Trauma Monthly 2021; 26(5): 252-257

10.30491/TM.2021.262592.1212

Trauma Monthly

Original Article

Mortality Prediction in Multiple Trauma Patients Using GAP, RTS and NTS Models

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Received 2020-12-14; **Accepted** 2021-08-16; **Online Published** 2021-08-30.

Abstract

Introduction: There are several models to predict the prognosis of trauma patients. The present study aimed to evaluate age, systolic blood pressure (GAP), revised trauma score (RTS), and new trauma score (NTS) to predict mortality rate in multiple trauma patients referring to Imam Reza Hospital, Tabriz, Iran.

Methods: The present descriptive-analytical study was carried out on 544 multiple trauma patients from July 2018 to Aug 2019. GAP, RTS, and NTS models were adopted to collect data on the variables. The GAP, RTS, and NTS scores were calculated, and their relationship with hospital outcome was then assessed.

Result: In total, 31 patients out of the selected sample died during the study. The cut-off point (sensitivity and specificity) of RTS, NTS, and GAP models for hospital survival rates was equal to 6.07 (0.97 and 0.98), 5.59 (0.94 and 0.99), and 15.5 (0.97 and 0.97), respectively. A logistic regression test was run to determine the effects of GCS, GAP, RTS, and NTS models. The results showed that the RTS and NTS scores had the highest value in determining the chances of survival, with the respective odds ratios (OR) of 13.74 and 10.207.

Conclusion: Considering the high sensitivity and specificity of RTS, GAP, and NTS models in determining patient survival rates, these models have good predictive value in determining hospital outcomes. The effect of these models on the patient outcome based on OR values, RTS and NTS models showed high values.

Keywords: Outcome, Mortality, Multiple trauma, Emergency ward.

Introduction

Today, trauma is increasingly being considered as a major cause of death and disability in developed and developing countries.[1] Time is a vital factor in the treatment of traumatic patients and plays a main role in determining the outcome of trauma patients. Most trauma-related deaths usually occur before reaching the hospital or in the early hours following injury.[2]

The severity depends on the patient's mortality risk and admission prognosis by definition.[3] Prognosis is defined considering severity, outcome or probable processes related to healthcare conditions over time.[4] Prognostic trauma models should include mortality risk, admission prognosis, and triage indicators.[5,6] A scoring system must have appropriate accuracy, reliability, and specificity to predict trauma-related mortality.[1,2] The two most widely used and important scoring systems include revised trauma score (RTS) and trauma and injury severity score (TRISS) systems.[7,8,9] The injury severity score (ISS) system is employed in four areas: injury prevention, injury severity prediction, mortality prediction, and improvement of hospital service quality.[7,10]

Initial prediction prognosis indices usually depend on quickly measurable variables that most of which measure the body's physiological response to decreased intravascular blood volume, especially in the case of bleedings such as hypertension, capillary filling, Glasgow coma scale (GCS), heart rate (HR), and respiratory rate (RR).[11] Jeong showed in a study that NTS has higher accuracy than RTS.[12] Rahmani found that GAP, MGAP, and GCS scores had similar values in predicting the patient outcome.[2] Perel et al.'s prognostic model performed well to predict the early death in patients with bleeding trauma.[13]

Since the NTS is a new model for evaluating the outcome of multiple-trauma patients, the present study aimed to assess the accuracy of three NTS, GAP, and RTS scores in determining the outcome of multiple-trauma patients referred to a Level III trauma center.

Methods

Setting

This descriptive-analytic study was conducted on 544 multiple-trauma patients at the Trauma Center affiliated University of Medical Sciences during Dec 2018 to Aug 2019.

Study design

Inclusion criteria included multiple trauma patients over 18 years referred to the emergency department by the pre-hospital emergency system or family members. Exclusion criteria included patients with isolated trauma, patients referred from other hospitals, patients with cardiac arrest upon arrival to the emergency department, and unwillingness to participate in the study.

Sample size

Sensitivity (0.88) and specificity (0.85), reported for GAP score to predict mortality in multi-trauma patients in Rahmani's study,[2] were used to calculate sample size with the minimum of 544 patients based on the number of multiple trauma patients admitted to the emergency room (30%). The considered value was based on hospital statistics and acceptable 5-unit change in the reported sensitivity value, 0.95 confidence interval, $\alpha = 0.05$, and $\beta = 80\%$.

