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Original Article

A new method to predict the in-hospital outcome of multi-trauma patients: R-GAP

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Abstract

Objective: Awareness of the severity of trauma and the outcome of patients can help physicians decide how long to treat patients. The objective of this study is to design a new score (R-GAP: Revised-GCS, Age, Pressure) for multi-trauma patients and determine its predictive value concerning in-hospital outcome of these patients.

Methods: This cross-sectional study was performed in the emergency ward of Imam Reza (AS) and Shohada hospitals (referral centers for trauma patients) affiliated to Tabriz University of Medical Sciences from 2019 to 2020. The sample size of this study was estimated to be 2000 people. Required information was collected and the final diagnosis of the patients was recorded. The hospital outcome was recorded at the time of discharge. Patients' outcome was also recorded using the Glasgow Outcome Scale (GOS) system. Based on the obtained data, GAP, R-GAP, new trauma score (NTS) scores were also collected and their results were compared with the designed model. *Receiver operating characteristic* (ROC) curve and logistic regression were used to analyze the predictive value of the scores.

Results: The mean age of the subjects was 34.09 (± 15.23) years. The highest outcome of patients based on the GOS system was recovery, moderate disability, and severe disability with 1309 cases (54.9%), 743 cases (31.2%), and 212 cases (8.9%), respectively. The mean of GAP, R-GAP, and NTS scores were 21.83 (± 3.1), 21.47 (± 3.4), and 21.27 (± 3.3), respectively. The intensity of GAP, R-GAP, and NTS in most subjects was low with 2143 cases (89.9%), 1994 cases (83.6%), and 2138 cases (89.7%). Among the significant variables included in the regression model, O2sat, primary GCS, GAP, R-GAP, and NTS with modulation on other variables, significantly equalized the mortality chance by 0.416, 0.622, 0.595, 0.601, 0.637, respectively (P value < 0.001).

Conclusion: According to the study results, it seems that GAP, R-GAP, and NTS respectively, have the highest strength of predictive value in the survival of patients with multiple traumas. It is suggested that a comprehensive study be conducted to better estimate this issue.

Keywords: Multiple traumas, Outcome, Mortality

Introduction

Trauma is any injury caused by an increase in energy entering the body (1, 2). The severity of trauma can be evaluated based on the mechanism and location of injury, or on the characteristics of the cause of the trauma, etc (3). One of the leading causes of death and primary disability in the world is trauma. However, advances in pre-hospital and hospital interventions have reduced the number of disabilities caused by major injuries (4,5). Emergency medicine technicians (EMTs) in the pre-hospital setting must quickly assess the patient and severity of the trauma for accurate evaluation and dispatch of patients (6). According to the World Health Organization (WHO), by 2024, accidents will be the second leading cause of lost years of life worldwide. The death rate of trauma in one hundred thousand population in the world was 88 people and in Iran it was 39 people (7).

Trauma has also imposed many direct and indirect economic and social costs on society. In developed countries, to solve this problem, the trauma system has been established, a system for proper management and treatment of the injured from the scene of the accident to the end of treatment and rehabilitation and his/her efficient return to society (8). The trauma severity scoring system consists of four components: injury prevention, injury severity prediction, death prediction, and improving the quality of hospital services (9,10). Scoring systems for multi-trauma patients are used in two situations: one at the scene and before transferring the patient to decide how to transfer to the destination

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hospital and the other in the hospital to decide on the severity of the trauma, patient prognosis, and informing the patient's family about the patient's condition (11). In the study conducted by Khajoei et al, among the scores used to predict the outcome of trauma patients, new trauma score (NTS) had high accuracy (12).

Based on the current data, the GAP score is currently introduced as a severity assessment score for multi-trauma patients by the emergency organization and is evaluated by the Traffic Research Center of Tabriz University of Medical Sciences. In assessing this score, the age variable is only divided into two ranges under 60 and over 60 years, and the age condition is not very effective in dividing the severity of trauma; Therefore, this study aimed to evaluate the adjusted GAP score (age and SBP variables adjustment) and compare it with the main GAP score in determining patients' outcome.

Methods

This descriptive-analytical cross-sectional study was performed in the Pre-Hospital Emergency Center and two emergency departments (EDs) of the hospitals (referral centers for trauma patients) affiliated to the University of Medical Sciences. The period of the study was from June 2019 to August 2021. The sampling method used to obtain data was census based on the inclusion and exclusion criteria until reaching the final sample size. After explaining the study to the participants and their first-class companions and obtaining informed consent, relevant information and final diagnosis of patients were recorded. The outcome of patients was recorded using the Glasgow Outcome Scale (GOS) system.

