ORIGINAL ARTICLE

Various scoring systems for predicting mortality in Intensive Care Unit

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Abstract

Context: Various scoring systems have been developed to predict mortality and morbidity in Intensive Care Unit (ICU), but different data has been reported so far.

Aims: This retrospective clinical study aims to evaluate predictability of Acute Physiology and Chronic Health Evaluation II (APACHE II), APACHE IV, Simplified Acute Physiology Score III (SAPS III) scoring systems regarding with mortality.

Settings and Design: Sixteen bed surgical-medical ICU in university hospital.

Materials and Methods: The study comprised 487 patients older than 18 years treated in ICU for at least 24 h. Age, gender, body weight, initial diagnosis, clinic of referral, intubation, comorbidities, APACHE II, APACHE IV, Glasgow coma scale, SAPS III scores, length of hospitalization before referral to ICU, length of stay in ICU, mechanical ventilation were recorded.

Results: Most of the patients (54.6%) were consulted from operating room. The most frequent diagnosis was acute respiratory failure. Total mortality rate was 26%. Mortality rate was higher in patients admitted from wards other than surgery (48%) ($P < 0.005$). In the presence of comorbidities, mortality rate was higher with comorbidities than without ($P < 0.05$). Regression analysis indicated a significant positive relationship between length of stay in ICU, length of mechanical ventilation and high mortality risk in patients referred from emergency service ($P < 0.05$). Accuracy rates of predicting mortality were 81%, 79%, and 81% for APACHE II, APACHE IV, and SAPS III, respectively.

Conclusions: The investigated scoring systems are similar in sensitivity and specificity mortality prediction whereas the accuracy was higher for SAPS III and APACHE II than APACHE III in our patient population.

Key words: Intensive Care Unit, morbidity, mortality, scoring systems

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Introduction

There are several scoring systems used in Intensive Care Units (ICUs) that aim to predict patient morbidity and mortality.[1-3] Numerous studies have been undertaken to evaluate the predictability of various severity of illness scores, and conflicting data have been reported so far.[4-8] There is a need for more studies evaluating various scoring systems in terms of sensitivity and specificity to predict mortality in different patient population. While Simplified Acute Physiology Score II (SAPS II) was shown to have best performance, because of superior calibration Acute Physiology And Chronic Health Evaluation II (APACHE II) was found to be the most appropriate model for comparisons of mortality rates in different ICUs.[9,10] The present study

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was undertaken to compare the scoring systems in predicting morbidity and mortality in our geographic database, in department of ICU, at University Hospital of Pamukkale, Denizli, a province in Southwestern Turkey.

Materials and Methods

This retrospective clinical study was conducted with ethical guidelines, including the World Medical Association's Declaration of Helsinki, as revised in 2008. The study was approved by the Local Ethics Committee of the Pamukkale University, School of Medicine. Once participant eligibility was established, written informed consent was obtained from each patient next of kin or health care proxy. A total of 487 patients were included in the study between July 2010 and July 2011. Patients older than 18 years of age, who stayed 24 h or more in the ICU, were included. Because of caring at separate special ICUs, patients with a history of coronary artery surgery, a major burn, recipients of organ transplants could not have included and patients referred from other ICUs other than their 1st day of admission were excluded from the study. Moreover, only the first data set of patients with a history of multiple admissions in ICU was included in data analysis.

Patients' data comprising age, gender, body weight, body mass index, and diagnosis on admission in ICU were all recorded. Source of referral, presence or absence of intubation on admittance, presence of comorbidities were also recorded. All data were obtained from patients' files. APACHE II, APACHE IV, Glasgow coma scale, and SAPS III scores were calculated from patient's data.

Length of stay in ICU, length of hospital stay before admittance in ICU, length of mechanical ventilation, outcome of treatment (excitation, referral to another clinic, or discharge) were recorded from patients' files.

A statistical software program (SPSS 16.0 for Windows, SPSS, Inc., Chicago, IL, USA) was used for statistical analysis. Normal distribution of data was tested by the Kolmogorov–Smirnov test. Categorical variables were compared between the study groups by Pearson Chi-square test. Quantitative variables were compared by independent samples *t*-test, Kruskal–Wallis, and Mann–Whitney U-tests. Multivariate logistic regression analysis was used to evaluate the risk factors. The obtained scoring data with all three systems were standardized by normal distribution curve in 0–1 probability intervals. Receiver operating characteristic (ROC) curve was used to determine a cut-off value for mortality and sensitivity and specificity of each scoring system for prediction of mortality. All tests were performed at $\alpha = 0.05$ significance level.

