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Designing a Model to Predict the Mortality in Multiple Trauma Patients due to Traffic Accidents

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Abstract

Background: It is of prime importance to manage trauma patients in the early hours and use easy trauma severity scoring systems to make decisions and evaluate patient prognosis.
Objectives: The present study aimed to design a predictive model of the mortality of multi-trauma patients due to traffic accidents.
Methods: This cross-sectional analytical study was performed on 600 patients who suffered from multi-trauma caused by traffic accidents from December 2019 to September 2021. Collected data included age, sex, vital signs, trauma mechanism, involved vehicle in the accident, accident location, and hospital outcome.
Results: In this study, 600 multi-trauma cases caused by traffic accidents were evaluated. Among the significant variables included in the regression model, age, Mean Arterial Pressure (MAP), Glasgow Coma Scale (GCS), AVPU (Alert, Verbal response, Pain response, Unresponsive), and vehicle versus fixed objects (in Vehicle 2) in the presence of other variables in the model, significantly predicted patient outcomes. Therefore, with the other variables being constant, one unit increase in the age variable increases the probability of death by 1.04 times, one unit increase in the score of the two variables of MAP and GCS, and also the transfer of trauma mechanism from the fixed object to the vehicle reduces death by 0.92, 0.62, and 0.10 times, respectively. In the AVPU variable, the transition from Alert to Verbal, the transition from Verbal to Pain, and the transition from Pain to Unresponsive increases the probability of death by 32, 104, and 567, respectively.
Conclusion: In this study, AVPU, age, MAP, primary GCS, and trauma mechanism due to hitting a vehicle with a fixed object had significantly the highest predictive power of hospital mortality in patients with multiple trauma due to traffic accidents, respectively. It is suggested that further studies be performed to replace the AVPU variable with GCS in the newly designed formulas for calculating the severity of trauma to simplify these scores.

Keywords: Mortality, Multiple trauma, Outcome, Predictive model, Traffic accidents

1. Background

Accidents and traumas are important because they lead to economic losses in addition to physical and psychological injuries. The highest rate of death due to unintentional injuries is related to traffic accidents in the world. Meanwhile, Iran has the highest status, with about 30 per 100,000 deaths (1). Trauma injuries threaten health worldwide, and account for 9% of global deaths (2). In 2009, trauma was identified as the sixth leading cause of death, accounting for 10% of deaths in the world. In many countries, such as the United States, after cancer and heart disease, trauma is the leading cause of premature death in people under 65 years (3). Trauma is one of the leading causes of death and primary disability worldwide (4).

The evaluation, management, and resuscitation (if necessary) of trauma patients, especially in the first hour, are critical because trauma is one of the time-sensitive conditions. Moreover, in the hospital emergency room, these systems help decide the severity of the injury and the patient's prognosis and inform the patient's family about the condition (5). Trauma severity scoring systems are used in four areas, namely injury prevention, injury severity, mortality prediction, and the improvement of the quality of hospital services (6). Simple and practical scoring systems for trauma severity help physicians decide on the duration of treatment (7).

Numerous studies have been conducted in this regard, most of them emphasizing using simple and practical scoring systems (8). Nirula et al. suggested that the rapid triage of severely traumatized patients to the trauma center without initial stabilization is associated with increased mortality (9). The findings of a study by Mostafaei H. et al. showed that some trauma score had moderate predictive value in determining the outcome of trauma in elderly individuals (10). Gomez D. et al. concluded that the level 3 trauma centers are the best option for providing definitive care to critically ill multi-trauma patients (11).

2. Objectives

Various systems, such as the "global alignment and proportion" (GAP), "mechanism, GCS, age, and arterial pressure" (MGAP), "revised trauma score" (RTS), and "new trauma score" (NTS) have been introduced for trauma scoring (7, 8, 12). These systems are effective in the correct triage of patients and in predicting the severity of injury and death of patients. However, these systems have been developed in other countries, and their validity has been assessed in those countries based on the available facilities and equipment. Therefore, we decided to design a model based on the collected data to predict the hospital mortality of multi-trauma patients due to traffic accidents in Iran.

