

## Predictive value of SAPS II and APACHE II scoring systems for patient outcome in a medical intensive care unit

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### Introduction

There are many intensive care unit (ICU) scoring systems, and many new ones are being developed to achieve an objective and quantitative description of the degree of organ dysfunction and evaluation of morbidity in ICU patients. Scoring systems such as: Acute Physiology and Chronic Health Evaluation (APACHE) II, III and IV, Sim-

**Objective.** The aim is to determine SAPS II and APACHE II scores in medical intensive care unit (MICU) patients, to compare them for prediction of patient outcome, and to compare with actual hospital mortality rates for different subgroups of patients. **Methods.** One hundred and seventy-four patients were included in this analysis over a one-year period in the MICU, Clinical Center, University of Sarajevo. The following patient data were obtained: demographics, admission diagnosis, SAPS II, APACHE II scores and final outcome. **Results.** Out of 174 patients, 70 patients (40.2%) died. Mean SAPS II and APACHE II scores in all patients were  $48.4 \pm 17.0$  and  $21.6 \pm 10.3$  respectively, and they were significantly different between survivors and non-survivors. SAPS II  $>50.5$  and APACHE II  $>27.5$  can predict the risk of mortality in these patients. There was no statistically significant difference in the clinical values of SAPS II vs APACHE II ( $p=0.501$ ). A statistically significant positive correlation was established between the values of SAPS II and APACHE II ( $r=0.708$ ;  $p=0.001$ ). Patients with an admission diagnosis of sepsis/septic shock had the highest values of both SAPS II and APACHE II scores, and also the highest hospital mortality rate of 55.1%. **Conclusion.** Both APACHE II and SAPS II had an excellent ability to discriminate between survivors and non-survivors. There was no significant difference in the clinical values of SAPS II and APACHE II. A positive correlation was established between them. Sepsis/septic shock patients had the highest predicted and observed hospital mortality rate.

plified Acute Physiology Score (SAPS), Sepsis-related Organ Failure Assessment Score (SOFA), Mortality Prediction Model (MPM), Multiple Organ Dysfunction Score (MODS), and Logistic Organ Dysfunction Score (LODS) have become a necessary tool to describe ICU populations and to explain differences in mortality (1).

The Acute Physiology and Chronic Health Evaluation II (APACHE II) is the

most commonly used severity-of-disease scoring system in ICUs around the world (2). Within the first 24 hours of patient admittance, the worst value for each physiological variable is calculated into an integer score from 0 to 71. Higher scores represent a more severe disease and a higher hospital mortality risk. The first APACHE model was presented by Knaus et al. in the 1980's (3). It has not been validated for use in patients under the age of 16. Even though newer scoring systems have been developed, APACHE II still continues to be used because so much documentation is based on it. The relationship between APACHE II scores and approximate mortality interpretation in medical (non-surgical) patients is shown in Table 1.

The Simplified Acute Physiology Score II (SAPS II) was first described in 1984 as an alternative to the APACHE scoring system (4). The SAPS II score is calculated from the

worst value of 12 routine physiological measurements during the first 24 hours of patient admission, information about previous health status and some information obtained at admission. 24 hours after admission to the ICU, the measurement is completed and this results in an integer point score between 0 and 163, and predicted hospital mortality between 0% and 100%. There is a sigmoidal relationship between SAPS II score and mortality rate. SAPS II score and mortality rate interpretation are shown in Table 2.

Previous studies have reported the varying performance of these scoring systems in predicting hospital mortality. Several studies had reported better performance by APACHE II (5, 6). Other studies on different patient populations validated SAPS II as a good prediction scoring system (7, 8). Juneja et al. (9) reported that the difference in performance of the scoring systems was not significant and depends on local preferences. Newer scoring systems have been developed, such as APACHE III and IV, to refine the previous APACHE II. However, APACHE II and SAPS II as the simplest and inexpensive scoring systems are still used in our medical intensive care unit (MICU).

The aim of this study is to determine the SAPS II and APACHE II scores in patients admitted to the MICU and compare them for prediction of the outcome in these patients (survivors i.e. patients who were discharged from the hospital, and non-survivors i.e. patients who died during the same hospitalization). Predictive scores were calculated and actual hospital mortality rates were compared for different subgroups of MICU patients.

## Materials and methods

### *Study design and data collection*

The Clinical Center of the University of Sarajevo is a 1952-bed tertiary university hospital, with a 7-bed closed MICU with a

Table 1 APACHE II score and hospital mortality interpretation for non-surgical patients (3)

APACHE II score	Hospital mortality*
0-4	4%
5-9	8%
10-14	15%
15-19	24%
20-24	40%
25-29	55%
30-34	73%
35-100	85%

\*Approximate interpretation (non-surgical patients).

