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Predictive value of the quick Sequential Organ Failure Assessment Score (qSOFA) for in-hospital mortality in adult trauma patients

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Abstract

Background: Recognizing and determining severe trauma is essential for choosing the appropriate treatment strategy.
Objectives: The aim of this study was to find the predictive value of the quick sequential organ failure assessment (qSOFA) score for in-hospital mortality in adult trauma patients.
Methods: This prospective observational study was conducted on adult patients with multiple trauma presenting to the emergency department. The qSOFA score was calculated according to the initially recorded variables. The primary outcome was in-hospital mortality. The predictive value of qSOFA was evaluated using the Area Under Receiver Operating Characteristic (AUC) analysis.
Results: Finally, 775 multiple trauma patients with a mean age of 38.68±18.74 were admitted. Of these, 34 people (4.39%) died and 741 subjects were discharged from hospital. The mean qSOFA score was 0.41±0.64, significantly higher in the survived patients than in the non-survived patients ($P < 0.001$). The AUC of qSOFA score to predict in-hospital mortality was 0.878 (95% confidence interval: 0.853-0.900); thus, qSOFA was a good predictor of in-hospital mortality in multiple trauma patients.
Conclusion: The qSOFA score can be considered a simple and rapid screening tool for identifying multiple-trauma patients.

Keywords: Emergency Department, Injuries, Scoring Systems, Outcome, Mortality.

Introduction

Trauma remains an important public health problem all over the world, including in Iran. Trauma and injuries are responsible for more than 10% of diseases in adult patients and more than 80% of trauma mortality occurs in low and middle-income countries.[1,2] In addition, severe complications, disability, and financial and social costs are consequences of trauma.[3]

The increasing trend of deaths caused by traffic accidents, especially in low- and middle-income countries, is a great threat to human well-being and life in such areas. Currently, traffic accidents are known as the most dangerous accidents worldwide.[1,4]

Approximately 1.3 million people die each year due to road traffic crashes. The World Health Organization data revealed that the mortality rate due to motor vehicle accidents in Iran was 20.5 deaths per 100,000 people, which was more than the average mortality rate in developed and developing countries (9.2 and 18.4 deaths per 100,000 people, respectively).[5,6] Motor vehicle accidents are the first cause of death among young people in the world, especially between the ages of 15 and 29.[5]

Considering the high mortality rate of trauma patients, researchers are always looking for a way to diagnose patients at risk of death faster and more accurately. Different scoring systems have been used to predict outcomes in trauma patients. In recent decades, a variety of anatomical scoring systems, physiological scoring systems, and a combination of anatomical and physiological scoring systems have been performed to estimate the severity and survival of trauma subjects.[1-3]

The Injury Severity Score (ISS) is an anatomically scoring system for predicting the outcome of patients with multiple injuries. ISS is known as an effective scoring, but

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it has complex and time-consuming calculations.[1,7]

One of the recently introduced physiological scoring systems is the qSOFA score (quick Sequential Organ Failure Assessment), which was initially used as a new tool to quickly and easily determine the risk of death in patients with suspected infection admitted outside the intensive care unit (ICU).[8-10]

Furthermore, it has been stated that qSOFA predicts mortality in emergency department (ED) patients without suspected infection.[10] Therefore, calculating the qSOFA score can lead to a better allocation of resources to emergency department patients. The qSOFA score includes three variables that can be easily evaluated: Glasgow coma score (GCS), systolic blood pressure (SBP), and respiratory rate (RR).[8,10] Glasgow coma score, Age, Systolic Blood Pressure score (GAP), Revised Trauma Score (RTS), and Rapid Emergency Medicine Score (REMS) are some of the most commonly used physiological scoring systems.

GAP score is a simple and quick physiological scoring system that can be easily used by nurses and emergency medical technicians.[11,12] Like qSOFA, RTS consists of three physiological variables: GCS, SBP, and RR.[13,14] Of course, the way to calculate the score is different.

REMS was originally developed as a strong predictor of in-hospital mortality among (non-trauma) medical patients. REMS consists of age and five physiological parameters including mean arterial pressure (MAP), heart rate (HR), RR, Oxygen saturation (SpO_2), and GCS.[1,3]

Objectives

This study aimed to evaluate the relationship of the qSOFA score calculated in the ED with the outcomes of adult multiple trauma patients and to compare the predictive values of GAP, RTS, REMS, and ISS with that of qSOFA in predicting in-hospital mortality of trauma patients.