To calculate the sample size, according to the reported sensitivity 99% and specificity 98% in the study conducted by Rahmani et al (13), and to predict the hospital mortality of multi-trauma patients and the calculated prevalence of 30% for multi-trauma patients related to traffic accidents transferred by pre-hospital emergency and considering the acceptable error rate of 10% (D = 0.1) and using Dr. Lin Naing software with 95% confidence level, the sample size was 1271 patients. Considering the attrition rate of 20% and the design effect of 10%, the sample size increased to 1600 patients.

Inclusion criteria included all multi-trauma patients due to traffic accidents over the age of 18 who were transferred by emergency medical services (EMS) to the EDs. Exclusion criteria included unwillingness to participate in the study, discharge with personal consent during hospitalization, trauma caused by other causes, pregnant women, and penetrating trauma.

A checklist related to the study variables was completed by researchers. These variables were age, sex, respiratory rate, O2 saturation, heart rate, systolic blood pressure (SBP), primary GCS, trauma mechanism (pedestrian hit by a car, car accident, car hit a fixed object, rollover, motorcycle, and bicycle), hospital outcome.

GAP scoring system was calculated based on previous studies (13,14). This score is described in Table 1. In the RGAP scoring system introduced in this study, we modified the age and SBP variables. According to the definition of shock for systolic blood pressure below 90 mmHg; this threshold was included in the classification of blood pressure variables. For the age variable because older age patients have underlying diseases and problems that are caused by aging and the use of various drugs can have a greater impact on mortality; the age division was done accordingly (Table 1). For the severity classification of R-GAP, this score was divided into 4 categories: mild (20-25), moderate (14-19), severe (8-13), and very severe (0-7).

Data were analyzed by using SPSS software version 26. The normality of the data was checked using the Kolmogorov-Smirnov test. Frequency (percentage) was used to describe qualitative data, mean (standard deviation) was used for quantitative data, and median (25th and 75th percentiles) was used if data distribution was not normal. To analyze the qualitative data in both groups, χ^2 test and if there were no conditions for its use, Fisher's exact test was used. T-test was used to analyze quantitative data in both groups and Mann-Whitney test was used if data distribution was not normal. We used the receiver operating characteristic (ROC) curve to calculate the area under curve (AUC), cut off point, sensitivity, and specificity of scores. Logistic regression was used to calculate the odds ratio (OR). The level of statistical significance *P* value was considered below 0.05.

Results

In this study, which was performed in hospitals of the university of medical sciences, 2384 patients were studied whose mean age (standard deviation) was 34.09 (± 15.23) years. Most of the people in this study were men with 1982 cases (83.1%). The most common mechanism of trauma in the subjects was motorcycle with 880 cases (36.9%), on the other hand, the trauma mechanism variable was statistically significantly related to mortality (*P* value < 0.001). Of these, 824 (34.6%) were admitted to the ICU. The highest outcome of patients based on GOS system was recovery, moderate disability and severe disability with 1309 cases (54.9%), 743 cases (31.2%) and 212 cases (8.9%), respectively. Hospital mortality rate was 4.8% (115 patients).

Table 1. Calculation method of GAP and R-GAP scores

Score	Age (y)	SBP (mm Hg)	GCS
GAP	<60 = 3 >60 = 0	>120 = 6 60-110 = 4 <60 = 0	3-15
R-GAP	<50 = 3 50-70 = 0 >70 = -3	≥120 = 6 90-119 = 4 60-89 = 2 <60 = 0	3-15

Data related to the comparison of characteristic features and vital signs between the two groups based on hospital outcome is shown in Table 2. As can be seen from Table 2, there were statistically significant differences concerning all variables except gender between the two groups (*P* value<0.001). Also, the most common mechanism of trauma in the mortality group was rollover and pedestrian, while in the other group it was motor and car accidents.

Table 3 shows the comparison of three trauma scores between the two groups of patients. In our study based on R-GAP category classification, the mortality rate in mild, moderate, severe, and very severe groups were 0.5%, 10.1%, 57.3%, and 86.7%, respectively.

To calculate the predictive value of GAP, R-GAP, and NTS trauma scores in the survival of patients, we used the ROC and then calculated the AUC, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and Youden index (Figure 1 and Table 4). As shown in Table 4, the AUC of scores are approximately similar.

We entered the GAP, R-GAP, and NTS scores in the regression model to evaluate the predictive value of these scores in multi-trauma patient outcomes. Table 5 shows the results of the test. As it shows, all of these scores have a significant role in patient outcomes (*P* value <0.001). The OR of the GAP and R-GAP scores are higher than NTS. If the other variable is constant, one unit increase in the GAP, R-GAP, and NTS scores reduces 1.637, 1.623, and 1.588 the probability of a patient's death.

