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The Ability of SOFA Score to Predict Mortality Rate and ICU Length of Stay for Trauma Patients

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Abstract

Background:

The sequential organ failure assessment (SOFA) is one of the most valid outcome prediction systems for patients with sepsis. Numerous methods have been used to predict outcome in trauma patients.

Objectives:

This study examined the validity of the SOFA scoring system for predicting outcome in multiple trauma patients admitted to the intensive care unit (ICU) of Bahonar Hospital, Kerman, Iran.

Methods:

This was a prospective cohort study conducted from September 2017 to September 2018 on trauma patients admitted to the ICU at Bahonar Hospital, Kerman, Iran. After data collection, the discriminatory ability of SOFA (to discriminate between survivors and non-survivors) and its calibration ability (to make predicted probabilities in agreement with the actual outcomes) were calculated. $P < 0.05$ was regarded as the significance level.

Results:

In this study, 454 patients aged 18 - 91 years were evaluated. Their mean age was 51.96 ± 18.15 years. Two hundred and eighty (61.7%) of the patients were male and one hundred and seventy-four (38.3%) were female. The mortality rate in the study was 27.3% (n = 123), and the discriminatory power of SOFA was poor (AUC = 0.648). Based on the Youden Index (sensitivity and specificity), an optimal cut-off point of 5.5 (sensitivity 58.4% and specificity 69%) was calculated for SOFA. The ROC area under the curve was 0.648 ± 0.036 (P = 0.001).

Conclusions:

In this study, the discriminatory and calibration power of SOFA were poor and acceptable, respectively. SOFA was accurate in predicting the probability of death among the trauma patients in the ICU.

Keywords: Sequential Organ Failure Assessment; Intensive Care Unit; Trauma

1. Background

Scoring systems that are designed based on disease severity are an important tool for determining patient prognosis (1). Prediction of mortality probability is also of great significance in trauma patients (2). The increasing incidence of trauma has led to the development of several statistical models such as APACHE (Acute Physiology and Chronic Health Evaluation) and SAPS (Simplified Acute Physiology Score) for determining objective prognosis

in critically ill patients (3). In addition, Sequential Organ Failure Assessment (SOFA) has been used to estimate mortality probability in patients with sepsis (4). Serum lactate level of trauma patients has been recently employed to evaluate their prognosis (5).

Trauma scoring systems summarize the severity of injury in a single value and provide a better classification of trauma patients via a common language thereby enabling comparisons between hospitals or trauma treatment centers (6). Patients with multiple traumas are typically in a critical state and are often hospitalized in ICUs after emergency treatment (7). In a number of studies, SOFA score has not been verified as an independent predictor of mortality rate in trauma patients (8).

The intensive care unit is a specialized unit in which the most critically ill patients are treated and cared for by the most skilled nursing and medical personnel (9), and lack of proper patient care will result in such problems as increased costs, longer length of stay (LOS), impairment and death. According to global estimates, mortality rate in ICUs ranges from 6 to 40% largely depending on the severity of the illness and the patient's deteriorating condition (10). The results of a number of studies in Iran have estimated the mortality rate among ICU patients to be between 8 and 45% (11).

ICUs account for about 13% of hospital costs and 4.2% of healthcare costs and long ICU LOS is largely responsible for increases in these costs (12).

Considering the above issues, clinical evaluation of disease severity is an essential component of mortality and morbidity prognosis in ICU patients so that the limited ICU facilities can be allocated to patients awaiting admission to ICUs in a reasonable and fair fashion (12).

Predictive scoring systems seem to be able to help in this regard to some extent. For almost three decades now, these systems have been proposed and developed to measure the severity of disease and determine the prognosis of patients admitted to ICUs (13). Such scoring enables the healthcare team to estimate the probability of patient recovery (14). It also shows the degree of patients' physiological instability upon admission to ICUs (15). These systems can be used along with clinical evaluation to assess survival probability more accurately (16). Other benefits of using these systems include assistance in clinical decision making and judgment, standardization of research on intensive care, specification of work pressure, optimized allocation of human and technical resources and comparison of the quality of care among different ICUs (17).