Methods

Study setting and design

This prospective cohort study was conducted on patients with multiple trauma presenting to the ED of Al-Zahra and Kashani hospitals in Isfahan, Iran, from April 2020 to November 2022.

Participants

Adult multiple trauma patients (≥ 18 years) admitted to the ED were included in the study. Patients transferred from other hospitals, patients with burn or drowning-related injuries, pregnant women, and patients transferred to other hospitals or discharged against medical advice were excluded.

Data gathering

After the patient entered the triage unit, the triage nurse determined the severity of the disease based on the Emergency Severity Index (ESI) version 4, and then the patient was admitted to the ED based on the severity of the injury. Then the emergency medical assistants visited all the patients and took care of them. The ESI is a nurse-driven five-level ED triage algorithm that, in a clinical classification, divides patients into five groups from 1 (most urgent) to 5 (least urgent) based on acuity and resource needs.

After entering the emergency room, necessary variables including age, sex, vital signs (SBP, DBP, RR, HR, temperature, SpO_2), GCS, injury mechanism, and triage level (based on ESI) were collected. Length of stay and outcome of the patients were also recorded.

The qSOFA, RTS, GAP, and REMS scores were calculated according to the initially recorded variables. Also, ISS was calculated after a comprehensive injury assessment.

Measurements

The qSOFA consists of three variables with one point each for SBP ≤100 mm Hg, RR ≥22 bpm, or GCS ≤14.[9] The total score was between 0 and 3. A higher score shows a higher severity of the disease.

The RTS comprises three variables: GCS, SBP, and RR. Each of the variables is given a score based on Table 1 and then these three scores are used to obtain a weighted sum with RTS=0.9368 GCS + 0.7326 SBP + 0.2908 RR. The total score ranges from 0 to 7.8408.[13] A lower score indicates greater injury severity.

GAP consists of age and two physiological variables. The patient received 3 to 15 scores based on GCS score, three scores for age< 60 years, and six scores for SBP> 120 mm Hg or four for SBP of 60 to 120 mm Hg. The total score ranges from 3 to 24, with a lower score predicting a worse prognosis.[14]

The REMS includes age and five physiological variables [Table 2]. Scores range from 0 to 26, with a higher score indicating a worse prognosis.[3]

The primary outcome was in-hospital mortality during the present hospital stay. The accuracy of qSOFA, RTS, GAP, REMS, and ISS scores was compared to determine the outcome of patients.

Table 1. Revised trauma score parameters

Glasgow Coma Scale	Points	Systolic Blood Pressure	Points	Respiratory Rate	Points
13-15	4	>89	4	10-29	4
9-12	3	76–89	3	>29	3
6-8	2	50–75	2	6–9	2
4-5	1	1–49	1	1–5	1
3	0	0	0	0	0

Statistical analysis

Variables were analyzed with SPSS version 25.0 (IBM, Armonk, NY). Variables were expressed with frequency (%), mean and standard deviation (SD), or 95% confidence interval (CI). Data comparison was performed using chi-square tests, Fisher's exact test, independent samples t-test, or Mann-Whitney U test.

The area under the receiver operating characteristic curve (AUC) was used to compare the discriminatory power of qSOFA, RTS, GAP, REMS, and ISS in order to determine in-hospital mortality. Sensitivity, specificity, positive and negative likelihood ratios (LR), and positive and negative predictive values (PPV and NPV) were plotted for each score. A P-value <0.05 was considered statistically significant.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki. The ethics committee of Isfahan University of Medical Sciences approved the study protocol (IR.MUI.MED.REC.1398.340). All the patients signed an informed consent form.

Results

Finally, 775 patients with multiple trauma who were admitted to the ED were included in the study. Of these, 34 people (4.39%) died and 741 subjects were discharged from hospital. The patients had a mean age of 38.68±18.74 years and most of them were male (n=613, 79.1%). Traffic accidents were the main cause of the injuries (69.6%). The baseline demographic and clinical characteristics are reported in Table 3.

The mean qSOFA, RTS, GAP, REMS, and ISS scores were 0.41±0.64, 7.64±0.66, 21.38±2.71, 1.98±2.90, and 11.76±10.29, respectively. All scores were significantly higher in the survived patients than in the non-survived patients (P<0.001). There was a statistically significant difference between the survived and non-survived patients regarding age (P=0.002), ESI triage level (P<0.001), GCS (P<0.001), SBP (P<0.001), and pulse rate (P=0.001) [Table 3].

