations

1. It is a retrospective study.
2. Data is not representative and small in number since our hospital is located in rural area.
3. Contributory factors like thoracic, abdominal and large limb bone injuries are not taken into consideration as far as final outcome is measured.

Disclaimer

1. No special finding is received from any agency.
2. No conflict of interest intra or interdepartmental.
3. It is a retrospective record based study and ethical approval taken from IEC.
4. No identification of patients is revealed in any manner.
5. Sole purpose of this article is for academic purpose only.

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Abbreviations

TBI: traumatic brain injury, SI: shock index, rSI: reverse shock index, GCS: Glasgow coma scale, rSIG: reverse shock index *GCS, SBP: systolic blood pressure, HR: heart rate, ED: Emergency Department.

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