3. Methods

3.1. Study design

This cross-sectional study was performed from December 2019 to September 2021 in the pre-hospital and hospital emergency centers affiliated with the Tabriz University of Medical Sciences, Tabriz, Iran, as referral centers for trauma patients. Razente study (13) was used to calculate the sample size based on the reported sensitivity of 81.8% and specificity of 96.2% for predicting hospital mortality in multi-trauma patients and also considering the acceptable error rate of 3% and 95% confidence level, the sample size of 600 patients was estimated using sample size calculation formula based on sensitivity and specificity. The sampling method was census based on the inclusion and exclusion criteria to reach the final sample size.

3.2. Participants

All patients with multi-trauma due to traffic accidents and over 18 years who were transferred by pre-hospital emergency systems to the referral trauma emergency centers of the Tabriz University of Medical Sciences hospitals were included in the study. The exclusion criteria entailed trauma by other causes, discharge with personal consent during hospitalization, pregnant women, penetrating trauma, and dissatisfaction with participation in the study.

3.3. Data collection

Data were recorded regarding their age, gender, respiration rate, oxygen status, heart rate, initial blood pressure, primary Glasgow Coma Scale (GCS), AVPU (Alert, Verbal response, Pain response, Unresponsive), trauma mechanism (e.g., pedestrian by car, car by car, a car with a fixed body, car overturning, motorcycle, and bicycle), involved vehicles in the accident (Vehicle 1: is the vehicle that the assessed injured was the passenger or driver of it, Vehicle 2: is the vehicle that crashed into vehicle 1), accident location (e.g., alley, street, road, highway, and freeway), and hospital outcome at the time of discharge of the patients. The outcome was recorded as death or survival at discharge from the hospital. The patients' outcome was assessed with a Glasgow outcome score (GOS). Based on the obtained data, the GAP, RTS, and NTS scores (7, 8, 12) were compared with the designed model.

3.4. Statistical Analysis

Data were analyzed using the SPSS software (version 26). The normality of data distribution was checked by the Kolmogorov-Smirnov test. The qualitative variables, quantitative factors, and variables without normal distribution were presented as frequency (percentage), mean (standard deviation), and median (25th and 75th percentiles). The χ^2 test was used to analyze the qualitative data in both groups. The Independent sample's t-test and Mann-Whitney U test were utilized to analyze quantitative data in both groups if the distribution was normal and not normal, respectively. The predictive power of the studied variables in the mortality of patients under study was analyzed by applying logistic regression. A *P*-value of less than 0.05 was considered statistically significant.

4. Results

In this study, 600 patients with a mean age of 34.5 ± 16.7 years were evaluated. A total of 484 (80.7%) participants were male. Among patients, 435 (72.5%) were discharged from the emergency room, 116 (19.3%) were admitted to the general ward, and 38 (6.3%) were admitted to the Intensive Care Unit. The most common outcomes of patients based on the GOS system were recovery, severe disability, and moderate disability, with 243 (40.5%), 162 (27%), and 158 cases (26.3%), respectively.

Table 1 shows the comparison of the studied variables between the two groups of patients with and without hospital mortality. As shown in Table 1, except for age, gender, heart rate, respiratory rate, and seating in the car, all others had a statistically significant relationship with hospital mortality ($P<0.05$).

The variables age, O_2sat, Mean Arterial Pressure (MAP), Vehicle 1, Vehicle 2, and GCS were entered in the regression model to investigate the prediction of patient outcome. It was observed that age, MAP, GCS, and vehicle hitting fixed objects (in Vehicle 2) in the presence of other variables showed a significant role in predicting patient outcomes. As a result, with the other variables being constant, one unit increase in age augmented the probability of death by 1.04 times while one unit rise in MAP, GCS, and the vehicle hitting fixed objects reduced death by 0.92, 0.62, and 0.1 times, respectively. Other variables in the model showed no significant predictive role. In the AVPU variable, the transition from alert to verbal, verbal to pain, and pain to unresponsive increased the probability of death by 32, 104, and 567 times, respectively. Other variables in the model

Table 1. Comparison of the variables between two groups of the patients (with or without mortality)

