

## Original Article

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## The Accuracy of GAP and MGAP Scoring Systems in Predicting Mortality in Trauma; a Diagnostic Accuracy Study

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### Abstract

**Introduction:** Trauma scoring systems help physicians and nurses to be informed of injuries to a patient and assist their decision making in the cases of trauma and importantly prediction of their outcome and prognosis.

**Objective:** This study aimed to compare the accuracy of GAP and MGAP scoring systems as predictors of mortality in trauma patients.

**Methods:** This diagnostic accuracy study was conducted amongst 1861 trauma patients admitted to Rajaei Hospital in Shiraz, Iran, during 2017. The data on demographic features were extracted from the patients' records. Then, trauma scoring systems including injury severity score (ISS), GAP, MGAP, and Glasgow coma scale (GCS) were compared to evaluate their accuracy in predicting mortality. Area under the receiver operating characteristic (ROC) curve was used to evaluate the accuracy of different trauma scoring systems and detect the sensitivity and specificity in order to predict status of discharge after 24 hours.

**Results:** Based on the results, the area under the ROC curve was 0.8 for GCS. Moreover, Area Under Curve (AUC) of GAP was 0.91 and amongst different values, GAP value of  $\leq 18$  was selected as the cut-off point, since it exhibited the best sensitivity and specificity (72.99 and 95.52, respectively). In addition, the area under the ROC curve was 0.9 for MGAP, and value of  $\leq 23$  was selected as the cut-off point because it showed the best sensitivity and specificity (81.04 and 87.70, respectively). Additionally, AUC of ISS was 0.88.

**Conclusion:** Both GAP and MGAP methods were able to appropriately predict mortality and were not significantly different; hence, both can be used for the right triage of patients and to predict the severity of injuries and subsequent mortality. Moreover, GAP and ISS had the best specificity and sensitivity, respectively.

**Key words:** Glasgow Coma Scale; Mortality; Multiple Trauma; Prognosis; Trauma Severity Indices

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### INTRODUCTION

Trauma is one of the four leading causes of death and also the first cause of years of potential life lost (YPLL) in the developing countries such as Iran (1, 2). Management, rehabilitation, and post-traumatic care during the first hours after a traumatic event are the key actions in order to reduce the risk of death and disability of trauma patients (3). Therefore, proper evaluation, triage, and delivery of timely care, to a large extent, can minimize the associated long-term pain and suffering (4, 5). Recently, modified scoring systems including GAP and MGAP were developed to predict the chance of survival amongst trauma patients. In fact, the main advantage of these systems is their easy to use, which is based on age, Glasgow coma scale (GCS), and systolic blood pressure (SBP) that can be simply measured at the

early steps of patients' evaluation. Moreover, trauma mechanism is also considered in MGAP system (6).

It seems that previous studies have differently and inconsistently reported the superiority of each of the two systems over other systems, and even reported them as equal in some instances. For example, in a study by Sartorius et al., the researchers concluded that MGAP score can accurately predict hospital mortality in trauma patients (7). On the other hand, Kondo et al. reported that GAP scoring system is able to predict hospital mortality more accurately than the previously developed trauma scoring systems (3). Therefore, this study aimed at evaluating the accuracy of GAP and MGAP versus two previous well-known and frequently used scoring systems,

Injury Severity Score (ISS) and GCS, in terms of predicting mortality amongst trauma patients.

## Methods

### **Study design and setting**

This diagnostic accuracy study was conducted amongst trauma patients admitted during 2017 to Rajaei hospital, the main referral trauma center for emergency medical services in Fars province, southern Iran. This project has been approved by the research ethic committee by Shiraz University of Medical Sciences (SUMS) and the code IR.SUMS.REC.1394.S1062 has been assigned. Patients' approval was verbally obtained in order to make their illness information available publicly.

