Original Article

Predictive Value of the Glasgow Coma Scale, Age, and Arterial Blood Pressure and the New Trauma Score Indicators to Determine the Hospital Mortality of Multiple Trauma Patients

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Abstract

Background: Authoritative trauma scoring systems can quickly assess the damage and show its severity plus prognosis. The purpose of this study was to investigate the predictive value of the new Glasgow Coma Scale, age, and systolic blood pressure (GAP) and the new trauma score (NTS) indicators to determine the mortality of trauma patients in hospitals in Sirjan in 2019. **Materials and Methods:** In a descriptive-analytical study, 2570 patients with multitrauma caused by traffic accidents transferred by the prehospital emergency were enrolled in the study. Demographic variables of patients as well as GAP and NTSs were collected and calculated, with the outcome of patients followed up and recorded during hospitalization. The predictive value of these scores was determined in clarifying the outcome of patients using SPSS software. **Results:** Of the total number of patients studied, 14 (0.5%) patients died during hospitalization. The mean GAP and NTS scores in dead patients were 12.78 ± 6.92 and 11.64 ± 7.36, respectively. Furthermore, in surviving patients, they were 22.19 ± 1.12 and 22.30 ± 1.22, respectively, with a $P < 0.05$ in each case. Based on the above tools with 95% confidence level, the area under the curve for the mortality was 0.932 for the GAP system and 0.944 for the NTS ($P > 0.001$). **Conclusions:** Both indicators could predict the mortality of patients with multitrauma. It could also be used to determine the priority of dispatch at the scene of the accident and the triage of the injured (people). Based on the results of the receiver operating characteristic curve, the NTS score has a higher accuracy.

Keywords: Emergency ward, mortality, multiple trauma outcome

Introduction

According to the World Health Organization statistics, about 5.8 million people die each year as a result of injuries. This accounts for 10% of the world's deaths, with road traffic crashes causing the deaths of approximately 1.35 million people around the world each year and leaving between 20 and 50 million people with nonfatal injuries.[1,2] It is the leading cause of death in the first four decades of life.[3-5] In Iran, traffic accidents are known as the second-leading cause of mortality.[6] Classically, mortality secondary to trauma is described as having a trimodal distribution. The first peak occurs in the first seconds to minutes following trauma due to

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fatal injuries. The second one occurs minutes to several hours after, causing serious, potentially fatal injuries if there is no intensive care. Finally, the third peak occurs several days to weeks after trauma, due to complications such as sepsis and multiple organ failure.[2]

In addition to the human suffering caused by trauma, trauma results in significant, disability and morbidity, while incurring serious health care costs, posing an enormous burden on society.[7,8] Trauma mortality rates depend on injury severity, time to assessment, and time to reach an appropriate care center.[8] Management, evaluation, resuscitation, and providing special cares are very important in the early hours of trauma.[9] There are several tools for the multiple trauma care for better management of these patients. Some of these tools include the trauma scores, which are quantified by numerical scores, and vary according to the severity of injuries resulting from trauma.[10-12]

Trauma scoring systems can determine the burden of injuries and be used for comparison against the results observed; thereby comparing the therapeutic as well as diagnostic functions plus hospital function with each other.[13] Hence, these scores could be used as triage tools, and in predicting the severity of injuries as well as mortality in trauma patients. It also allows the ambulance technician to make rational judgments about the choice of hospital, based on the severity of trauma.[14]

Revised trauma score (RTS) and triage RTS are the most widely used scores in the prehospital setting, but they are not easy to calculate. Hence, mechanism, Glasgow Coma Scale, age, and arterial pressure (MGAP) was designed which can predict mortality better than RTS does. Then, the Glasgow Coma Scale, age, and systolic blood pressure (GAP) score was introduced, which had more predictable and generalizable power than MGAP. This score was easier to calculate.[14-17]

In 2017, Jeong *et al*. designed a new trauma score called NTS. NTS uses the same component used in RTS. In calculating NTS, the actual Glasgow Coma Scale (GCS) score is used instead of the GCS code, where Peripheral Capillary Oxygen Saturation (SPO_2) is used instead of the number of breaths and systolic blood pressure (SBP).[18] In the study by Jeong *et al*., the NTS could predict in-hospital mortality substantially better than the RTS and not inferior to the MGAP and GAP.[18] Considering that since the design of NTS score, no other study has been done regarding the ability of this score and its comparison with other scores in predicting inhospital mortality, we decided to conduct a study to assess the predictive value of GAP and NTS indicators to determine the hospital mortality of multiple trauma patients.