Results

In the present study, 215 females and 272 males aged between 18 and 96 years were included. Demographic variables for the patient population are outlined in Table 1.

Most of the patients (54.6%) were referred from surgery room, whereas 23.8% were referred from emergency service and 20% from different clinics. The most frequent diagnosis on admittance was cardiovascular diseases (28.6%) followed by abdominal surgery (23.6%), endocrine diseases (20.2%), and respiratory system diseases (13.2%). The mortality rate was higher in the presence of comorbidities such as gynecological, hematological, respiratory, gastrointestinal system diseases, and malignancies ($P < 0.005$).

When the outcome was evaluated, 360 patients were found to be discharged from the ICU (73.9%) and 127 died (26.1%) out of 487 patients evaluated. The

Table 1: Demographic variables of patients involved in the study

	Mean	SD	Minimum	Maximum
Age (year)	58.58	18.00	18	96
Body weight (kg)	74.85	23.76	35	180
Height (cm)	165.26	7.47	140	187
BMI	27.12	14.03	13	275
Gender (%)				
Female	215 (45)			
Male	272 (56)			

BMI=Body mass index; SD=Standard deviation

Table 2: Scores and length of stay in ICU

APACHE II, IV and SAPS III scores

	n	Mean	SD	Minimum	Maximum
APACHE II	487	16.11	11.65	0	48
APACHE IV	487	49.73	27.96	4	139
SAPS III	487	42.77	21.67	16	99
Length of stay in hospital before admission in ICU	454	2.69	4.07	0	28
Length of stay in ICU	487	6.99	16.18	1	196
Length of mechanical ventilation	381	6.34	16.68	0	196

SD=Standard deviation; ICU=Intensive Care Unit; APACHE=Acute Physiology and Chronic Health Evaluation; SAPS=Simplified Acute Physiology Score

Table 3: Scoring values in survivor patients and died patients in the ICU

	Survivors		Nonsurvivors		*t*	*P*
	Mean	SD	Mean	SD		
APACHE II	11.631	9.011	28.811	8.521	−18.733	0.000
APACHE IV	39.419	20.332	78.969	25.933	−15.580	0.000
SAPS III	33.916	15.344	67.787	16.885	−20.817	0.000

SD=Standard deviation; ICU=Intensive Care Unit; APACHE=Acute Physiology and Chronic Health Evaluation; SAPS=Simplified Acute Physiology Score

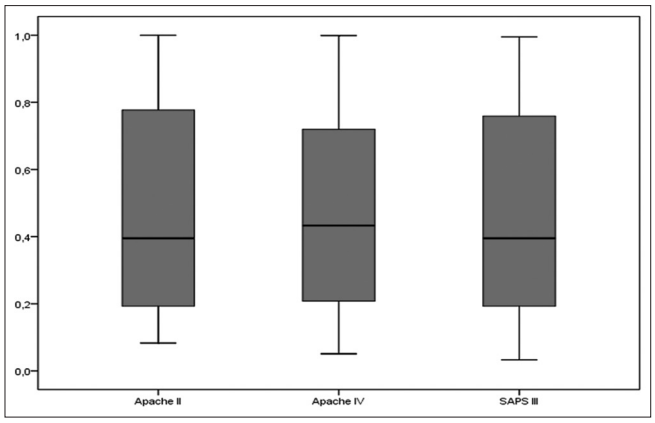

Figure 1: Comparison of standardized scores

Table 4: Relationship between mortality, risk factors and scoring systems (logistic regression)

	B	*P*	OR	95% OR	
				Lower	Upper
APACHE II	−0.01	0.745	0.99	0.94	1.04
APACHE IV	−0.03	0.006**	1.03	1.01	1.05
SAPS III	−0.05	0.010*	1.05	1.01	1.09
Age	0.01	0.381	1.01	0.99	1.03
Emergency service	2.23	0.000**	9.29	3.14	27.48
Other clinics	0.45	0.427	1.56	0.52	4.69
Length of stay in hospital before admission in ICU	−0.10	0.090	1.10	0.98	1.23
Length of stay in ICU	0.67	0.000**	1.94	1.50	2.52
Length of mechanical ventilation	−0.68	0.000**	1.97	1.52	2.54

*P<0.01; **P<0.001. ICU=Intensive Care Unit; OR=Odds ratio; APACHE=Acute Physiology and Chronic Health Evaluation; SAPS=Simplified Acute Physiology Score

mortality rate was significantly lower in postoperative patients (11.8%) than those referred from the other clinics (50.4%) ($P < 0.01$). When the diagnosis on admittance was considered, the highest mortality rate was detected in patients with respiratory deficiencies (30.7%) followed by patients with cardiopulmonary arrest (16.5%). When the patients were grouped according to the age, the highest mortality rate was detected in patients aged between 60 and 69 years ($P < 0.001$).