### **Study population**

Multiple trauma patients over the age of 15 were eligible. Discharge or death before 24 hours of admission, death on arrival, trauma patients without the data necessary for calculating their trauma score, patients whose Abbreviated Injury Scale (AIS) values were not measurable, patients with unknown type of trauma and those with very mild injuries, such as soft tissue damage and isolated fractures were excluded. Sampling was performed retrospectively. Using the systematic random sampling method, 10% of the hospitalized patients were enrolled in this study. The first patient was selected on the basis of randomization and all samples were collected by selecting the interval of ten patients after each selection. Consequently, of every 10 patients admitted to the hospital, one was enrolled.

### **Definitions**

AIS value was determined based on the diagnosis of injuries in accordance with the latest guideline published by the American Association for the Surgery of Trauma (AAST) (8). To determine the severity of trauma, the injured body was divided into 6 areas: head and neck, face, chest, abdomen, organs, and body surface. Then, each of the above-mentioned areas received one of the following scores: 1 (mild injury) to 6 (an injury considered 'incompatible with life'). Each of these scores is called an AIS. Three of the largest AISs were identified in these six areas, changed to a power of 2, summed up, and the resulting number called an ISS with a value between 1 and 75. Using the data on the variables of GCS, SBP, and respiratory rate values were calculated via a formula presented in Champion et al paper (9).

In GAP scoring system, using GCS, each patient received a score of 3-15 which indicated the level of consciousness. In addition to the measuring the level of consciousness, patients' age and SBP were

also considered in GAP scoring system. Accordingly, people younger than 54 years old scored 3 points while people over 55 received zero point. Moreover, patients with a SBP of above 120 mmHg received a score of 6 point, patients with a SBP of 60 to 120 mmHg received a score of 4 points, and those with a SBP of less than 60 mmHg received a score of zero point. Thus, patients were scored 3-24 points, based on GAP score. In MGAP scoring system, in addition to age, GCS and SBP, it is also necessary to consider trauma mechanism; thus, it was calculated in accordance with the method described in Cando et al paper (3).

### **Data gathering**

Using a pre-prepared checklist, required data including gender, age, mechanism of injuries, triage level, type of injuries, ISS, GCS, MGAP and outcome of injury were recorded. Clinical and paraclinical examination tests including radiologic and medical chart of patients were utilized by an expert physician.

### **Outcome assessment**

Patient status at discharge time was considered as outcome assessment.

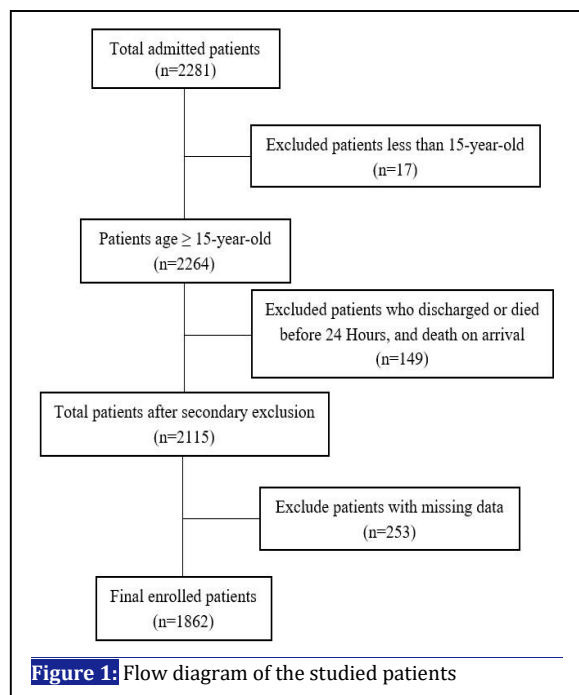
### **Statistical analysis**

The produced results and respective data were analyzed via stata14 and MedCalc software. Descriptive indicators were expressed as mean± standard deviation (SD) or percentages using the obtained data. Univariate analysis and the Chi-square (or Fisher's exact test if needed) and independent t-test or its nonparametric equivalent were used to discover the individual relationships between each category and continues variables and status of patients after 24 hours. P-value < 0.05 was considered to be the significance level in all tests.