Objectives

The purpose of this study was to investigate and compare the accuracy of GAP and NTS indicators in predicting mortality of trauma patients following traffic accidents in hospitals in Sirjan in 2019.

Materials and Methods

Study design

This is a retrospective descriptive-analytical study in patients over 18 years of age who were taken to the hospital by prehospital emergency. The study ran within April 2019–March 2020. This study was approved by the ethics committee of Sirjan University of Medical Sciences with the code IR.SIRUMS.REC.1399.014. The STARD statement was used for this report.

Study setting

The study was conducted in a reference population of 400,000 inhabitants, in Sirjan city of Kerman province in Iran. Sirjan is the second most populous city in Kerman province in southeastern Iran. Kerman is the largest province in Iran in terms of area. Patients would enter through the 115 emergency number. Once the call was analyzed by nurses, the most appropriate ambulance code would be sent. In Emam Reza (AS) and Gharazi hospitals, patients were admitted through the emergency department. The two hospitals have general and specialized wards, with the total number of beds in these two hospitals being 428 beds.

Ethical issues

This study was approved by the ethics committee of Sirjan School of Medicine with code IR.SIRUMS.REC.1399.014.

Participants

In this study, all patients with multi-trauma caused by traffic accidents who were taken to the hospital by prehospital emergency were recruited. Patients' information was extracted from the databases of Sirjan prehospital emergency center.

In this study, census sampling method was used. In the course of the study, 3523 patients entered the study via full-census method, and 906 patients were excluded from the study due to the dissatisfaction with the transfer to the medical center and the death of the patient at the scene. Next, 47 patients were excluded from the study due to the incomplete documentation in the patients' files, whereby finally 2570 patients were evaluated. The flow chart of enrolled patients is presented in [Figure 1].

The inclusion criteria for the study were trauma patients caused by traffic accidents who were transferred to the medical center by the prehospital emergency. The exclusion criteria included age below 18 years, incomplete registration of documentations in the patient's file, death of the patient at the scene of accident, and lack of consent to be transferred to the medical center.

Data collection

This study using available data in which the ability of GAP and NTS scoring systems was examined to determine the mortality rate of trauma patients admitted by the prehospital emergency of Sirjan city in 2019.

The study data included demographic, age, gender, and physiological information of patients (Glasgow coma score, SBP, arterial blood SPO_2), which were initially assessed at the scene of accident by emergency operation personnel. They were extracted from the prehospital emergency operating automation system of Sirjan city. Patients' GAP and NTS scores were calculated.[9,18] Clinical information and index test results were available to the assessors of the reference standard. After collecting information and calculating GAP and NTS indicators, the outcome of patients in the hospital was followed up and patients were divided into two groups, those who survived and those who died in hospital. Gap and NTS scores were calculated using the formula:

Statistical analysis

The collected data were introduced into SPSS software (version 22.0, Chicago, USA). The Kolmogorov-Smirnov was used to evaluate the normal distribution of the data; regarding $P > 0.05$, the data distribution was normal. Descriptive statistical methods (ranges, frequency, percentage and mean ± standard deviation) were used to describe the data. Statistical methods of independent sample's *t*-test and Chi-square were used to compare quantitative and qualitative data between the two groups of dead and surviving patients, respectively.

The discriminate predictive power of GAP and NTS were compared using the area under the receiver operating characteristic (ROC) curve with a 95% confidence interval. It has been determined the cut off point of each scale that offered highest sensitivity and specificity using the Youden index.[19-20] The larger the area under the ROC curve, the more accurately the respective trauma score can predict and differentiate between those who died and those who survived. In all tests performed, a confidence level of 95% and a $P < 0.05$ were considered significant..