Table 2 SAPS II score and hospital mortality interpretation (4)

SAPS II score (points)	Mortality
29	10%
40	25%
52	50%
64	75%
77	90%

nurse/patient ratio of 1:3.5. One hundred and eighty-nine (189) patients were admitted to the MICU in the Clinical Center of the University of Sarajevo from October 2014 to September 2015. Patients were either admitted from the emergency department or transferred from a hospital ward. There were 15 patients who had exitus letalis in the first 24 hours of hospitalization in the MICU, for which SAPS II and APACHE II scores could not be calculated. The remaining 174 patients that were hospitalised for more than 24 hours in the MICU were included in the study. Out of 174 patients, 89 were admitted from the emergency department and 85 were transferred from a hospital ward. For patients with multiple admissions, only the first data set was included in the data analysis. For each patient the following data were obtained: demographic data, admission diagnosis, parameters for SAPS II and APACHE II scores and the final outcome (survivors i.e. patients who were discharged from the hospital, and non-survivors i.e. patients who died during the same hospitalization). The reasons for admission were grouped into five categories: sepsis / septic shock (based on the presence of systemic inflammatory response syndrome and a source of infection with/without hypotension and hypoperfusion despite adequate fluid resuscitation), respiratory failure (hypoxemia and/or hypercarbia requiring non-invasive ventilation or mechanical ventilation), cardiovascular (based on clinical, laboratory and ECG and/or echocardiography findings), neurological (based on clinical and diagnostic findings of central nervous system damage) and other causes. Surgical, burns, coronary care and cardiac surgery patients were not admitted to this MICU. When multiple diagnoses were present, the leading one, with the worst prognosis was selected as the main reason for admission. SAPS II and APACHE II were calculated 24 hours after admission to the MICU. The SAPS II score was cal-

culated from the following parameters: age, heart rate, systolic blood pressure, temperature, Glasgow Coma Scale, mechanical ventilation or continuous positive airway pressure (CPAP), PaO<sub>2</sub>/FiO<sub>2</sub>, urine output, urea, sodium, potassium, bicarbonate, bilirubin, leucocyte count, chronic diseases, type of admission. The APACHE II score was calculated from the patient's age and 12 parameters: PaO<sub>2</sub>, temperature, mean arterial pressure, arterial pH, heart rate, respiratory rate, sodium, potassium, creatinine, hematocrit, leucocyte count and Glasgow Coma Scale. Also, information about previous health status (surgery, history of organ insufficiency, immunocompromised state) was calculated into the result. The worst parameters in the first 24 hours of hospitalization were selected for calculation of the scores.

### **Statistical analysis**

Data were presented for continuous variables as means and standard deviation, and for categorical variables as absolute and relative frequencies. The data were analysed using t-test, Fisher's exact and chi-square test. A receiver operating characteristic (ROC) curve was used to determine a cut-off value for mortality, and the sensitivity and specificity of each scoring system for prediction of mortality. Pearson's correlation was used for evaluating the correlation between the scoring systems. Statistical significance was interpreted as  $p \leq 0.05$ . Graphically, data were presented in the form of tables and figures. Data were analysed using SPSS for Windows version 20.0 (SPSS Inc., Chicago, IL, USA).

### **Results**

Out of 174 patients included in the study, 104 patients (59.8%) survived and 70 patients (40.2%) died. One hundred patients were male (57.5%). Their mean age was  $61.7 \pm 16.3$  years (range 19-87). When survi-

vors v. non-survivors were compared, there was no statistical difference in patient age ( $59.6 \pm 14.7$  vs.  $62.3 \pm 15.9$ ;  $p=0.654$ ) or gender (61 males vs. 43 females in the survivor group and 39 males vs. 31 females in the non-survivor group;  $p=0.232$ ). Mean SAPS II and APACHE II scores in all admitted patients were  $48.4 \pm 17.0$  and  $21.6 \pm 10.3$  respectively. The mean SAPS II score was  $41.2 \pm 14.1$  in survivors and  $63.9 \pm 11.2$  in non-survivors ( $p < 0.0001$ ). The mean APACHE II score was  $16.9 \pm 6.4$  in survivors and  $31.5 \pm 10.2$  in non-survivors ( $p < 0.0001$ ). The receiver operating characteristics curve results of SAPS II and APACHE II scores in prediction of fatal outcome are shown in Figure 1.