Ethical consideration

This study was reviewed by the ethics committee of the University of Medical Sciences and approved on 02. Dec.2018 with the Ethic Code IR.ARUMS.REC.1397.165.

Data gathering

After the patient was admitted to the emergency department and diagnostic-therapeutic procedures were performed, informed consent was obtained from the patient or, if needed, the patient's companion. The variables required to determine the trauma severity were collected using GAP, RTS, and NTS indices, including age, sex, level of consciousness based on GCS, blood pressure, arterial oxygen saturation percentage (SaO2), and RR. The hospital outcome of the patients was followed up and determined after taking necessary measures, which included death or survival upon discharge. Among GCS variables, systolic blood pressure (SBP) and age were used to calculate the GAP index;[14] SBP and RR were employed to calculate RTS (9); and SBP and SaO2 percentage determined the NTS index (12).

Statistical methods

Data were entered into SPSS ver. 17, and, Kolmogorov-Smirnov test was run to determine the normal distribution of data. Frequency (percentage) statistical method was used to describe qualitative data, mean ± standard deviation to describe quantitative data. Independent sample t-test and chi-square test were employed to compare quantitative and qualitative data between the two groups of patients, respectively. To determine the predictive value of GAP, RTS, and NTS scores, ROC curve with 95% confidence interval, cut-off point, sensitivity, specificity, positive and negative predictive value (PPV and NPV, respectively) were applied. The P-value less than 0.05 was also set as statistically significant in all tests.

Results

The present study was carried out on 544 multiple trauma patients. The mean (SD) age of the patients was 35.45 (16.80) years. 395 (72.6%) of the patients were male, and the rest were female. The mode of injury (MoI) was car-to-car accidents in 34% patients (n=185), with 61.2% (n=333) patients suffering from multiple trauma in streets, and 5.6% (n=31) dying during hospitalization. Patient outcome was also evaluated based on the GOS index with the following results: 31 patients died (5.7%), 15 patients had a severe disability (2.8%), 389 patients had moderate disability (71.5%), and 109 patients recovered and were discharged from hospital (20%).

Table 1 shows a comparison of demographic variables, vital signs, and trauma severity indices based on patient outcome (deceased or survived). The above table shows a statistically significant difference between deceased and survived groups in terms of all studied variables except for sex, RR, and length of stay (LOS). This table also shows the comparison of trauma severity indices evaluated in deceased and survived groups. As can be observed, all the indices were significantly different in the two groups being significantly lower in the deceased patients (Table 1).

ROC curve was used to determine the predictive value of RTS, NTS, and the GAP indices in determining the hospital survival of the studied patients (Figure 1). Based on the ROC curve, cut-off point, sensitivity, specificity, positive and negative and positive predictive values, positive and negative likelihood ratios, and J point were calculated (Table 2).

Logistic regression was used to evaluate the effects of GCS, O2 saturation, RTS, NTS, and GAP variables in predicting hospital mortality of multiple trauma patients. Results of this test and OR values of each variable are shown in Table 3. The results of investigating OR values for each unit change in each index showed that a one-unit increase in RTS and NTS scores leads to a 13.74-fold and 10.207-fold increase in the odds ratio of in-hospital mortality by keeping the other variables constant, respectively.

Table 1. Comparison of demographic variables, vital signs, and trauma severity indices based on patient hospital outcome

Outcome / Variables	Alive (513 patients)	Dead (31 patients)	P value (95% Confidence Interval)
Age	34.83±16.27	45.87±21.73	<0.001 (5.00-17.08)
Gender (male/female)	369/144	26/5	0.104
Time between event to hospital (minutes) • Median (IQR %25-%75)	45 (35-90)	120 (60-120)	<0.001
Vital signs • Systolic blood pressure • Respiratory rate • Saturation of O2 • GCS	115.84±17.38 17.90±4.04 93.70±7.17 14.42±1.57	76.74±33.21 18.35±11.27 53.19±13.92 6.03±2.20	<0.001 (-45.86- -33.34) 0.607 (-1.27-2.17) <0.001 (-43.31- -37.70) <0.001 (-8.98- -7.80)
Duration of admission (day) • Median (IQR %25-%75)	1 (1-2)	1 (1-8)	0.553
Intubation (yes/no)	53/460	31/0	<0.001
RTS	7.71±0.42	4.10±1.37	<0.001 (-3.80- -3.42)
NTS	9.93±1.21	3.52±1.46	<0.001 (-6.85- -5.96)
GAP	21.92±2.40	10.35±3.62	<0.001 (-12.46- -10.66)

