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Original Article

Predicting outcomes in trauma patients by using reverse shock index multiplied by Glasgow coma scores (rSIG): A retrospective cross-sectional study

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Abstract

Introduction: This study aimed to determine the predictive value of the reverse shock index (rSI) using the Glasgow Coma Score (GCS) to predict the outcome of traumatic patients.

Methods: This study included all patients with a traumatic injury aged ≥ 18 years with ISS score ≥ 16 and head Abbreviated Injury Scale (AIS) ≥ 2 admitted to the Imam Reza hospital of Tabriz, Iran from 1 March, 2021 to 1 July, 2021. After excluding the patients with incomplete data, 216 patients were enrolled. In this study, the rSIG is the product of rSI multiplied by the GCS score. The patients' symptoms were recorded routinely in the summary section of all patients' records using the studied indexes. Data collection was performed using the researcher-made forms. The SPSS software v.21 was used to analyze the data. A P value < 0.05 was considered as statistically significant.

Results: The results of data analysis demonstrated that the regression model by two predicting variables of rSI and rSIG was statistically significant. Also, the model can distinguish between the patients who died and those who were discharged. In addition, the Hosmer-Lemeshow test confirmed the model's advantage and its accuracy ($\chi^2 = 14.12$, $df = 8$, $P > 0.05$).

Conclusion: So, the predictive value of rSI with GCS in predicting the outcome of traumatic patients was high.

Introduction

Trauma is the major leading cause of death worldwide. Even with the best medical care, hemodynamic and metabolic changes by traumatic injuries in the body lead to numerous complications or death. The primary causes of mortality among these patients include hemorrhagic shock and traumatic brain injury.[1-4] The mortality rate of traumatic patients in the hospital during the first 24 hours is increased with a high Injury Severity Score (ISS) and high transfusion frequency.[5] So, the importance of identifying traumatic patients who are at risk of death cannot be overstated. The Shock Index (SI), as the heart rate (HR) to systolic blood pressure (SBP) ratio, was invented to identify trauma patients in hypovolemic shock.[6] The SI value of 0.7 is considered normal, whereas the SI > 1 shows severe hemodynamic instability and enhanced mortality.[7-9] SBP less than HR is usually considered an unstable condition by most physicians. Hence, a research group in Taiwan proposed a concept known as Reverse Shock Index (rSI), which indicates the ratio of SBP to HR. Study results suggested that rSI values below 1 lead to poor outcomes and could even be used in traumatic patients without hypotension.[10-13] Chuang et al used the rSI to identify high-risk patients. They found that patients with an rSI of less than 1 compared to the patients with rSI > 1 usually had a higher severity of the traumatic injury, low Glasgow Coma Score (GCS), poor outcomes, as well as longer intensive care unit (ICU) stays (10). Based on the study by Han et al, patients in the emergency department with rSI < 1 had a higher likelihood of severe conditions and experienced necessary procedures.[14] GCS is an instrument used to evaluate the level of consciousness. It provides a strong correlation between mortality and traumatic brain injury.[15,16] Japanese researchers have developed a novel tool by multiplying the rSI by the GCS (rSIG). Accordingly, the rSIG score (rSIG = SBP/HR × GCS score) is a good predictor tool to estimate the risk of in-hospital mortality.[17] Based on a retrospective

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analysis of patients from 2008 to 2016, Lammers et al found that the rSI multiplied by GCS is a good mortality predictor in pediatric trauma patients.[18] Another study by Wu et al used the rSI with GCS scores to estimate the mortality in trauma patients. The rSIG, Revised Trauma Score, and SI scores were calculated using the patients' vital signs and GCS score. The rSIG has a lower diagnostic value compared to other scores for predicting in-hospital mortality. Based on cut-off point 14, the rSIG score has a sensitivity of 61.5% and a specificity of 94.5% for predicting mortality in trauma patients without head trauma.[19] Chu et al evaluated the mortality estimates in trauma and head injury patients. Patients with rSIG less than 14 had a seven times more possibility for in-hospital mortality. In this study, sensitivity, specificity, positive, and negative predictive values were 0.71, 0.75, 0.49, and 0.89, respectively.[14,17,19-21]

As far the researchers of this study investigated, no study has been carried out to evaluate the diagnostic value of rSIG in defining mortality risk for traumatic patients so far. Hence, this study aimed to determine the predictive value of rSI with GCS score in the outcome of trauma patients.