The sequential organ failure assessment score (SOFA score), previously known as the sepsis-related organ failure assessment score (18). is used to track a person's status during the stay in an intensive care unit (ICU) to determine the extent of a person's organ function or rate of failure (19). The score is based on six different scores, one each for the respiratory, cardiovascular, hepatic, coagulation, renal and neurological systems (Table 1).

Table 1. The Sequential Organ Failure Assessment (SOFA) Score

SOFA score	**1**	**2**	**3**	**4**
PaO_2/FIO_2 (mm Hg)	<400	<300	<220	<100
SaO_2/FIO_2	221-301	142-220	67-141	<67
Platelets $\times 10^3/mm^3$	<150	<100	<50	<20
Bilirubin (mg/dL)	1.2-1.9	2.0-5.9	6.0-11.9	>12.0

Cardiovascular[b]	MAP <70	Dopamine ≤5 or dobutamine (any)	Dopamine >5 or norepinephrine ≤0.1	Dopamine >15 or norepinephrine >0.1
Glasgow Coma Score	13-14	10-12	6-9	>6
Creatinine (mg/dL) or urine output (mL/d)	1.2-1.9	2.0-3.4	3.5-4.9 or <500	>5.0 or <200

The use of any of these systems does not appear to be appropriate without validation. Therefore, given the simplicity of the SOFA system and the possibility of its quick and easy evaluation, it was decided to examine its validity in terms of its power in predicting mortality and morbidity of trauma patients hospitalized in the ICU of Bahonar Hospital, Kerman, Iran.

2. Objectives

The purpose of this study was to evaluate the validity and accuracy of the SOFA scoring system in trauma patients hospitalized in the ICU so that, if its validity is confirmed, it can be used more extensively in trauma ICUs.

3. Methods

This prospective study was conducted from September 2017 for 2 years. During this period, all sever trauma patients over 18 years of age with injury severity score (ISS) ≥ 16 who were admitted to the intensive care unit of Shahid Bahonar Hospital in Kerman (Kerman Province Trauma Referral Center) were included in the study. on all trauma patients admitted to the ICU of Shahid Bahonar Hospital Kerman, Iran, after receiving an ethics code (IR.KMU.AH.REC.1396.1697) from the Vice Chancellor for Research at Kerman University of Medical Sciences.

All demographic information, the patients' SOFA scores upon admission to the ICU and their outcomes (survivors or non-survivors) were recorded in a medical record checklist and analyzed in SPSS v. 20 using the Hosmer–Lemeshow test, AUC-ROC curve, the *t*-test and the chi squared test. Model validation was performed employing the relevant standardized tests. The discriminatory power of the model, which analyzes its ability to discriminate between survivors and non-survivors, was examined using the AUC-ROC curve. AUC = 0.05 means a random probability, AUC > 0.7 an acceptable power and AUC > 0.8 good predictive power of the scoring system. The calibration power, which measures the agreement between the actual results and the predicted probabilities, was calculated using the Hosmer–Lemeshow goodness-of-fit test. $P < 0.05$ was considered the significance level.