The data of scoring systems and length of stay in hospital and ICU are given in Table 2. The scoring values were higher in the patients who died than survived patients ($P < 0.005$) [Table 3]. Multivariate regression analysis indicated a significant positive relationship between mortality and APACHE IV, SAPS III, patients referred from emergency service, length of stay in ICU, length of mechanical ventilation, ($P < 0.05$) [Table 4].

The obtained scoring data with all three systems were standardized by normal distribution curve in 0–1 probability intervals. No significant difference between the mean

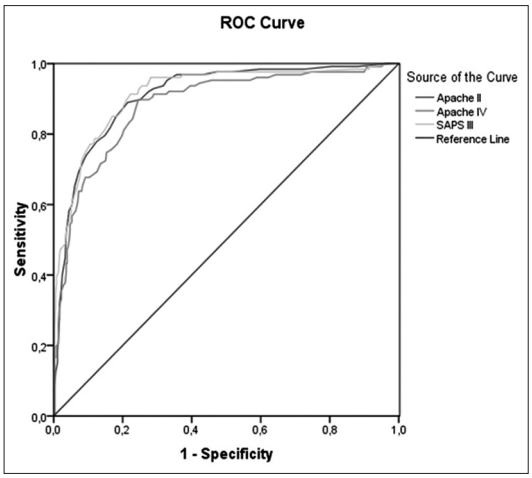

Figure 2: Receiver operating characteristic analysis of the three scoring systems

of the scores of the three scoring systems [Figure 1]. APACHE II score indicated an accuracy rate of 81.3% in predicting mortality together with a positive predictability of 59.5% and a negative predictability of 95.3% (confidence interval 95%, 0.06–0.11, $P < 0.5$). These values for APACHE IV score were 79.3%, 56.4%, and 95.4% and for SAPS III score were 81.3%, 59.2%, and 96.2%, respectively [Figure 2]. Despite not statistically significant, the highest accuracy rates of predictability were obtained by SAPS III and APACHE II followed by APACHE IV.

Discussion

Fast progress in pharmacology and medical technologies; require updating these critical scoring systems. Considering the possibility of a superiority of one system to others, the present study aimed to compare the third generation scoring systems (APACHE IV and SAPS III) with the commonly used system; APACHE II in our critically ill patients.

ICU mortality rates vary based on the population and organizational characteristics. Knaus *et al*. reported that mortality rate differed between 6.4% and 40% in 42 ICUs and 16.222 patients.[11] However, Özbilgin *et al*. indicated a rather high mortality rate of 46% in an ICU.[12] A mortality rate of 35.7% has been reported in a study by Günal *et al*.[13] A mortality rate of 25% was found in a previous study by our group, where 120 patients were included and possible relationships between scoring systems, thrombocyte counts and mortality rate were sought in septic and aseptic patients treated in ICU.[14] The mortality rate is 26.1% in this study. The present findings are in line with that of our previous study.[14] Our results significantly lower than those reported by Özbilgin *et al*.,[12] but parallel to the report of Knaus *et al*.[11]

Patient's age has been included within the context of parameters related with increasing mortality rate in the

three scoring systems evaluated.[1,15] Although Leong and Tai did not find any significant relation between increasing age and mortality rate, they stated that age could not be a determining factor in patient admittance in ICU.[16] Similarly, Ursavaş *et al*. did not observe any interaction between age and mortality rate.[17] However, Sikka *et al*. evaluated 357 elderly patients with severe pneumonia. They reported better performances and higher accuracies in predicting mortality with the scoring systems (APACHE II, SAPS II, and Mortality Probability Model [MPM II]) in the younger group (<75) than in the older one (>75). Thus, increasing age was suggested to decrease the power of predictability of these scoring systems.[18] These findings conflict with those of the scoring systems that indicate a positive relation between the increasing mortality rate and patient's age. We reported in this study that the mean age of patients who died was significantly higher than that of the survivors. According to our findings, there was a trend of increase in APACHE IV and SAPS III scores with increasing patient's age. However, logistic regression analysis indicated no significant affect of age on the mortality rate.