Methods

The study was conducted in accordance with the Declaration of Helsinki, and the approved retrospective study on 20 February 2021 by the Ethics Committee of Islamic Azad University of Tabriz. Since the patients' information was used in a completely confidential manner, no informed consent was obtained from the participants.

This study included all adult patients with a traumatic injury aged ≥ 18 years with ISS score ≥ 16 and head Abbreviated Injury Scale (AIS) ≥ 2 admitted to the Imam Reza hospital of Tabriz, Iran from March 1, 2021 to July 1, 2021. After excluding the patients with incomplete data, 216 patients were enrolled in the study. The choice of patients with head AIS ≥ 2 was due to the fact that head injuries with head AIS = 1 do not cause death, and the mortality rates of patients with head AIS = 2, 3, 4, and 5 were 0.1%, 1.9%, 2.9%, and 31.1%, respectively.[22]

The demographic information, including age, sex, mechanism of injury, vital signs, patient outcome, and the results of laboratory and paraclinical exams were recorded. SI score (SI = HR/SBP) of above 0.9 indicated a poor outcome,[23] while rSI score (rSI = SBP/HR) below 1 indicated a poor prognosis, including length of hospital stay and mortality.[10] The rSIG is the product of rSI multiplied by the GCS score. The patients' symptoms were recorded routinely in the summary section of all patients' records using the studied indexes.

Based on previous studies,[17] using Power and Sample Size software, and considering the alpha error of 5%, power of 90%, and an average difference of 11.37 points in rSIG, the sample size was determined. Data were analyzed by SPSS software version 21 (IBM Corporation, Armonk, NY, USA). All results were presented as means ± standard errors. A P value < 0.05 was considered as statistically significant. A binary regression model and Chi-squared test were employed to estimate the relationship between variables. To evaluate the predictive power with determining the cut-off point and calculate sensitivity, specificity, negative, and positive predictive values, the receiver operating characteristic (ROC) analysis was used.

Results

The present study included 216 trauma patients (age range: 18-83 years; mean age: 37.43 years; standard deviation: 17.37 years), of whom 149 (69%) were male and 67 (31%) were female. The mean age (and standard deviation) by gender was 32.85 (13.11) for females and 39.49 (18.65) for males. Among the 216 patients, 146 (67%) had been discharged and 70 (32%) died. In both genders, traffic accidents were the primary cause of injuries. Both genders reported more frequent scores of 3 and 15 in the GSC. The mean (and standard deviation) of the GSC score was 8.45 (5.7) for females and 6.67 (4.53) for males (Table 1). As shown in Table 2, females had a higher rSIG index than males, but on the rSI index, males and females were almost equal. Skewness and kurtosis indices indicated the normal distribution of data. Only the rSIG index of the variables in males was slightly higher

Table 1. Frequency of GCS scores, types of trauma, and patient status by gender

	Males		Females	
	Frequency	**Percent**	**Frequency**	**Percent**
Types of trauma				
Accident	95	63.8	52	77.6
Fall	38	25.5	6	9.0
Roll over	7	4.7	6	9.0
Stab	9	6.0	0	0
DAI	0	0	3	4.4
GCS Score				
3	67	45.0	20	29.85
4	7	4.7	2	2.99
5	8	5.4	7	10.44
6	11	7.4	3	4.48
7	7	4.7	6	8.95
10	2	1.3	4	5.97
12	16	10.7	2	2.99
13	3	2.0	3	4.48
15	28	18.8	20	29.85
Patient status				
Discharged	95	63.8	51	76.1
Died	54	36.2	16	23.9
Total	149	100.0	67	100.0

DAI, Diffuse axonal injury; GCS, Glasgow Coma Scale.