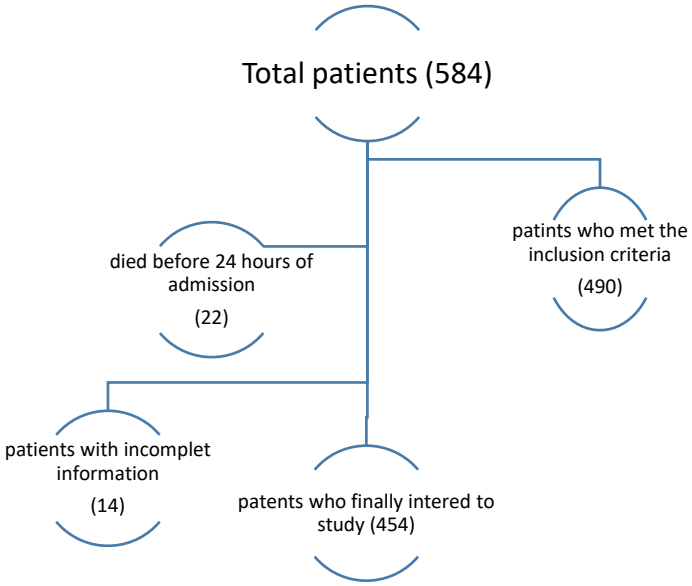

Figure 1. CONSORT flow diagram

4. Results

During the study period, a total of 584 trauma patients were admitted to Shahid Bahonar Hospital ICU, and finally 454 patients were evaluated due to their inclusion criteria. The mean age of the patients was 51.96 ± 18.15 years. Two hundred and eighty (61.7%) of them were male and one hundred and seventy-four (38.3%) females. The mortality rate in the study was 27.3% (n = 123). It was 28.6% in male (n = 80) and 24.8% in female (n = 43), demonstrating no statistically significant difference them (P > 0.05) (Table 2).

Table 2. Comparison of the Frequency of Survivors and Deaths by Gender

Gender	Group		Total (454)	p-value
	Survivors(231)	Deaths (123)		
Male	131(75.2 %)	43(24.8 %)	280 (61.7 %)	0.28
Female	survivors(231)	Deaths(123)	174 (38.3%)	

The mean age of survivors (46.37 ± 58.60) was significantly lower than that of the non-survivors (68.02 ± 38.50) (P = 0.001). The mean SOFA score of the non-survivors was significantly higher than that of the survivors (6.18 ± 2.04 and 5.2 ± 28.10, respectively) (P = 0.001). However, the mean ICU LOS was not significantly different between the two groups (15.44 ± 4.57 and 18.6 ± 27.87 days, respectively) (P = 0.06) (Table 3).

Table 3. Comparison of Mean Age, Length of Stay in ICU and SOFA between the Two Groups

Variables	**Group**		**Total (454)**	**P-Value**
	Survivors (231)	**Deaths (123)**		
Age (y)	46.37 ± 58	68.02 ± 38	51.96 (91 - 2)	0.001
LOS1 in ICU (day)	14.63	18.89	7/15 (60 - 2)	0.06
SOFA score	5.14	6.21	5.42(14 - 1)	0.001

Abbreviations: SOFA, sequential organ failure assessment; ICU, intensive care unit; LOS, longer length of stay.

This study, the discriminatory power of SOFA was poor (AUC = 0.648). Based on the Youden Index (sensitivity and specificity), an optimal cut-off point of 5.5 (sensitivity 58.4% and specificity 69%) was calculated for SOFA. The area under curve was ROC = 0.648 ± 0.036 (P = 0.001) (Table 4).

Table 4. Evaluation of the Performance of the SOFA Scoring System in the Two Surviving and Deceased Groups

58.4%	specify
69%	sensitivity
0.24	Youden index
5.5	Cutting point
(0.704-0.565) 0.648	area under the curve ROC[1]
0.04	SE
0.000	Sig

39.65%	Positive predictive value
82.3%	Negative predictive value
66.4%	Precision

5. Discussion

This study evaluated the performance of SOFA in predicting the outcomes of patients admitted to a trauma ICU. The mean SOFA score in the non-survivor group was significantly higher than that in the survivor group. The predictive power of scoring systems is generally examined by the discriminatory (AUC-ROC curve) and calibration (the chi-squared statistic of the Hosmer–Lemeshow test) power of models. The same method was used in the present research to examine the predictive power of the SOFA system. The discriminatory power of SOFA was poor in our group of patients (ROC = 0.648). Differences in the discriminatory power of scoring systems may be attributed to the greater suitability of one system for a collective group of patients and to the different LOS in the various systems. However, the Hosmer–Lemeshow goodness-of-fit test pointed to an acceptable SOFA calibration power (X^2 = 12.006, P = 0.048) for our group of patients. The optimal cut-off point for SOFA was determined to be 5.5 by the Youden Index, which was calculated based on its sensitivity, specificity, positive and negative predictive values and accuracy of prediction. As can be seen, the predictive accuracy of this system was appropriate for the mortality rate of trauma patients admitted to the ICU. In this study, younger patients had a higher chance of being placed in the survivor group, and this difference was statistically significant.