Table 2. Predictive value of patients' GCS, RTS, NTS, GAP, and Saturation of O2 in determining the hospital mortality

Predictive value / Score	Cut off point	AUC (95% Confidence Interval)	Sensitivity	Specificity	PPV	NPV	LR+	LR-	J point
GCS	8.5	0.980 (0.94-1.00)	0.99	0.94	0.94	0.99	16.5	0.01	0.93
RTS	6.07	0.995 (0.99-1.00)	0.98	0.97	0.97	0.98	32.6	0.02	0.95
NTS	5.59	0.996 (0.991-1.00)	0.99	0.94	0.94	0.99	16.5	0.01	0.93
GAP	15.5	0.991 (0.984-0.998)	0.97	0.94	0.94	0.97	16.16	0.03	0.91
Saturation of O2 (%)	77.5%	0.991 (0.983-0.998)	0.94	0.94	0.94	0.94	15.66	0.06	0.88

Table 3. Effect of patients' GCS, RTS, NTS, GAP, and Saturation of O2 in patients' mortality

Items	Variable	Coefficient (β)	Odds ratio	P value
Mortality	GCS	1.230	3.42	<0.001
	RTS	2.621	13.744	<0.001
	NTS	2.32	10.207	<0.001
	GAP	0.80	2.227	<0.001
	Saturation of O2	0.211	1.235	<0.001

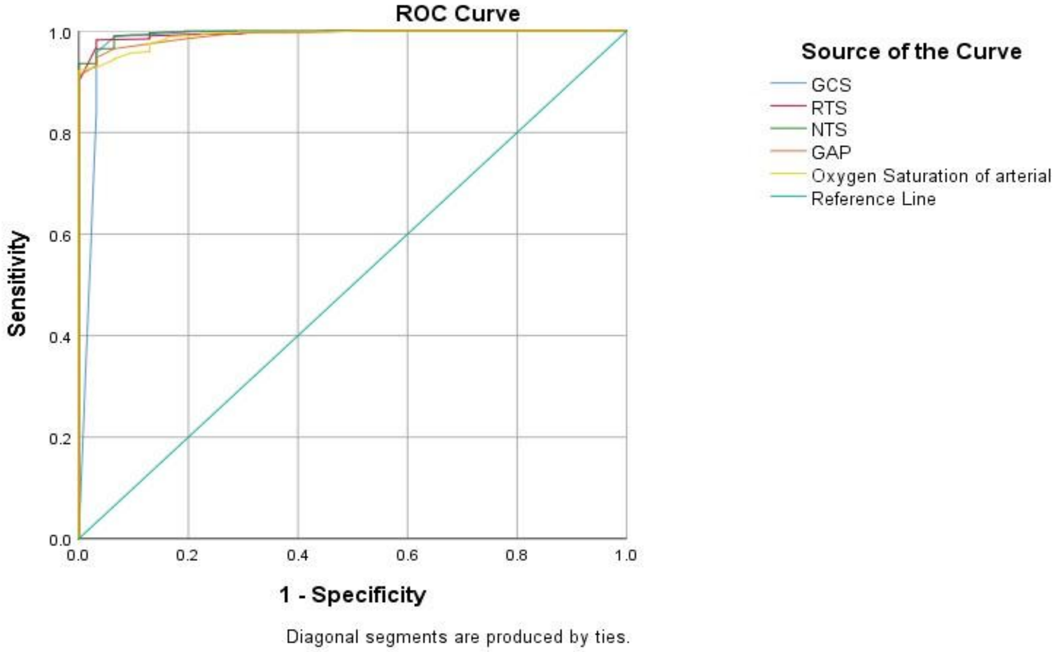

Figure 1: Value of GCS, RTS, NTS, GAP, and Saturation of O2 in predicting mortality of patients

Discussion

In this study, 31 patients died, and 513 patients were discharged from the hospital. Based on the evaluations of the three indices with GCS and O2 saturation, ROC, NTS, and RTS scores were higher than the other variables, and these variables had higher values of OR in predicting in-hospital mortality than the other indices. However, the ROC of all the indices was above 0.98.