The AUCs of qSOFA, RTS, GAP, REMS, and ISS scores to predict in-hospital mortality were 0.878 (95% CI: 0.853-0.900), 0.848 (95% CI: 0.820-0.872), 0.889 (95% CI: 0.865-0.910), 0.938 (95% CI: 0.918-0.954) and 0.869 (95% CI: 0.843-0.892), respectively (Table 4, and Figure 1). The qSOFA score was a good predictor of in-hospital mortality for patients with multiple trauma; it was similar to REMS (p=0.107), GAP (p=0.785), RTS (p=0.530), and ISS (p=0.779) (Table 5). The NPVs of the qSOFA, RTS, GAP, REMS, and ISS scores for in-hospital mortality were 99.6%, 98.8%, 99.2%, 99.8%, and 99.8%, respectively [Table 4].

The method of DeLong et al. (1988) was used to calculate the statistical significance of the difference between 2 to 6 AUC curves (derived from the same cases).[9] The REMS was more successful than RTS (P=0.037) and ISS (P=0.020) in predicting in-hospital mortality for multiple trauma patients [Table 5].

Table 2. Rapid emergency medicine score

Variables	Score						
	0	+1	+2	+3	+4	+5	+6
Age	<45		45–54	55–64		65-74	>74
Heart rate (bpm)	70–109		55–69 110–139	40–54 140–179	<40 >179		
Respiratory rate (bpm)	12–24	10–11 25–34	6–9	35–49	<6 >49		
Mean arterial pressure (mm Hg)	70–109		50–69 110–129	130–159	<49 >159		
Glasgow coma scale	>13	11 –13	8–10	5–7	<5		
O_2 saturation	>89	86–89		75–85	<75		

Bpm, beats per minute

Table 3. Demographic and clinical characteristics of multiple trauma patients

Characteristics	Total (n=775)	Survived (n=741)	Non-Survived (n=34)	P value
Age; year	38.68±18.74	38.05 ± 18.23	52.29 ± 24.28	0.002
Sex (%) **Female**	162(20.9)	158(21.3)	4(11.8)	0.278
Male	613(79.1)	583(78.7)	30(88.2)	
Mechanism (%)				
Traffic accidents	539(69.6)	516(69.6)	23(67.6)	0.097
Fall	131(16.9)	121(16.3)	10(29.4)	
Assault	83(10.7)	82(11.1)	1(2.9)	
Others	22(2.8)	22(3.0)	0(0.0)	
Triage level (%)				
1	156(20.1)	134(18.1)	22(64.7)	<0.001
2	414(53.4)	406(54.8)	8(23.5)	
3	205(26.5)	201(27.1)	4(11.8)	
Glasgow coma scale (%)				
3-8	46(6.0)	20(2.8)	19(55.9)	<0.001
9-12	30(3.8)	27(3.6)	5(14.7)	
13-14	24(3.1)	27(3.6)	2(5.9)	
15	675(87.1)	667(90.0)	8(23.5)	
Length of stay; day	6.25±5.73	6.22±5.73	6.97±5.75	0.463
Initial Vital signs				
PR; bpm	87.31±14.06	86.95±13.62	95.12±20.29	0.001
SBP; mmHg	129.89±20.11	138.06±41.44	119.28±17.62	<0.001
MAP; mmHg	99.35±15.31	102.92±29.16	89.70±11.74	<0.001
RR; bpm	19.18±3.64	19.31±3.46	20.10±6.50	0.051
Temp; °c	36.97±0.30	36.97±0.34	36.93±0.17	0.420
O_2 SAT; %	94.60±3.10	95.18±5.02	94.57±2.99	0.266
Initial laboratory tests				
HCT, Mean±SD	34.29±6.48	34.36±6.44	34.22±6.51	0.685
WBC, Mean±SD;*103/ml	15.9±6.4	15.9±6.2	16.3±7.1	0.196
BE, Mean±SD	-4.79±6.91	-4.57±6.92	-5.44±7.63	0.072
BUN, Mean±SD	14.9±5.7	15.0±5.7	14.7±5.4	0.384
ISS	11.76±10.29	11.26±10.17	22.50±6.58	<0.001
REMS	1.98±2.90	1.65±2.40	9.15±3.59	<0.001
qSOFA	0.41±0.64	0.37±0.61	1.18±0.76	<0.001
GAP	21.38±2.71	21.58±2.34	16.88±5.30	<0.001
RTS	7.64±0.66	7.69±0.53	6.30±1.42	<0.001