Area under curve (AUC) was used to evaluate the accuracy of different trauma scoring systems including ISS, GAP, MGAP, GCS and detect its sensitivity and specificity in order to predict the status of discharge "Death or Alive" after 24 hours. Younden's index was applied to Maximize both, sensitivity and specificity, with the formula Maximum=Sensitivity + Specificity - 1. Hence, best cut-off point was determined based-on Younden's index for different trauma scoring systems.

## RESULTS

In this study, 1862 patients were randomly selected. Flow diagram of all included and excluded patients is shown in figure 1. Table 1 shows comparison of the examined variables between survival and non-survival patients; And table 2 reports comparison of the assessed scores between the two groups. Of all, 211 patients (11.33%) died



and 1651 patients (88.66%) survived after 24 hours of admission. The ratio of deaths in males compared to females was 2.7 to 1. The results indicated that the mean age of patients who had died was significantly higher than the survivors ( $57.51 \pm 20.57$  vs.  $42.51 \pm 20.04$  years;  $P$ -value  $< 0.001$ ). Moreover, the most prevalent causes of mortality amongst trauma patients were traffic accidents (67%) and fall (30%). On the other hand, 71.62% of the patients died at the first level of triage and the percentage of deaths decreased at the other levels of triage. The highest percentage of mortality was observed among patients with upper and lower limb injuries and neck and head injuries. Based on the obtained data, the area under the ROC curve was 0.88 (0.87-0.9) for the GCS. Among the different values of GCS of consciousness (between 3 and 15), the GCS of 14 was selected as the cut-off point, since it had the best sensitivity and specificity (81.52 and 92, respectively). The area under the ROC curve was 0.91 (0.9-0.92) for the GAP. Among the observed values, GAP value of  $\leq 18$

**Table 1:** Comparison of the examined variable between survival and non-survival patients

Variables	Death (n=211)	Alive (n=1651)	P-value
	Number (%)		
<b>Gender</b>			
Male	154(12.18%)	1110(87.82%)	0.053
Female	57(9.53%)	541(90.47%)	
<b>Mechanism of injuries</b>			
Road injuries	143(14.43%)	848(85.57%)	<0.001
Fall	63(7.93%)	731(92.07%)	
Assault	1(1.56%)	63(98.43%)	
Gunshot	3(33.33%)	6(66.67%)	
Others	1(25%)	3(75%)	
<b>Triage level</b>			
Level 1	53(71.62%)	21(28.38%)	<0.001
Level 2	121(45.50%)	101(45.50%)	
Level 3	32(2.20%)	1423(97.8%)	
Level 4	5(0.50%)	106(95.50%)	
<b>Type of injuries</b>			
Head and neck	115(15.75%)	615(84.25%)	<0.001
Face	92(19.83%)	372(80.17%)	<0.001
Thorax	62(18.51%)	273(81.49%)	<0.001
Abdomen	72(24.16%)	226(75.84%)	<0.001
Spine	21(6.34%)	310(93.66%)	<0.001
Upper & lower extremities	110(9.52%)	1045(90.48%)	<0.001
External	6 (10.53)	51(89.47%)	0.447

**Table 2:** Comparison of the assessed scores between survival and non-survival patients

Variables	Death (n=211)	Alive (n=1651)	P-value
	Mean $\pm$ SD		
Injury severity score	15.66 $\pm$ 12.02	6.79 $\pm$ 5.86	<0.001
Glasgow coma scale	7.97 $\pm$ 4.79	14.63 $\pm$ 1.54	<0.001
GAP	14.02 $\pm$ 5.15	22.06 $\pm$ 2.16	<0.001
MGAP	18 $\pm$ 5.29	26.49 $\pm$ 2.73	<0.001

**Table 3:** Analysis of area under receiver operating characteristic curve, positive and negative predictive value for ISS, GCS, MGAP and GAP scores