The area under the ROC curve was calculated to evaluate the predictive value of the scoring systems. The SAPS II scoring system represents a statistically significant predictive marker of fatal outcomes of patients (area under the curve of 0.892, CI 0.84-0.94,  $p=0.001$ ). Cut off value for SAPS II was 50.5, with the sensitivity of 90.2% and specificity of 75.7%. The APACHE II scoring system represents a statistically significant predictive marker of fatal outcomes of patients (area under the curve of 0.920, CI 0.87-0.97,

$p=0.001$ ). Cut off value for APACHE II was 27.5, with sensitivity of 74.5% and specificity of 93.4%. When the ROC curves were compared, that there was no statistically significant difference in the clinical values of SAPS II vs APACHE II ( $p=0.501$ ). By using Pearson's correlation, a statistically significant positive correlation was established between the values of SAPS II and APACHE II ( $r=0.708$ ;  $p=0.001$ ). This means that when SAPS II value increases, so does the value of APACHE II, as shown in Figure 2.

SAPS II and APACHE II scores and hospital mortality for patients based on their admission diagnoses, are shown in Table 3.

Respiratory failure was the leading cause for ICU admission (62 patients, 35.6%), followed by sepsis /septic shock (49 patients, 28.1%) and cardiovascular failure (31 patients, 17.8%). Patients with admission diagnosis of sepsis/septic shock had the highest values of both SAPS II and APACHE II scores, and also the highest hospital mortality rate of 55.1%. Patients in the group admitted for other causes had the lowest SAPS II score. Patients with respiratory failure had the lowest APACHE II score and lowest hospital mortality rate.

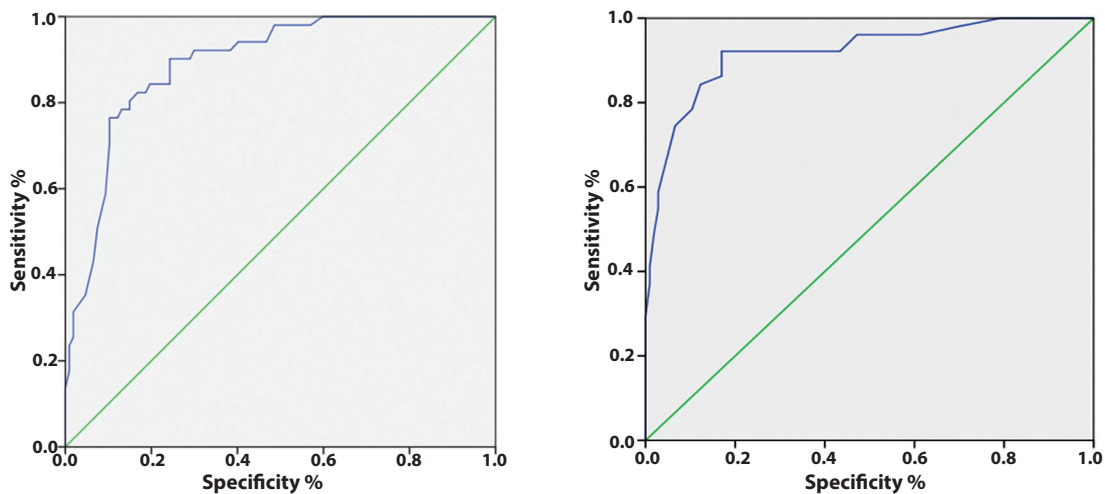


Figure 1 Receiver operating curve for predicting fatal outcome according to SAPS II and APACHE II scoring systems.

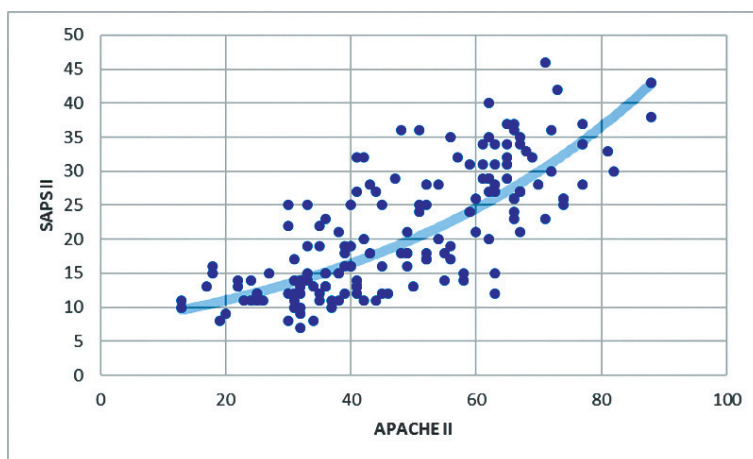


Figure 2 Correlation between SAPS II and APACHE II scores.