Data shown n (%) or Mean ± SD. SD: Standard deviation, PR: Pulse rate, SBP: Systolic blood pressure, MAP: Mean arterial pressure, RR: Respiratory rate, O2 Sat: Oxygen saturation, Temp: Temperature, HCT: Hematocrit, WBC: White blood cell, BUN: Blood urea nitrogen, BE: Base excess, RTS: Revised trauma score, ISS: Injury Severity Score, REMS: Rapid Emergency Medicine Score, GAP: Glasgow coma scale, Age, and Systolic Blood Pressure score, qSOFA: quick sequential organ failure assessment.

Discussion

The main goal of managing trauma patients is to preserve their survival. Trauma is known as one of the four main causes of death in developing countries such as Iran.[3,15] Trauma and injuries are associated with severe complications, disability, and financial and social costs. Mortality and disability rates following trauma are related to the severity of the injury, time to diagnosis, and time to reach the appropriate care facility.[3] Consequently, it is very important to find critically ill patients who are at risk of death. Therefore, triage and scoring systems are used to find patients at risk. In addition to determining the prognosis of trauma, these systems are also effective in predicting the severity of the injury.[1,13] The first scoring system for trauma patients was presented about 60 years ago and many improvements have been made in this field.[1,16]

Table 4. The ROC analysis results of physiologic scoring systems and Glasgow coma scale in prediction of in-hospital mortality

Variables	REMS	GAP	RTS	qSOFA	ISS
Cut-off	**≥4**	**≤19**	**≤6.9**	**≥1**	**≥13**
Sensitivity (95% CI)	96.97 (84.2 - 99.9)	84.85 (68.1 – 94.9)	75.76 (57.7 – 88.9)	93.94 (79.8 – 99.3)	96.97 (84.2 - 99.9)
Specificity (95% CI)	81.03 (78.0 – 83.8)	86.86 (84.2 – 89.2)	89.54 (87.1 – 91.7)	69.65 (66.2 – 72.9)	65.18 (61.6 - 68.6)
PPV (95% CI)	18.6 (16.3 - 21.2)	22.4 (18.6 – 26.7)	24.5 (19.6 – 30.2)	12.2 (10.7 - 13.7)	11.1 (10.0 - 12.3)
NPV (95% CI)	99.8 (98.9 - 100.0)	99.2 (98.3 - 99.7)	98.8 (97.8 - 99.3)	99.6 (98.5 - 99.9)	99.8 (98.6 - 100.0)
PLR (95% CI)	5.11 (4.35 - 6.00)	6.46 (5.10 – 8.16)	7.24 (5.44 – 9.64)	3.09 (2.69 - 3.56)	2.78 (2.48 - 3.13)
NLR (95% CI)	0.04 (0.01 - 0.26)	0.17 (0.08 - 0.39)	0.27 (0.15 - 0.50)	0.09 (0.02 - 0.33)	0.05 (0.01-0.32)
AUC (95% CI)	0.938 (0.918-0.954)	0.889 (0.865-0.910)	0.847 (0.820-0.872)	0.878 (0.853-0.900)	0.869 (0.843-0.892)
P value	<0.001	<0.001	<0.001	<0.001	<0.001

REMS: Rapid Emergency Medicine Score, GAP: Glasgow coma scale, Age, and Systolic Blood Pressure score, RTS: Revised trauma score, qSOFA: quick sequential organ failure assessment, ISS: Injury Severity Score, CI: Confidence interval, NPV: Negative predictive value, PPV: Positive predictive value, PLR: Positive likelihood ratio, NLR: Negative likelihood ratio, AUC: Area under the curve

Table 5. Comparison of the different AUC of four different tools with statistical significance (P-value)

	REMS	GAP	RTS	qSOFA	ISS
REMS		0.247	**0.037**	0.107	**0.020**
GAP			0.395	0.785	0.608
RTS				0.530	0.561
qSOFA					0.779
ISS					

REMS: Rapid Emergency Medicine Score, GAP: Glasgow coma scale, Age, and Systolic Blood Pressure score, RTS: Revised trauma score, qSOFA: quick sequential organ failure assessment, ISS: Injury Severity Score, AUC: Area under the curve