Assessment of trauma severity includes clinical findings, previous anatomical problems, MoI, and pre-trauma health status. These evaluations can provide a good prognosis for trauma patients.[6] A trauma scoring system must have the appropriate accuracy, reliability and specificity to predict trauma-related mortality.[1,2] Trauma scoring has been designed as one of the key components of pre-hospital triage and predicting morbidity and mortality, which provides valuable assistance to physicians in examining patients for appropriate healthcare services and choosing the appropriate treatment center.[15]

Most of the prediction indices measure the body's physiological response to decreased intravascular blood volume, especially in the case of bleedings such as hypertension, capillary filling, level of consciousness (GCS), HR, and RR.[11] Overall, two different types of trauma criteria can be examined, the first focusing on easy and measurable triage of patients based on the physiological response of the injured individual and the second on the severity and type of injuries sustained.[16]

There are scoring systems for assessing the severity of the injury and predicting outcomes in multiple trauma patients.[13] But, most of them include variables that are not usually available in pre-hospital conditions, such as a CT scan or paraclinical results.[13,17] Hasler showed in his study that the MGAP and GAP scores are valid for triage and risk assessment in trauma patients.[18] In a study of patients with major trauma, Perel et al. concluded that the GAP score could be employed to predict mortality both at the site of trauma and upon admission.[13] Kondo introduced a new GAP scoring system to predict hospital mortality of trauma patients. The c-statistic for the GAP scores (0.933 for long-term mortality, and 0.965 for short-term mortality) were more accurate than the trauma scores calculated by other assessment scales.[14] In a study, Sartorius compared MGAP scoring system with older models and showed that this score had equal to or higher predictive value in predicting in-hospital mortality than older scores. [19] Ahun showed that the GAP score was more readily applicable at the site of trauma and in the emergency department to accurately predict patient outcomes.[20]

Recent studies have reported that hypoxia and prehospital hypertension have increased mortality in traumatic brain injury (TBI) patients.[21] The GCS scale is a practical method for assessing neurological function [22] used as a physiological index in the triage of function.[12] Accordingly, new ISS was designed by Jeong, and NTS global characteristics performed significantly better than RTS, but similar to MGAP and GAP, in predicting mortality in a cohort validation.[14]

The efficiency of NTS and GAP scoring systems was similar in both Jeong et al.' s and the present study. However, the superiority of the NTS to RTS score has not been demonstrated, due possibly to the non-measurable SPO2. It can be explained by low oxygenation or poor circulation due to hemorrhagic shock, tension pneumothorax, and cardiac tamponade.[12] The results of the present study revealed that all of the scores had almost the same value in predicting hospital mortality in multiple trauma patients. Although, the previous study showed that the GAP score was better in terms of simplicity and practicality.[2] Comparing the RTS and NTS scores showed that these two scores had OR values above 10. However, NTS was more practical than determining RR/minute for performing pulse oximetry. Currently, ambulances and emergency departments are equipped with pulse oximetry device that evaluates this score easier.[14]

Limitations

One of the limitations of the current study was to discharging of some patients on their risk despite medical recommendations for the treatment caused to excluding from the study. Moreover, patients were excluded from the study considering the initiation of treatment at a primary health center and the probable change in vital signs.

Conclusion

According to the results of the present study, it can be concluded that considering the high sensitivity and specificity values of the RTS, GAP, and NTS models, in determining patient survival, all of these scoring systems have good predictive values. Therefore, it is recommended to promptly begin diagnostic and therapeutic procedures to define the mortality rate in all multiple-trauma patients. For the accessibility and applicability of these models, designing a mobile application for these models is recommended. Therefore, the medical staff in the pre-hospital or hospital emergency department can easily calculate and record these models in the patient's medical record.

Acknowledgments

The authors are grateful to all who participated in the study. This article was written based on the dataset of SAF's thesis entitled" Evaluation of GAP and RTS, and NTS Trauma Scores to Predict Prognosis of Multiple-trauma Patients ", registered in the University of Medical Sciences (No: 0778).

Conflict of Interest Disclosures

The authors declare no potential conflict of interest.

Authors' Contributions

All authors have read and approved the manuscript. HEB conceived and designed the experiments, SAF performed the experiments, HS and KA analyzed and interpreted the data, HS and HEB contributed reagents, materials, analysis tools or data, and FR wrote the paper.

Funding Sources

There wasn't any financial support for this work.

Ethical Statement

This study was reviewed by the ethics committee of University of Medical Sciences and approved on 02, Dec.2018 with the Ethic Code IR.ARUMS.REC.1397.165.

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