Table 2. Comparison of the characteristic features, and vital signs between the two groups based on hospital outcome

	Group		*P* value
	Without mortality (N=2269)	With mortality (N=115)	
Age	39.91±19.11	33.80±14.95	<0.001[a]
Gender			
Male	1879 (82.8%)	103 (89.6%)	0.059[b]
Female	390 (17.2%)	12 (10.4%)	
Vital signs			
GCS	14.38±1.97	6.70±3.49	<0.001[a]
SBP	117.85±13.70	100.42±30.27	<0.001[a]
O2 saturation	95.20±4.39	83.13±16.83	<0.001[a]
Mechanism of trauma			
Motor	859 (37.9%)	21 (18.3%)	
Car to car	468 (20.6%)	16 (13.9%)	
Rollover	429 (18.9%)	30 (26.1%)	<0.001[b]
Pedestrian	240 (10.6%)	24 (20.9%)	
Truck	144 (6.3%)	4 (3.5%)	
Fixed objects	116 (5.1%)	19 (16.5%)	
Bicycle	13 (0.6%)	1 (0.9%)	
ICU admission			
Yes	723 (31.9%)	101 (87.8%)	<0.001[b]
No	1546 (68.1%)	14 (12.2%	

[a] Independent sample's *t* test, [b] Chi-square.

Discussion

The objective of this study was to design a new score (R-GAP) for multi-trauma patients and determine its predictive value concerning in-hospital outcome of patients. The results of the study showed that these scores had a significant predictive power for hospital mortality in multi-trauma patients (*P* value < 0.001).

The study by Kondo et al was conducted on 35 732 trauma patients. The results showed that C-score for GAP score (0.933 for long-term mortality and 0.965 for short-term mortality) was better or comparable to trauma scores using other scales. The conclusion of this study was that GAP compared to other previous trauma severity scoring systems can predict in-hospital mortality with high accuracy (14). In a cross-sectional descriptive study by Rahmani et al, which included 374 multi-trauma patients, findings revealed that GAP score could be used to accurately predict the outcomes of trauma patients (13). In the study conducted by Sartorius et al, the new trauma scoring system (MGAP) was compared with older models and they found that the MGAP system was significantly more accurate in predicting in-hospital mortality than previous models (15).

In a cohort study by Hasler et al with 30-day mortality as the primary outcome for two-score validation (MGAP and

Table 3. Comparison of three trauma scores (GAP, R-GAP, and NTS) between the two groups of patients

	Group		*P* value
	Without mortality (N=2269)	With mortality (N=115)	
GAP	22.25±2.40	13.67±3.82	<0.001[a]
GAP categories			
Mild	2130 (93.9%)	13 (11.3%)	<0.001[b]
Moderate	132 (5.8%)	80 (69.6%)	
Severe	7 (0.3%)	22 (19.1%)	
R-GAP	21.93±2.60	12.41±4.40	<0.001[a]
R-GAP categories			
Mild	1985 (87.5%)	9 (7.8%)	
Moderate	232 (10.2%)	26 (22.6%)	<0.001[b]
Severe	50 (2.2%)	67 (58.3%)	
Very severe	2 (0.1%)	13 (11.3%)	
NTS	21.75±2.42	11.85±4.65	<0.001[a]
NTS categories			
Low	2124 (93.6%)	14 (12.2%)	
Moderate	111 (4.9%)	41 (35.7%)	<0.001[b]
High	34 (1.5%)	54 (47.0%)	
Very high	0 (0%)	6 (5.2%)	

GAP: GCS, age, pressure; R-GAP: Revised GAP; NTS: new trauma score.
[a] Independent sample's *t* test, [b] Chi-square.

Table 4. Predictive value of GAP, R-GAP, and NTS trauma scores in hospital survival of patients using ROC curve

Score	Cut off point	AUC (95% CI)	Sensitivity	Specificity	PPV	NPV	J point
GAP	19.5	0.948 (0.922-.0974)	0.913	0.913	0.91	0.91	0.826
R-GAP	18.5	0.947 (0.920-0.974)	0.912	0.913	0.91	0.91	0.825
NTS	19.5	0.944 (0.918-0.971)	0.921	0.896	0.90	0.91	0.81

AUC: area under curve; PPV: positive predictive value; NPV: negative predictive value; GAP: GCS, age, pressure; R-GAP: Revised GAP; NTS: new trauma score.

Table 5. The results of logistic regression analysis of GAP, R-GAP, and NTS trauma scores in outcome of patients

Score	B	SE	df	OR	*P* value
GAP	0.493	0.029	1	1.637	<0.001
R-GAP	0.484	0.030	1	1.623	<0.001
NTS	0.463	0.028	1	1.588	<0.001

GAP) findings showed that GAP scores were reliable and a highly accurate triage tool for trauma risk classification (16). In a prospective study undertaken by Ahun et al on a total of 100 severe trauma patients who were 18 years old or older in the University of Uluda Medical School, patients' revised trauma score (RTS), injury severity score (ISS), trauma injury severity score (TRISS), MGAP, and GAP scores were calculated. The results indicated that the GAP score could be easily used in EDs to accurately predict outcomes (17). Given these results on the predictive power of GAP score in-hospital mortality in trauma patients, the present study was compatible with all studies that noted that GAP significantly had the predictive power of hospital mortality in multi-trauma patients. Also in this study, NTS significantly had the power to predict hospital mortality in multi traumatic patients (P value < 0.001).