Results

In this study, 2570 multitrauma patients caused by traffic accidents were included in the study. Out of the total number of patients, 2556 patients (99.5%) were discharged from the hospital alive and 14 patients (0.5%) died. Of these, 1942 were men (75.6%) and 625 (24.3%) were women. The mean age of the subjects (persons) was 15.62 ± 31.05 years. The mean GAP of the total patients was 22.14 ± 1.41 and the mean NTS of the total patients was 22.24 ± 1.54.

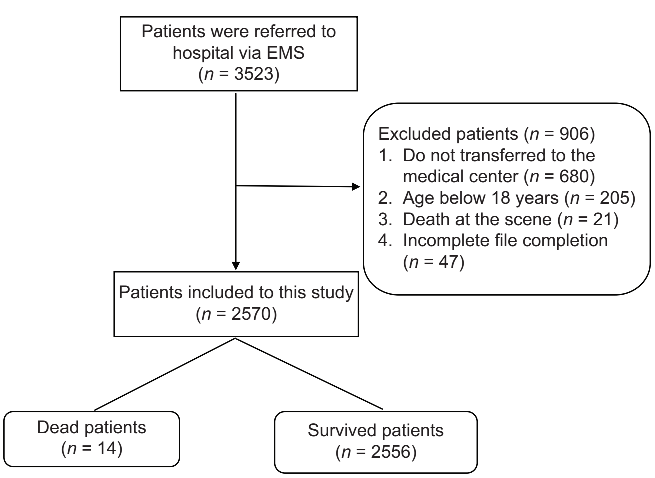

Figure 1: Flow chart enrolled patients

Table 1 compares the demographic variables and vital signs as well as NTS and GAP scores in two groups of patients who died and survived. Based on the table, it is determined that all variables except the gender variable have had a statistically significant difference between the two groups.

Table 2 compares the mortality rate in each group based on GAP and NTS scores. Based on Table 2, it is observed that according to the mortality rate reported in our study and its comparison with the values reported in Kondo *et al*. studies based on GAP scale, the mortality rate in the high risk, moderate risk, and low risk groups in our study was 100%, 10.7% and 0.2%, respectively, while in the study of Kondo *et al*., they were 74.2%, 21.4%, 1.8% respectively. Thus, the mortality rate in our study in the high-risk group was higher than the values reported in the study by Kondo *et al*. Further, in the group with moderate and low risk, the mortality rate was lower than the values reported in the study of Kondo *et al*.[9]

According to the mortality rate reported in our study and its comparison with the values reported in the study of Jeong *et al*., based on the NTS scale, the mortality rates in the very high risk group, high risk, moderate risk, and low risk in our study were 100%, 50%, 14.3%, 0.2% and in the study of Jeong *et al*. were 98.5%, 75.2%, 32%, and 2%; thus, the mortality rate in our study in the very high risk group was higher than the values reported in the study of Jeong *et al*. as also, it was lower than the values reported in the Jeong *et al*.'s study in the high, medium, and low risk groups.[18]

The ROC curve was used to determine the predictive value of GAP and NTS scores as well as GCS variables, to determine

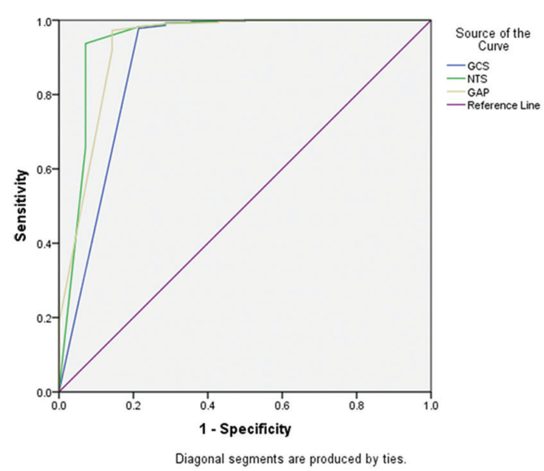

Figure 2: Receiver operating characteristic curve for Glasgow Coma Scale, Age, and Systolic Blood Pressure, The new trauma score, Glasgow Coma Scale, and Saturation of Oxygen

Table 1: Comparison of the demographic features, vital sign and trauma scores between two groups