Table 3 Predictive scoring systems and hospital mortality rate in studied patients according to admission diagnosis

Characteristics	Patients admitted to the ICU with the primary admission diagnosis (n=174)				
	Respiratory failure (n=62)	Sepsis/septic shock (n=49)	Cardiovascular failure (n=31)	Neurological causes (n=16)	Other causes (n=16)
SAPS II ( $\bar{x} \pm SD$ )	42.4±14.9	58.4±15.0	47.6±17.8	55.4±17.0	40.9±15.0
APACHE II ( $\bar{x} \pm SD$ )	17.5±7.5	27.0±11.9	21.5±9.8	26.0±11.0	20.1±9.1
Hospital mortality rate (%)	17.7	55.1	51.6	50.0	25.0

## Discussion

According to our results, a SAPS II score higher than 50.5 can predict the MICU patients' mortality rate with good sensitivity (90.2%) and lower specificity (75.7%). An APACHE II score higher than 27.5 can predict the MICU patients' mortality rate with good specificity (93.4%) but with lower sensitivity (74.5). Based on further analysis, there was no significant difference in the clinical values of SAPS II and APACHE II. Haq et al. (10) also showed similar performance by SAPS II and APACHE II. Sathe et al. (11) and Mosenson et al. (12) showed that APACHE II had better discrimination than SAPS II.

APACHE II was a less sensitive predictor than SAPS II, but with higher specificity. The specificity of APACHE II was 93.4% which is higher than reported by Sekulic et al. (13).

In a study of 11,300 patients from 35 hospitals in California, the authors noted that only the APACHE II scoring system showed good discrimination for predicting ICU mortality (14). However, Sekulic et al. (13) concluded that SAPS II was a better predictor for hospital mortality in ICU patients. In a study by Ho et al. (15) SAPS II was confirmed to have the best performance overall.

As different subpopulations of critically ill patients are admitted to our MICU every day, there was a need to evaluate which subgroup had the worst expected and actual prognosis. The way in which the patients were divided is in accordance with the study by Breslow et al. where the diagnosis was documented within the first ICU day; it reflected the primary reason for ICU admission; and, when multiple diagnoses were relevant, the diagnosis with the worst prognosis (e.g., sepsis rather than hyper-



glycemia) was the leading one (16). When our patients were divided into subgroups according to their admission diagnosis, the leading cause of admission was respiratory failure, followed by sepsis / septic shock. Severe sepsis and septic shock were shown to be major reasons for ICU admission and also the leading causes of mortality in non-coronary ICUs (17). Hospital mortality in patients with sepsis was 55.1% which is in accordance with the results by Mohan et al. study (18). In our study, patients with respiratory failure had a hospital mortality rate of 17.7% which is lower than 30.7% as reported by Evran et al. (19).

Juneja et al. (9) indicated that the newer scoring systems performed better than their older counterparts, and were more accurate. Nevertheless, the difference in performance was not statistically significant and the choice of scoring system may depend on the ease of use and local preferences.

### **Limitations of study**

The present study has some limitations. First, our small sample size is a limiting factor in analysis. Also, being a single center study, there is possibly some amount of bias due to differences in ICU admission policies.

### **Advantages of study**

The results of this study and of past studies suggest ambiguous and inconclusive results regarding outcome, and they are heavily dependent on patient populations and medical interventions used on those patients. This must be taken into consideration when it comes to the interpretation of results. The existence of a large number of scoring systems suggests that the ideal model has yet to be found. Differences in the performance of scoring systems reinforce the need to validate them using data from independent samples from different ICUs in different

countries due to variations in the structure and quality of medical care, as well as genetic differences between populations.

### **Conclusion**

In conclusion, both APACHE II and SAPS II have an excellent ability to discriminate between survivors and non-survivors. ROC curve analysis showed that there was no significant difference in the clinical values of SAPS II vs APACHE II in MICU patients. Also, a positive correlation was established between the values of SAPS II and APACHE II scores. Sepsis/septic shock patients had the highest predicted and observed hospital mortality rate.

### **What is already known on this topic**

*Scoring systems predict patient outcomes in intensive care units. Over the years, many studies have evaluated the predictive ability of various scoring systems, and conflicting data have been reported so far. Although there are newer scoring systems, some of the most widely used are SAPS II and APACHE II. There is a need for more studies evaluating various scoring systems to predict mortality in different patient populations.*

### **What this study adds**

*To the best of our knowledge, this is the first study to evaluate predictive scoring systems of patient outcome in a medical intensive care unit in Bosnia and Herzegovina.*

**Authors' contributions:** Conception and design: AG and SJ; Acquisition, analysis and interpretation of data: AK, IT and AR; Drafting the article: AA and AG; Revising it critically for intellectual content: AI and AK; Approved final version of the manuscript: AG and IT.

**Conflict of interest:** The authors declare that they have no conflict of interest.

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