The study undertaken by Jeong et al showed that NTS had better discrimination in comparison to RTS (AUC 0.935 vs. 0.917; $P = 0.001$, respectively) and it was similar to MGAP and GAP. In the validation group, the NTS score for mortality prediction was significantly better than RTS (AUC 0.919 vs. 0.906, $P = 0.013$, respectively) and it was similar to MGAP and GAP (18). The study by Cassignol et al showed that different triage scores were associated with the superiority of MGAP and NTS scores over T-RTS. Calculating MGAP or NTS scores with Vittel criteria reduces the risk of excessive triage counting in level 1 trauma centers (19). In the study by Galvagno et al, results showed that the MGAP scoring system had higher sensitivity and specificity than NTS for mortality and NTS was not a significant predictor of mortality in multi-trauma patients (20).

According to the results obtained on the predictive power of NTS score in-hospital mortality in trauma patients, in this study, we determined the predictive value of the new R-GAP score and compared it with previous GAP and NTS scores. The initial hypothesis for designing a new score based on the GAP score was that considering the role of age, especially old age in the incidence of death for multi-trauma patients; the age variable was divided into three subgroups and negative scores were considered for older ages. Also, according to the definition of shock, the SBP variable was divided into four subgroups, and the role of the SBP threshold of 90 mm Hg was applied accordingly. Finally, by comparing the new score and the old scores in determining the outcome of inpatient multi-trauma patients, no clear and significant difference was observed. The present study was inconsistent with the study of Galvagno et al (20) indicating lack of significant predictive power of NTS score in-hospital mortality in trauma patients; but it was consistent with other studies suggesting that NTS was a significant predictor of mortality in trauma patients.

This study had several limitations. First, data collection was at the time of COVID-19 restrictions. Second, we did not determine the type of car brand, wearing or not wearing a seat belt, seating place in the car, underlying diseases or the use of drugs or any other substances that affect the quality of driving, and the time of the accident.

Conclusion

In this study, the highest outcome of patients based on the GOS system was recovery, moderate disability, and severe disability, respectively. The severity of GAP, R-GAP,

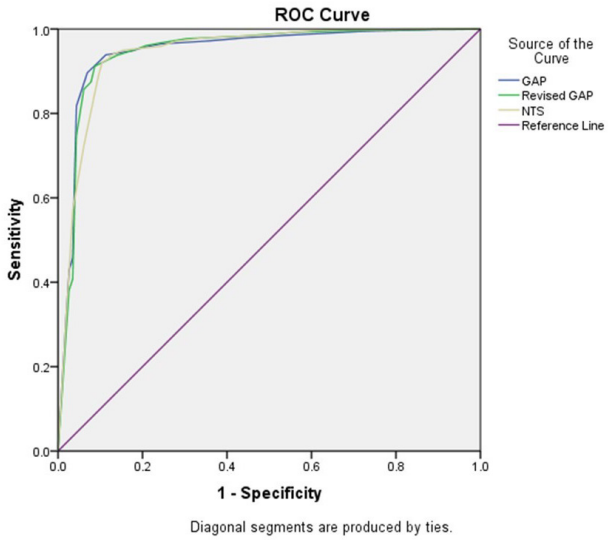

Figure 1. ROC curve of GAP, R-GAP, and NTS variables in predicting hospital survival.

and NTS was low in most subjects in this study. In this study, GAP, R-GAP, and NTS variables had the highest predictive power of survival chance for in-hospital multi-trauma patients, respectively. To further evaluate this new score, it is necessary to conduct further studies in various trauma centers to examine its value.

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Authors' contributions

All authors have read and approved the manuscript. PS, AMS, and HEB performed the data collection, writing, critical revision and drafting of the manuscript. FR and HEB undertook the major parts of the study design and performed the statistical analysis, data analysis, and data interpretation.

Ethical issues

Ethical permission to conduct the study was obtained from the Regional Ethics Committee on Research of Tabriz University of Medical Sciences with code number IR.TBZMED.REC.1398.051 on the 8th of April 2019. Informed consent was obtained from all patients or their first-class companions. All patients' information was kept confidential. For illiterate people, the study conditions were fully explained. All cases of the Helsinki Ethics Convention were observed in the research. There were no additional costs or delays in treating patients in this study.

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