Statistical index	Criteria			
	ISS	GCS	MGAP	GAP
Cut of point	>8	$\leq$ 14	$\leq$ 23	$\leq$ 18
Sensitivity (CI)	89.10 (86.90 – 92.34)	81.52 (78.12 – 85.16)	81.04 (79.18 – 84.29)	72.99 (68.23 – 75.36)
Specificity (CI)	61.11 (56.15 – 64.14)	92.00 (87.25 – 96.94)	87.70 (86.29 – 89.95)	95.52 (92.15 – 97.68)
Area Under the Curve	0.88*	0.80*	0.90*	0.91*
Positive predictive value (CI)	74.15 (71.03 – 76.25)	69.8 (63.12 – 74.14)	79.35 (76.39 – 82.17)	80.69 (79.03 – 81.95)
Negative predictive value (CI)	76.35 (74.24 – 78.43)	81.02 (79.25 – 83.14)	83.12 (81.25 – 85.36)	80.23 (79.54 – 81.68)

CI: Confidence Interval of value; ISS: Injury severity score; GCS: Glasgow coma scale

\*\* statistically significant

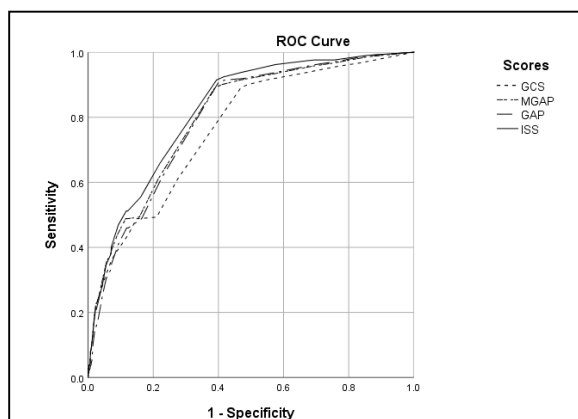
was selected as the cut-off point because it exhibited the best sensitivity and specificity (72.99 and 95.52, respectively). In addition, the area under the ROC curve was 0.9 (CI = 0.89-0.92) for MGAP. Among different values, MGAP value of  $\leq$ 23 was selected as the cut-off point, since it showed the best sensitivity and specificity (81.04 and 87.70, respectively). Additionally, AUC of ISS was 0.8 (0.78-0.82). Furthermore, ISS value of >8 was selected as the cut-off point, since it had the best sensitivity and specificity (89.10 and 61.11, respectively) (Table 3). As shown in the figure 2, there is no major difference between GAP and

MGAP in evaluating sensitivity and specificity of traumatic patients. Moreover, ISS has the highest sensitivity as well as GAP has maximum of specificity.

## DISCUSSION

In this study, predictive power of two trauma scoring systems, namely GAP and MGAP, in predicting mortality was evaluated, by assessing mortality outcomes after 24 hours' admission. In this study, both systems had a good performance in predicting the outcome of trauma patients, and there was no significant difference between the two scoring systems in terms of sensitivity, specificity, accuracy, positive and negative likelihood, and the area under the curve. However, considering the area under the curve, GAP scoring system was slightly better. In this study, each of the two systems was not superior over the other.

In fact, in line with the results of a study by Rahmani et al. the mechanism of trauma did not affect the patient outcomes (10). Considering the correlation between the studied variables in GAP and MGAP scoring systems (age, level of consciousness, systolic blood pressure, as well as the mechanism of trauma in MGAP), the results of this study showed that most of the people who died were younger than 55 years old, which is in line with the results of a study by Rahmani et al. who examined the predictive power of MGAP on trauma patients (10, 11). These results show the

**Figure 2:** Area under curve (ROC) of injury severity scales (GAP, MGAP, GCS, ISS) for "Death or Alive" after 24hours

importance of age for multiple trauma patients, which is one of the components in both GAP and MGAP scoring systems (12, 13).