Each scoring system has its limitations and advantages. A good scoring system has fewer parameters and is easy and accurate to use, especially in prehospital and emergency department settings.[1] In most multiple trauma patients, it is possible to determine the severity of the injury and the risk of death based on physiological parameters.[17] The qSOFA, RTS, GAP, and REMS are some of the most widely used scoring systems.[3,9,13,17] In this study, these scores and ISS were compared in predicting in-hospital mortality in adult multiple trauma patients admitted to the emergency department. These scoring systems were significantly associated with in-hospital mortality (AUCs of qSOFA, RTS, GAP, REMS, and ISS scores were 0.878, 0.848, 0.889, 0.938, and 0.869, respectively). REMS was an excellent predictor and qSOFA, RTS, GAP, and ISS were good predictors of in-hospital mortality. In the present study, the qSOFA score had a good predictive value compared to other scores (AUC) for determining mortality in trauma patients ($p<0.05$).

GAP and qSOFA consist of three parameters and they can be used simply, quickly, and functionally when entering triage.[11,17] RTS also consists of three parameters, but it is calculated in two steps and based on the formula; it cannot be used as quickly as the previous two scores in the triage unit.[17] REMS consists of six parameters.[3] The predictive value of REMS was higher than other scoring systems, which may be due to the high score considered for age in this scoring system. After REMS, the GAP score had the highest AUC, which also includes the age criterion in this score. Therefore, due to the fact that the age is significantly higher in the survived group than in the non-survived group, it seems that adding age to each of the scoring systems increases their predictive value.

In this study, the qSOFA score had a significant association with in-hospital mortality in patients with multiple trauma (AUC = 0.878). This result is in line with previous studies. Jawa et al.,[8] showed that the qSOFA score was an accurate predictor of in-hospital mortality in trauma patients in the emergency department (AUC: 0.73). The qSOFA score in the pre-hospital setting was also found to accurately predict in-hospital mortality in trauma patients transported by pre-hospital emergency personnel (AUC= 0.75 and 0.70).[18,19]

Huang et al.,[11] found a moderate predictive ability of qSOFA to predict death in the ED resuscitation room

among trauma patients (AUC=0.78). Miyamoto et al. reported that the predictive value of hospital qSOFA score in predicting in-hospital mortality was higher than pre-hospital qSOFA (AUC=0.74 vs 0.69, P<0.0001). They found that repeated calculation of the qSOFA score improved the AUC curve for in-hospital mortality.[20]

These results confirm the good diagnostic ability of qSOFA for in-hospital mortality in multiple trauma patients both in the pre-hospital and in-hospital settings. Based on this, the qSOFA score can be used for trauma patients, such as patients suspected of infection. Repeated assessments of the qSOFA score can be easily performed without special equipment, which increases the usefulness of the qSOFA score.

Moreover, a scoring system should have a high sensitivity to identify low-risk patients, and the qSOFA score seems to be a useful scoring system in this regard. The present study showed that a cutoff point of ≥1 in the qSOFA score was sufficient to maintain high sensitivity when triaging trauma patients to identify high-risk individuals (sensitivity=93.94%). Also, REMS and ISS have sufficient sensitivity to diagnose high-risk trauma patients (sensitivity=96.97%).

Conclusions

The REMS, qSOFA, RTS, GAP, and ISS scores were excellent and good predictors of in-hospital mortality in patients with multiple trauma. The qSOFA score for predicting mortality in trauma patients had a predictive value compared to other scores (AUC). The qSOFA score is simple and rapid and accurately can be used for the screening of multiple trauma patients in the ED. An early calculation of a qSOFA score in triage can help allocate required resources earlier to patients at higher risk of death.

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

Area Under Receiver Operating Characteristic: AUC;
Injury Severity Score: ISS;
quick Sequential Organ Failure Assessment: qSOFA;
Emergency department: ED;
Glasgow coma score: GCS;
Systolic blood pressure: SBP;
Respiratory rate: RR;
Mean arterial pressure: MAP;
Heart rate: HR;
Oxygen saturation: SpO_2;
GCS, Age, and Systolic Blood Pressure score: GAP;
Revised Trauma Score: RTS;
Rapid Emergency Medicine Score: REMS;
Emergency Severity Index: ESI.

Authors' contributions

All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. The ethics committee of Isfahan University of Medical Sciences approved the study protocol (IR.MUI.MED.REC.1398.340). All the patients signed an informed consent form.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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