Table 2. Descriptive indices related to rSI and rSIG

Gender	Type of index	Mean	Standard deviation	Skewness	Kurtosis	Minimum	Maximum
Males	rSI	1.16	0.27	0.38	-0.47	0.725	1.90
	rSIG	7.87	6.03	1.27	0.44	2.25	23.68
Females	rSI	1.17	0.28	0.29	-0.67	0.643	1.84
	rSIG	9.81	6.46	0.70	-0.86	2.58	23.68

rSI, reverse shock index; rSIG, reverse shock index multiplied by Glasgow Coma Scale score.

than 1, but logistic regression was not sensitive; so, it was not one of the assumptions of this test. In this study, patients' status (death or discharge) was considered as the outcome (dependent variable). Binary logistic regression was used to assess the predictive value of the rSI and rSIG indices. Hence, both variables were set as predictor and outcome variables in the model (died, code = 1 and discharged, code = 0). For the first comparison of the dead and discharged patients, the independent t-test was used. According to the results, there was a difference between the two groups in rSI ($P < 0.05$, t = 2.60) and rSIG ($P < 0.01$, t = 5.60). Indices were remarkably lower in the dead group compared to the discharged group. Using a simultaneous entry method (ENTER), binary logistic regression was performed by confirming the defaults (e.g., sufficient sample size, no multicollinearity data, and no outlier data). The cut-off point was considered 0.50. The results of data analysis demonstrated that the regression model by two predicting variables of rSI and rSIG was statistically significant. Having a two degrees of freedom as an independent variable, the chi-square value was 34.97, which was significant at the level of 0.01. This illustrates that the model can distinguish between the patients who died and those who were discharged. Likewise, the results showed that based on Cox and Snell, R square of 15%, and based on Nagelkerke R square, around 21% of the patients' status (death or discharge) could be described. In addition, the Hosmer-Lemeshow test confirmed the model's advantage and its accuracy ($\chi^2 = 14.12$, $df = 8$, $P > 0.05$). As indicated in Table 3, 66.2% of the items were correctly classified by the model. The model had 28.6 sensitivity and 71.4 specificity. The model's positive predictive value was 46%, and the negative predictive value was 71%. Table 4 shows a significant contribution of the rSIG index to the prediction of the status of trauma patients. The value of B is a negative predictor for this variable, which means the higher the B index, the less likely the trauma patient is to die. However, the rSI index was not a significant predictor ($P > 0.05$). When maintaining other variables, the odds ratio (OR) for the rSIG index showed that as the rSIG index increased by 1 unit, the probability of a patient dying decreased by 0.836 percent. To obtain the appropriate cutting point, ROC analysis was conducted. The area under the curve (AUC) was equal to 0.701, which was an acceptable level based on the classification provided by the researchers. Indeed, the AUC indicates the power of a test. The results showed that the shear level of 0.35 improved the sensitivity by approximately 70%. The optimal cut-off points for rSIG and rSI were determined 4.62 and 1.17, respectively, according to the criteria of being the closest point in a ROC curve.

Discussion

Trauma is one of the most important public health challenges worldwide. With the development of science and the industrialization of societies in the last century, trauma has become a crucial health problem. Trauma is also the leading cause of death and disability in developing countries.[24] Studies demonstrated that accidents and falls from heights accounted for more than 80% of the patients referred to the emergency trauma units of three hospitals. These are the most common cause of trauma in patients who die or require admission to the ICU. Most patients in good general condition were discharged from the emergency department.[25] By timely assessment and appropriate triage, the risk of mortality and disability can be reduced.[26] Trauma scoring systems have been used as a main part of the prehospital triage process to predict death after trauma and as a tool for measuring the severity of an injury.[27] Over the past 50 years, various trauma scoring systems have been developed that differ in complexity, design, and accuracy.[28] For example, SI was defined as a sensitive marker of shock and prediction of resuscitation success than vital signs alone in 1967. SI is computed easily and employed to determine mortality. SI is used for outcome prediction and trauma triage in emergency conditions. Regardless, SI may underestimate in older patients. Zarzaur et al[29] revealed that the SIA could be a good mortality predictor in patients older than 55 years. Also, the GCS score was identified as a powerful predictor in emergency settings. Based on this information, this study aimed to determine the predictive value of the rSI with a GCS score for predicting the outcome of traumatic patients. The population included all the traumatic patients (216 patients) referring to the emergency department of Imam Reza hospital. The results of data analysis demonstrated that the regression model by two predicting variables of rSI and rSIG was statistically significant. This study also illustrates that the suggestive model can distinguish between those patients who died and those who were discharged. A comparison of rSI measures demonstrated that the patients with rSI < 1 experienced unstable hemodynamic conditions,