Variables	Alive (2556 patients)	Dead (14 patients)	*P*
Age	30.96±15.53	46.71±22.74	0.004*
Gender (male/female)	1942/625	10/4	0.928#
GCS	14.92±0.62	7.85±5.27	<0.001*
Saturation of O_2	95.87±3.09	57.92±41.56	<0.001*
Systolic blood pressure	116.34±17.19	73.57±50.32	<0.001*
GAP score	22.19±1.12	12.78±6.92	<0.001*
NTS	22.30±1.22	11.64±7.36	<0.001*

*Independent samples *t*-test, #χ^2. GCS: Glasgow Coma Scale, GAP: GCS, age, and systolic blood pressure, NTS: New trauma score

Table 2: Comparison of the Glasgow Coma Scale, age, and systolic blood pressure and new trauma score risk groups between the two groups

Variables	Alive (2556 patients) (%)	Dead (14 patients) (%)	*P*
GAP score			
Low risk	2531 (99.02)	4 (0.2)	<0.001
Moderate risk	25 (0.97)	3 (10.7)	
High risk	0	7 (100)	
NTS score			
Low risk	2535 (99.17)	4 (0.2)	<0.001
Moderate risk	18 (0.70)	3 (14.3)	
High risk	3 (0.11)	3 (50)	
Very High risk	0	4 (100)	

GAP: Glasgow Coma Scale, age, and systolic blood pressure, NTS: New trauma score

Table 3: Predictive value of Glasgow Coma Scale, age, and systolic blood pressure, new trauma score and Glasgow Coma Scale based on patient's hospital outcome

Variable	AUC (95% CI)	Cut off point	Sensitivity (%)	Specificity (%)	PPV	NPV	J point
GAP	0.932	20.50	96.9	85.7	0.87	0.96	0.826
NTS	0.944	20.50	93	93	0.93	0.93	0.86
GCS	0.888	11.50	99.2	71.4	0.78	0.99	0.706

GCS: Glasgow Coma Scale, GAP: GCS, age, and systolic blood pressure, NTS: New trauma score, AUC: Area under the curve, PPV: Positive predictive value, NPV: Negative predictive value

patients' hospital outcomes, with the results presented in Table 3 and its diagram in Figure 2.

Discussion

In the present study, the predictive value of mortality in trauma patients of traffic accidents was evaluated and compared with GAP and NTS scoring systems. In this study, both scoring systems performed well in predicting the result of trauma patients, where there was no significant difference in sensitivity and specificity, accuracy, and the area under the curve of the two scoring systems. Nevertheless, with regard to the area under the curve, The NTS score functioned slightly better than the GAP, which was inconsistent with Jeong *et al*.'s study.[18] Jeong *et al*. found that NTS performance was significantly better than RTS in predicting mortality in trauma patients, but it was not better than MGAP and GAP. From several perspectives, MGAP and GAP are superior to NTS. For example, the MGAP and GAP components (mechanism, age, GCS, and SBP) are immediately available when presented, but NTS requires SpO_2. Nevertheless, measuring SpO_2 in a modern trauma treatment system is not time-consuming and costly.[18]

In previous studies, the GAP score could predict trauma severity as well as or better than the other trauma scores. Furthermore, the GAP score was easier to calculate than the others.[9] In this study, despite the better performance of NTS in predicting mortality in patients, the difference was not significant and all these scores functioned well in predicting mortality.

In this study, similar to other studies, the highest frequency of patients in terms of severity of trauma occurred in the low-risk, moderate-risk, and high-risk groups, respectively.[8,9,19,20] In the present study, the overall mortality rate based on low-, medium-, and high-risk GAP levels was 0.2%, 10.7%, and 100%, respectively. The overall mortality rate based on low-, medium-, high-risk and high-risk NTS levels was 0.2%, 14.3%, 50%, 100%, and 100%, respectively. According to GAP levels, 98.6 patients were in the low-risk category and 0.2% of them died. Furthermore, 0.3% of patients were in the high-risk category and 100% of them died. According to NTS levels, 98.8% of patients were in the low-risk category and 0.2% of them died, and 0.2% of the patients were in the high-risk category, and 100% of them died.