Variable	With mortality (N=34)	Without mortality (N=566)	*P*-value
Age	**39.50±18.88**	**34.20±16.51**	**0.072***
Gender			
• **Male**	29 (85.3%)	455 (80.4%)	0.655#
• **Female**	5 (14.7%)	111 (19.6%)	
Vital signs			
• **Heart rate (/minute)**	84.62±26.45	85.33±10.87	0.743*
• **MAP (mmHg)**	79.35±19.73	90.67±7.55	<0.001*
• **Respiratory rate (/minute)**	19.09±6.57	18.87±3.67	0.750*
• **GCS**	6.79±4.22	14.37±1.89	<0.001*
• **O_2 saturation**	90.88±16.65	96.80±2.51	<0.001*
AVPU			
• **Alert**	2 (5.9%)	458 (80.9%)	<0.001#
• **Verbal response**	5 (14.7%)	74 (13.1%)	
• **Pain response**	2 (5.9%)	16 (2.8%)	
• **Unresponsive**	25 (73.5%)	18 (3.2%)	
Mechanism of Trauma			
• **Motorcycle-Car**	9 (26.5%)	119 (21%)	<0.001#
• **Pedestrian-Car**	9 (26.5%)	99 (17.5%)	
• **Rollover**	7 (20.6%)	130 (23%)	
• **Car/motorcycle-Fix thing**	4 (11.8%)	40 (7.1%)	
• **Motorcycle-Motorcycle**	3 (8.8%)	4 (0.7%)	
• **Car-Car**	2 (5.9%)	164 (29%)	
• **Bicycle-Car**	0 (0%)	10 (1.8%)	
Place of injury			
• **Alley**	1 (2.9%)	18 (3.2%)	<0.001#
• **Street**	9 (26.5%)	352 (62.2%)	
• **Road**	20 (58.8%)	152 (26.9%)	
• **Highway**	4 (11.8%)	20 (3.5%)	
• **Freeway**	0 (0%)	24 (4.2%)	
GAP	13.5±4.62	22.39±2.28	<0.001*
GAP category			
• **Mild**	5 (14.7%)	538 (95.1%)	<0.001#
• **Moderate**	19 (55.9%)	28 (4.9%)	
• **Severe**	10 (29.4%)	0 (0%)	
NTS	13.09±4.85	22.07±2.12	<0.001*
NTS category			
• **Mild**	7 (20.6%)	545 (96.3%)	<0.001#
• **Moderate**	11 (32.4%)	14 (2.5%)	
• **Severe**	15 (44.1%)	7 (1.2%)	
• **Very severe**	1 (2.9%)	0 (0%)	
RTS	5.31±1.70	7.72±0.50	<0.001*

AVPU: Alert, Verbal response, Pain response, Unresponsive; MAP: Mean Arterial Pressure; GCS: Glasgow Coma Scale; GAP: GCS, Age, Pressure; NTS: New Trauma Score; RTS: Revised Trauma Score
*Independent Sample's t-test; # Chi square

demonstrated no significant predictive role (Table 2).

The area under the Receiver Operating Characteristic (ROC) curve of primary GCS, O_2sat, MAP, GAP, NTS, and RTS variables in predicting the hospital mortality of the studied subjects is presented in Table 3. As seen in the Table, among the variables in predicting the hospital mortality of the study subjects, the GAP, NTS, and initial GCS variables, in the aid order, had the highest power to predict hospital mortality (P<0.001). The ROC curve is shown in Figures 1 and 2.

Table 2. Predictive role of age, O_2sat, MAP, vehicle type, and GCS in patient's outcome

Variable	β Coefficient	*P*-value	Odds-ratio*	95% Confidence Interval	
				Lower	Upper
Age	0.038	0.022	1.038	1.005	1.072
O_2 saturation	-0.015	0.780	0.985	0.884	1.097
MAP	-0.083	0.011	0.920	0.863	0.981
Vehicle 1					
• **Car**	-1.507	0.090	0.222	0.039	1.267
• **Motorcycle**	-1.113	0.164	0.328	0.069	1.574
• **Truck**	0.547	0.717	1.727	0.090	33.339
• **Tractor**	-22.680	1.000	0	0	0
• **Bicycle**	-17.482	0.999	0	0	0
Vehicle 2					
• **Car**	-2.309	0.028	0.099	0.013	0.780