Haddad *et al*. investigated acute physiological scores in 641 patients of whom 78% required mechanical ventilation. The authors reported that APACHE III and APACHE IV show perfect discrimination but are poorly calibrated, whereas APACHE II system is well-calibrated when only the acute physiological scores are considered and APACHE IV predicts the mortality rate better than the others. Inclusion of respiratory parameters such as mechanical ventilation has been suggested to increase the power of prediction.[19] Zimmerman *et al*. investigated 131.618 patients in 104 ICUs and suggested that APACHE IV is a well-calibrated scoring system to predict hospital mortality in USA.[15] Kuzniewicz *et al*. evaluated the power of SAPS II, MPM III and APAPCHE IV in predicting mortality in 11.300 patients and reported that APACHE IV was more reliable than SAPS II and MPM III in predicting mortality.[10] Brinkman *et al*. performed an investigation in ICUs in The Netherlands to validate the mortality predictability of APACHE IV. They included 62.737 patients in 59 ICUs and stated that APACHE IV could provide a better discrimination than did APACHE II and SAPS II models. However, the investigators also pointed out that this difference has little clinical importance but the major superiority of APACHE IV was that it enables consideration of numerous diagnoses on admittance and thereby facilitates analysis of patient subgroups.[20] Stefani *et al*. compared APACHE II, APACHE IV and SAPS II scoring systems in 168 patients (male/female = 1) in postsurgery ICU in Brazil and they reported that APACHE IV had the poorest calibration whereas the best validation was achieved with APACHE II system.[21] In the present study, we found significantly higher APACHE IV scores in patients who died than those who survived. Thus, the present findings are in line with those of Zimmerman *et al*. providing support from a different ethnic population.[15]

In a mixed medical and coronary ICU patient population, Khwannimit and Bhurayanontachai compared the performances of SAPS II, SAPS III, and APACHE II scoring systems in 2.022 patients. The authors reported that SAPS III's performance was similar to those of the previous models and all existing scoring systems failed to provide a sufficient calibration.[22] Ledoux *et al*. investigated 851 patients to evaluate SASP III scoring system and compare its efficiency with those of APACHE II and SAPS II. The investigators reported mortality rates of 13.2% and 17.5%, respectively, for the ICU and hospital. The mean length of stay in ICU was 3 days and length of hospitalization was 14 days and the investigators stated that SAPS III version organized for the Central and Western Europe provided a better discrimination and calibration than did APACHE II but was no better than SAPS II.[23] In the present study, similar to APACHE II and APACHE IV scores, we found higher SAPS III scores in the patients who died than in those who survived in our patient population.

In a prospective study, Franchi *et al*. compared the power of SAPS III and SAPS II in predicting mortality and morbidity in 241 patients. They reported a mean SAPS II score of 35 and mean SAPS III score of 58, whereas the mortality and morbidity rates were 16% and 40.5%, respectively. The authors concluded that SAPS II is a convenient model to predict mortality but not morbidity. Furthermore, SAPS III was found to be better in predicting morbidity in patients with head trauma.[24] There are only two studies published so far comparing SAPS III, APACHE II, and APACHE IV scoring systems, two of which, were performed by the same group. The present findings are in line with those of Juneja *et al*. in that there was no significant difference between various scoring systems in efficacy and that SAPS III had better accuracy.[25,26] Juneja *et al*. also compared the ability of various scoring systems to predict mortality by ROC.[25] Our study is similar with their study in terms of study character, primary outcome measure and the results.

The present study has some strength including a single center study with standard care of patients and using regression curve analysis but potential limitations that should be taken into account. First, there was not a predefined sample size, as the aim was to assess comparing different scores regarding prediction of mortality. Second, the retrospective design of the present study may be considered as a limitation.

As a conclusion, the present findings suggest that these scoring systems are similar in sensitivity and specificity in predicting mortality whereas the accuracy was similarly high in SAPS III and APACHE II followed by APACHE IV. Further studies with larger patient numbers and preferentially with prospective character are warranted to better clarify the issue and help to build up a national, either individual consensus along with ICUs from different geographical regions.

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Conflicts of interest
There are no conflicts of interest.

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