Table 3. Classification table

			Predicted		
			Outcome		Percentage Correct
			Discharged 0	Died 1	
Observed	Outcome	Discharged 0	123 (True negative)	23 (False positive)	84.2 (Specificity)
		Died 1	50 (False negative)	20 (True positive)	28.6 (Sensitivity)
Overall percentage					66.2

Table 4. Logistic regression coefficients to predict the status of trauma patients

Variable	B	SE	Wald statistic	df	P	OR	95% Confidence Interval for OR	
							Lower Bound	Upper Bound
rSI	-0.493	0.608	0.658	1	0.417	0.611	0.186	2.010
rSIG	-0.179	0.041	19.269	1	0.000	0.836	0.772	0.906
Constant	1.097	0.698	2.472	1	0.116	2.996		

rSI, reverse shock index; rSIG, Reverse shock index multiplied by Glasgow Coma Scale score; SE, standard error; df, degrees of freedom; OR, odds ratio.

poor outcomes, prolonged admission rates in ICU, and higher mortality during a hospital stay. The results of this study are in line with those of WU et al.[19] Regarding the GCS index, the results of this study agree with Miller et al,[30] Goodacre et al,[31] and Ala et al.[20] Likewise, the rSI index results are in line with those of Han et al,[14] Lammers et al,[18] Chuang et al,[10] and Chu et al.[17] Generally, we could conclude that the predictive value of the rSI with GCS in predicting the outcome of traumatic patients was high. Calculating our suggestive score is simple without requiring additional equipment and seems a sensitive predictor for traumatized patient outcomes.

Limitations

This study had several limitations. First, since the study was retrospective, some selection bias may have occurred. Second, the vital signs and GCS scores used in this study were recorded at the patient's arrival time to the emergency department. So, it may have been affected by the pre-hospital resuscitation. Third, it may be difficult to generalize the results since the study was limited to one hospital, and the cutoff values for the different trauma systems may differ depending on the country or region studied. Generally, trauma has imposed many economic and social costs on the community. Thus, policymakers and those involved in health care systems have taken primary measures in this regard. Helping to establish a system for recording trauma patients' information can aid in establishing prevention programs and emergency care for trauma. Ultimately, this can reduce the death and disability rates related to trauma.

Conclusion

This study revealed that the predictive value of rSI with GCS in predicting the outcome of trauma patients was high. It is imperative that these patients receive more attention in the emergency room because they may be at risk of life-threatening health problems.

Study Highlights

What is current knowledge?

- Trauma is one of the most important public health challenges worldwide. Trauma scoring systems have been used as a main part of the prehospital triage process to predict death after trauma and as a tool for measuring the severity of an injury.

What is new here?

- As far the researchers of this study investigated, no study has been carried out to evaluate the diagnostic value of rSIG in defining mortality risk for traumatic patients so far. Hence, this study aimed to determine the predictive value of rSI with GCS score in the outcome of trauma patients.

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Competing Interests

The authors declare no conflict of interest.

Ethical Approval

The study was conducted in accordance with the Declaration

of Helsinki, and the approved retrospective study by the Ethics Committee of Islamic Azad University of Tabriz (code: IR.IAU.TABRIZ.REC.1399.127). Since the patients' information was used in a completely confidential manner, no informed con-sent was obtained from the participants.

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