Given that the best cut-off point for predicting mortality using GCS was less than 14, it can be concluded that patients with a consciousness level below 14 are at higher risk of mortality. Therefore, there was a significant negative correlation between the level of consciousness and mortality. This study is consistent with the results of several other studies, such as Park S-K et al. study (14).

In the present study, the best cut-off point for predicting mortality using GAP system was 18, which was associated with a sensitivity and specificity of 72.99 and 95.52, respectively. Thus, it can be concluded that patients with GAP value  $\leq 18$  are more at risk of death. Furthermore, the best cut-off point for predicting mortality, using MGAP scoring system was 23, which indicated that patients with MGAP value  $\leq 23$  are at higher risk of death. In Baghi et al. study, MGAP score of 22 was considered as the cut-off point for predicting hospital mortality, which is a one point different from MGAP cut-off point, observed in this study (1). However, in a study by Sartorius et al. MGAP score of 23 was considered as the best cut-off point in MGAP system, which is in line with MGAP cut-off point, observed in this study. In a study by Hasler et al. areas under the ROC curve were 87.2% for GAP score (95% confidence interval, 86.7-87.7) and 86.8% for MGAP score (95% confidence interval, 86.2-87.3) (15).

Since in this study the cut-off point of ISS was 8, it can be concluded that patients with a severity of trauma higher than 8 are at an increased risk of mortality. Regardless of the controversy surrounding trauma scoring systems, in the present study, both GAP and MGAP systems performed well in predicting the outcome of trauma patients, and the sensitivity, specificity, accuracy, positive and negative likelihood, and the area under the curve for the two scoring systems were almost equal. However, considering the area under the curve, GAP scoring system was slightly better. In fact, similar to the results of Sartorius et al. study, the area under the receiver operating characteristic curve of MGAP was not significantly different from that of the triage Revised Trauma Score, but MGAP has more sensitivity than of Revised Trauma (7). Our results are contrary to the results of Raux et al. study that showed the slight superiority of MGAP over GAP. It is worth noting that their sample size was small (100 patients) and included only two intrusive traumatic event, which could have led to the results (16). However, our

findings are in line with the results of studies by Kondo et al. (3). Rehn et al. conducted a systematic review of prognostic models for traumatic patients and reported that MGAP could properly predict survival. In addition, this scoring system had high quality in 11 out of 16 parameters of the qualitative evaluation of the prognostic models. However, the other four studied systems each had high quality in less than seven items; hence, they recommended MGAP system for the routine use. Unfortunately, in the mentioned systematic review, GAP system was not investigated (17), but in a study by Kondo et al. the researchers introduced GAP as a simpler and more generalizable method (3).

In this study, probability of death was computed based on covariates, such as type of injury and mechanism of injury by regression model. In other words, covariates variable for computing the ROC curve differs in two study. In addition, GAP and MGAP were compared with ISS and GCS which has additionally information Compared to the study. Moreover, Given the different pattern of injury in Iran compared to other countries, comparing the accuracy of injury severity methods with other studies can provide useful results.

#### **Limitations**

This study was conducted in Level-1 trauma center with large number of patients. In additional, all cause of trauma injuries, such as traffic, falling down, assault with weapon were included. All medical chart and radiologic examination of patients were carefully recorded. One of the limitations of the study was lack of information on patients who died before 24hours and death upon arrival. For future studies it is suggested to compare the indices expressed by the type of injuries as well as the mechanism of injury.

#### **CONCLUSIONS**

It can be concluded that both GAP and MGAP systems can appropriately predict the outcome of traumatic patients and have a high level of consistency with each other. In general, given the slight superiority of GAP and the convenience of calculating it, this study failed to offer any firm suggestions on the superiority of one system over the other. Thus, it is necessary to conduct a multi-center study with a higher sample size to examine the differences between the two systems in predicting mortality.

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#### AUTHORS' CONTRIBUTION

All the authors met the standards of authorship based on the recommendations of the International

Committee of Medical Journal Editors.

#### CONFLICT OF INTEREST

None declared.

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