In this study, the mean blood pressure (BP) in the dead patients was 73.57 ± 50.32, the mean SPO2 in dead patients was 57.92 ± 41.56 and the mean GCS in dead patients was 7.85 ± 5.27. The mean BP in the dead patients was 73.57 ± 50.32, which was lower compared to the surviving group.

The results of studies by G Manley *et al* and Spaite *et al* also showed an increase in mortality in BP <70.[21,22] Takahashi *et al*., Lalezarzadeh *et al*., and Herlitz *et al*. also introduced low SBP as a strong predictor for mortality in trauma patients.[19,23,24] In their study, Hasler *et al*. concluded that the mortality rate of trauma patients was twice in BP <100, tripled in BP <90, and 5–6 times in BP <70. Indeed, the mortality of patients started with BP <110, and as it decreased further, mortality would increase. Furthermore, since BP <90 is a late sign of hemorrhage in trauma patients, it is recommended that patients with BP <110 are transferred to dedicated trauma hospitals.[25] Fluid resuscitation in trauma patients with BP <90 can also reduce mortality rate.[26] Thus, regular monitoring of BP by prehospital emergency personnel and decisions to transfer patients to higher-level trauma centers, as well as fluid resuscitation based on the patient's condition, can have a significant effect on reducing mortality of patients.

The mean SPO_2 in dead patients was 57.92 ± 41.56. In studies by Filipescu *et al*., Sittichanbuncha *et al*., and Guyette *et al*., a decrease in arterial blood SPO_2 was also associated with an increased mortality rate in trauma patients.[27-29] Pulse oximetry devices should be available in all prehospital centers, and during prehospital care, arterial blood oxygen level should be monitored regularly and used as a warning sign along with vital signs control.[28] Controlling arterial blood oxygen level and oxygenation to patients with reduced SPO2 will also play an important role in reducing mortality of patients.

The mean GCS in dead patients was 7.85 ± 5.27. GCS is a good objective score for predicting mortality in trauma patients.[30] In Yadollahi's study, the risk of death was reduced by 40% for every unit increase in the patient's GCS.[31] The mean age of deceased persons was 17.24 ± 46.7 years. Most patients were at working age, which was consistent with previous studies.[25,30,32-34] In a study by Tan *et al*., the average age in the dead group was significantly higher than in the survived group.[30]

As trauma mostly affects young people, it causes more loss of work years and more Disability-Adjusted Life Year than other causes. In the Yadollahi's study, as age increases each year, the death rate increased by 6%.[31] This suggests the importance of trauma and the damages it incurs to the entire society. The high rate of accidents in men and at a young age can be considered relevant to the higher number of male drivers, the greater participation of this group in high-risk activities, as well as more sports activities in this group of individuals.[35]

A scoring system can enable the Emergency medical services (EMS) staff presenting at the scene to prioritize the transfer of trauma patients to the hospital. Note that the over-triage of trauma patients causes waste of much of socio-economic and medical resources, and patients must be transported to appropriate hospitals according to trauma scores. In patients with low-risk mortality, these patients can be transferred to low-level trauma hospitals. High-risk patients can be referred directly to the resuscitation room to receive special treatment from a trauma team, with this team consisting of physicians of the emergency ward, surgeons, and anesthesiologists. Further, the patients at moderate risk can be referred to a ward with specific trauma treatment and regular monitoring of the patient's vital signs and clinical conditions.

Limitations

The sample size was adequate to obtain results globally, but it would be necessary to increase the sample size for the accurate assessment of trauma severity scores. Another limitation of this study was the retrospective nature of the study. In addition, in this study, only traffic accident patients were considered while patients from other traumas were not considered. Furthermore, patients were transferred from a relatively small area with a radius of approximately 100 km to hospitals. Finally, our study was performed in only two medical centers, and so generalizing the results may be error prone. Accordingly, external validation must be performed on different populations and countries.

Conclusions

Both scoring systems appropriately predicted the outcome of trauma patients and can be considered as a suitable tool in the triage and management of trauma patients. However, the ability of the NTS score system to predict the mortality rate of trauma patients was better than that of the GAP system, and it is recommended that this score is used in the management of trauma patients.

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Conflicts of interest

There are no conflicts of interest.

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