• **Motorcycle**	-0.549	0.639	0.578	0.058	5.731
• **Truck**	-1.735	0.263	0.176	0.008	3.681
• **Tractor**	-1.547	0.662	0.213	0	220.087
• **Bicycle**	-1.058	1.000	0.347	0	-
• **Bus**	-2.108	0.410	0.121	0.001	18.304
GCS	-0.477	<0.001	0.621	0.532	0.724
AVPU					
• **Alert**		<0.001			
• **Verbal**	3.482	<0.001	32.521	3.701	285.780
• **Pain**	4.651	<0.001	104.736	7.636	1436.658
• **Unresponsive**	6.341	<0.001	567.216	51.699	6223.204

AVPU: Alert, Verbal response, Pain response, Unresponsive; MAP: Mean Arterial Pressure; GCS: Glasgow Coma Scale
* Logistic regression

Table 3. The area under the ROC curve of primary GCS, O_2sat, MAP, GAP, NTS, and RTS in predicting the hospital mortality

Variable	AUC (Confidence interval 95%)	*P*-value
Primary GCS	0.932 (0.879-0.985)	<0.001
O_2 saturation	0.759 (0.665-0.852)	<0.001
MAP	0.730 (0.621-0.840)	<0.001
GAP	0.945 (0.896-0.993)	<0.001
NTS	0.943 (0.899-0.988)	<0.001
RTS	0.894 (0.816-0.971)	<0.001

ROC: Receiver Operating Characteristic; GCS: Glasgow Coma Scale; MAP: Mean Arterial Pressure; GAP: GCS, Age, Pressure; NTS: New Trauma Score; RTS: Revised Trauma Score

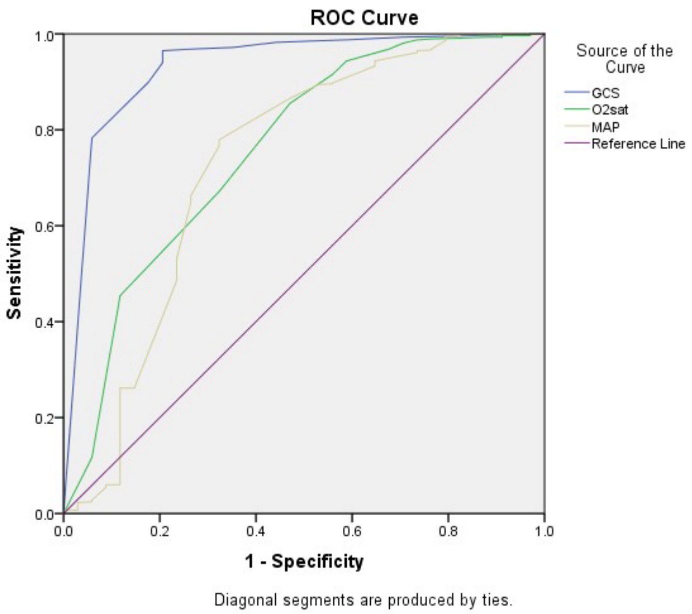

Figure 1. Receiver Operating Characteristic (ROC) curve of primary Glasgow Coma Scale (GCS), O_2sat, and Mean Arterial Pressure (MAP) in predicting hospital mortality

5. Discussion

The current study aimed to design a predictive model of the mortality of patients with multiple trauma due to traffic accidents. According to the results of this study, AVPU, age, MAP, primary GCS, and vehicle hitting fixed objects had the highest predictive power of hospital mortality in traffic accident trauma patients.

Simple and practical trauma severity scoring systems help physicians decide the length and quality of treatment. These scoring systems are used for multi-trauma patients in two situations, one of which is at the scene of the accident and before the patient is transferred to decide how to transfer to the destination hospital. The other situation is in the hospital to decide on the severity of the trauma and the patient's condition (7). Performance evaluation with a suitable model can identify the deficiencies and inadequacies of services provided in trauma centers. Using the model leads to a systematic evaluation and a comprehensive review of each trauma center's performance; then, we could perform interventions for revision of the faults (14).