In 1995, Massmo Antolini et al., After evaluation the relationship between Sofa Score with the incidence of organ failure and mortality, the duration of ICU hospitalization in trauma patients hospitalized in 16 countries, concluded that the initial Sofa Score and its serial check can be a predictor (20).

A group of German researchers surveyed 31,154 trauma patients and concluded that the Sofa scoring system overestimates the likelihood of organ failure in these patients (21). For this reason, some countries, such as Spain, have used a different grading system (RETRAUCI) to predict the incidence of multi organ failure in trauma patients (22).

In a study of 120 septic and non-septic patients admitted to ICU, Balci C et al. (2005) examined the ability of SOFA, acute physiology and chronic health evaluation (APACHE) II and APACHE III systems and platelet counts in predicting patient mortality. Their results showed that all of the mentioned systems were likely to have good prognostic ability, which is consistent with our results (23).

Sawicka W et al. studied 99 patients suffering from hematologic malignancies and admitted to ICU in order to examine the effectiveness of SOFA in determining their prognosis. They analyzed the risk factors for mortality by employing univariate logistic regression analysis and introduced SOFA (P = 0.00009) as the independent risk factors for mortality in these patients (24).

Ture M et al. examined the SOFA and APACHE II systems as well as the serum levels of free triiodothyronine (FT3) to predict mortality rate in patients with acute respiratory distress syndrome (ARDS). In addition to SOFA and APACHE II, low serum levels of FT3 were also found to be useful in predicting the short-term mortality of patients with ARDS admitted to ICU (25).

Examining the correlation between SOFA and APACHE II with LOS (length of stay) in cardiac and general surgery ICUs, Milic M et al. demonstrated the very good ability of the two systems in predicting LOS in general surgery ICUs. However, no such correlation was observed in cardiac surgery ICUs (26).

In a retrospective study, Chen SJ et al. examined the outcomes for 110 patients with bacteremia due to *Acinetobacter baumannii* using the SOFA scoring system. In this study, which was conducted in a 40-month

period, SOFA was identified as the independent predictor of the results during the multivariate analysis. The discriminatory power of this scoring system was reported to be “great” based on the AUC. Moreover, the model goodness-of-fit was reported to be “good”. In this study, the cut-off point for SOFA was greater than 8, which demonstrated the highest correlation with the 14-day mortality of these patients. They mentioned the convenient clinical application of SOFA as one of its advantages (27).

In two cohort studies, Cerro L et al. investigated 2530 adult patients with suspected sepsis admitted to non-intensive care units in order to validate the SOFA system. The performance of this scoring system was assessed by studying its calibration and discriminatory power. They maintained that, except in intensive care units, the calibration and discriminatory power of the system were limited (15).

Given the differences in patient characteristics, inpatient units, exclusion and inclusion criteria as well as the quality of medical and nursing care in different centers, a scoring system by itself lacks identical validity under all circumstances. The discriminatory power of primary systems varies owing to their differences from population to population. In order to maintain the predictive power of models, it is sometimes necessary to make a number of modifications. Improvements in the quality of care as well as continuous advancements in medical sciences, diagnostic methods and medical equipment indicate the need for periodic studies to validate predictive models. The discriminatory power of a model is closely associated with the study population, and the quality of medical and nursing care also influences the results. These were among the limitations of the present study.

5.1. Conclusions

In this study, the discriminatory and calibration power of SOFA were poor and acceptable, respectively. SOFA had acceptable prognostic accuracy, and its clinical application was more convenient due to its simplicity. Therefore, this model can be used to predict the condition of patients and, based on that, to take possible and appropriate therapeutic measures in order to reduce patient mortality.

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