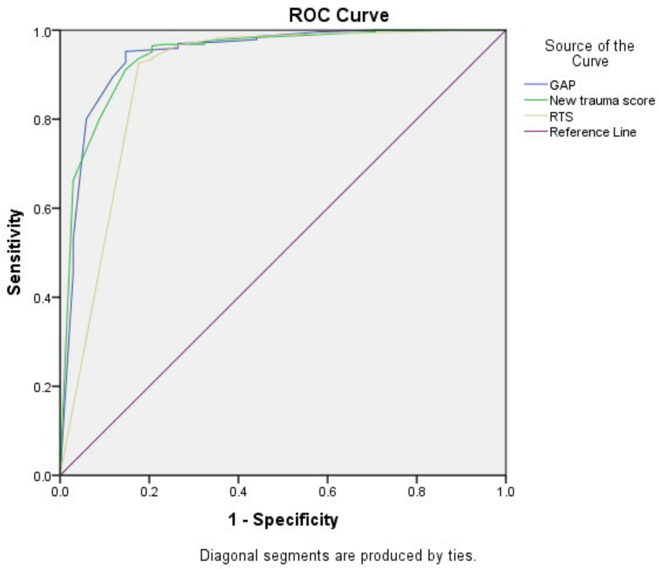

Figure 2. Receiver Operating Characteristic (ROC) curve of GAP (GCS, Age, Pressure), New Trauma Score (NTS), and Revised Trauma Score (RTS) in predicting hospital mortality

Kondo et al. showed that the GAP score could predict in-hospital mortality with higher accuracy than other trauma severity scoring systems (5). In the research by Rahmani et al., the GAP score could accurately predict the outcome of multi-trauma patients (7). In addition, Sartorius et al. concluded that the MGAP system was significantly more accurate in predicting in-hospital mortality than previous models (15). Hasler et al. reported the GAP score as a reliable and highly accurate triage tool for death risk classification (16). The results of Ahun et al. indicated that the GAP score could be easily used in emergency departments to predict the outcomes accurately (17). The present study was consistent with all the mentioned studies regarding the predictive power of GAP score for in-hospital mortality in patients with trauma due to traffic accidents. Moreover, in the present study, RTS had significant predictive power for in-hospital mortality in multi-trauma patients due to traffic accidents.

In the study by Emircan et al., the comparison of injury severity score (ISS), GCS, RTS, and trauma and injury severity score (TRISS) in patients with thoracic trauma revealed that the RTS model was not a significant independent predictor of mortality in these patients (18). Selim et al. demonstrated that the RTS trauma score significantly predicted the mortality of trauma patients (19). The results of Galvango et al. indicated that the MGAP scoring system had a higher sensitivity and specificity than RTS for predicting (20). Despite these, in our study, we want to design a score based on vital signs, level of consciousness, age of the injured, and type of vehicle. We evaluated them based on the patient's outcome. It was found that age and the level of qualitative consciousness have a larger odds ratio and important role in determining the outcome.

The results of the present study showed that age, blood pressure, level of consciousness, and trauma mechanism had a remarkable role in the predictive model of hospital mortality in patients with multiple traumas caused by traffic accidents. These results are consistent with the findings of previous investigations on the introduction of the GAP score, which consists of three variables, including age, level of consciousness based on GCS, and systolic blood pressure. Our results regarding the assessment of the level of consciousness based on the AVPU index showed that due to the simplicity of this index for evaluating the level of consciousness, we could adjust and use the GAP score instead of GCS to assess the level of consciousness, and make this score simpler and more practical.

5.1. Limitations

Limitations of the present research were the small sample size available due to the COVID-19 pandemic prevailing in the community and traffic restrictions. Furthermore, the car brand, wearing or not wearing a seat belt, where the injured person sat inside the car, underlying diseases, the use of drugs or any other substance affecting driving quality, time of accident occurrence, and final diagnosis of the injured patient were not taken into consideration.

6. Conclusion

In this study, the most common outcomes of patients based on the GOS system were recovery, severe disability, and moderate disability. We observed that AVPU, age, MAP, primary GCS, and trauma mechanism from the fixed body to the vehicle had the highest predictive power for hospital mortality in patients with multiple trauma due to traffic accidents. Further studies are recommended to replace the AVPU variable with GCS in the GAP score to simplify this score.

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Footnotes

Conflicts of Interest: The author(s) declare that they have no conflict of interest.

Author's contributions: All authors have read and approved the manuscript. EH, HEB, and FR collected the data, wrote a literature review, and drafted the manuscript. RME undertook the major parts of the study design and performed the statistical analysis.

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Ethical statements: This study has been approved by the Ethics Committee of the Tabriz University of Medical Sciences with the Ethics Code of IR.TBZMED.REC.1398.767.

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