The European Research Journal 2019;5(5):751-756 ORIGINAL ARTICLE

# The relationship of simplified acute physiology score 3 (SAPS 3) and C-reactive protein (CRP) levels with mortality rates and length of stay of patients in surgical intensive care unit

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DOI: 10.18621/eurj.422079

## ABSTRACT

**Objectives:** The individual risk of surgical patients is more often underestimated and < 15% of patients who underwent surgery were admitted to ICU. The prognostic scores were developed to assess the mortality rate and prognosis for critical patients including surgical ones. The Acute Physiology and Chronic Health Evaluation (APACHE) score and the Simplified Acute Physiology Score (SAPS) were most popular ones and they were revised with the improvements in health care opportunities. As a prognostic scoring system SAPS 3' results were defined as excellent in high risk surgical patient study group. CRP is useful as a prognostic indicator or an index of disease progression but its value has not been tested in acute settings adequately. The aim of this study is to test the calibration power of SAPS 3 score and identify correlations between hospital mortality and patient outcomes with SAPS 3 scores and CRP levels.

**Methods:** This retrospective and analytical study was conducted one year period in surgical ICUs of tertiary level of attention in a public institution. It was a case–control medical record review and the patients included in this study were those who admitted in the surgical ICU for any reason.

**Results:** A total of 806 patients admitted to the Gastroenterological surgical ICU was included in the study between March 2016 and March 2017. The relation between mortality rate, length of stay in ICU and SAPS 3 score was significant statistically and the relation of CRP levels with SAPS score and mortality rate was found significant statistically.

**Conclusion:** The discriminative power of SAPS 3 score was very good and the calibration was appropriate.

**Keywords:** Simplified Acute Physiology Score, C-reactive protein, mortality, surgical intensive care unit

***Received: May 8, 2018; Accepted: January 14, 2019; Published Online: June 30, 2019***

It has been widely accepted that surgical procedures are in a high risk procedure group and a significant proportion of intensive care unit patients is composed of surgical patients. But there is another fact that the individual risk of surgical patients is more often underestimated and less than 15% of patients who underwent those procedures were admitted to an intensive care unit [1, 2]. Adequate postoperative care affects surgical outcomes like preoperative surgical status so assessment of the risks of increased morbid-

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e-ISSN: 2149-3189

ity and mortality via predictors for this group of patients is mandatory [3]. There are many studies that have developed prognostic scores to assess the mortality rate and prognosis for critical patients including surgical ones. Probably the most used and the oldest general prognostic scoring models are the Acute Physiology and Chronic Health Evaluation (APACHE) and the Simplified Acute Physiology Score (SAPS) which were revised due to the improvements in treatment procedures and health care opportunities [4, 5]. Previous studies have suggested that the calibration of these scores may differ across countries, centers, and/or characteristics of patients and the most recent revision of the SAPS model- SAPS 3- was published in 2005 [6]. 20 simple parameters which are easy to measure are used in SAPS 3 system and the results were defined as excellent in high risk surgical patient study group [7]. There are two objective measures from the perspective of the performance of prognostic models: calibration and discrimination. It has been concluded that for clinical trials or comparison of care between ICUs, calibration –how closely the estimated probabilities of mortality correlate with the observed mortality- becomes superior to discrimination discrimination between survivors and individuals who will die [4]. While the calibration of the models studied by statistical goodness -of-fit showed that the observed hospital mortality was not distinct from the expected mortality in this particular group of patients for SAPS 3, pharmacological and medical improvements necessitates reassessment [8, 9]. C-reactive protein (CRP) which is a very well-known plasma protein and plays a role in inflammation and the acute-phase innate immune response has been used increasingly in clinical practice as an inflammatory marker [10]. Since the mid-1990s, there have been many studies reporting CRP is useful as a prognostic indicator or an index of disease progression. But this statement has not been studied adequately in an acute setting and serum CRP levels have not been used as a prognostic index [11]. The aim of this study is to test the calibration power of SAPS 3 score and identify –if any- correlations between hospital mortality and patient outcomes with SAPS 3 scores and CRP levels at the Türkiye Yüksek İhtisas Training and Research Hospital.

## METHODS

This retrospective and analytical study was conducted during the period March 2016–March 2017.It was performed in Gastroenterological Surgical ICU of tertiary level of attention in a public institution. The study was approved by the Local Ethics Committee of the Türkiye Yüksek İhtisas Training and Research Hospital and exempted from the signed informed consent form requirement, because it was a case–control medical record review. The patients included in the study were those who admitted in the surgical ICU for any reason either after surgery or from another department like other ICU or emergency department. To calculate the SAPS 3 score, physiological data and laboratory analysis on the day of ICU admission were used. Records, which had been obtained from patients' files, were reviewed from hospitalization to medical discharge or hospital mortality. Data were imported into a spreadsheet (Microsoft Excel 2013, Microsoft Corporation) for the calculation of the scores and their derived probabilities of death using the published equations and coefficients. Patients with incomplete records and length of stay less than 24 hours and patients who 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 the data analysis. Length of stay in the ICU, the outcome of treatment (excitation, referral to another clinic, or discharge) were recorded from patients' files. To forestall the variability in the data collection, all values were reviewed by the authors of the study.

### Statistical Analysis

Data were analyzed, and the results were expressed as mean ± standard deviation, or percentage. Variables were first evaluated with Reliability Statistics and Cronbach's Alpha while Cronbach's Alpha if Item deleted levels were considered to choose variable parameters. To choose the type of statistical tests –parametric or non-parametric test–variables were evaluated by One-Sample Kolmogorov-Smirnov test as a normality test. And the results showed that Asymp. Sig. (2-tailed) levels ≤ 0.05 so we decided to

use non-parametric tests. For statistical analysis, variables were evaluated for significance by using the Spearman's rho test. Categorical variables were evaluated by the Kruskal Wallis Test and Mann-Whitney U test of contingency. p values presented are from two-tailed tests, and values below 0.05 were considered statistically significant. The Hosmer-Lemeshow test was used to calculate the calibration of SAPS 3 test which express the ability of the test to determine the probability of death in accordance with the observed mortality. The discrimination, which express the ability of the individual systems to distinguish survivors and non-survivors, according to the estimated mortality was assessed using receiver operating characteristic (ROC) curves. The ROC curves were established as discrimination measurements with distributions per 10%, according to the predicted mortality and the obtained curve was appraised using the calculated area under the curve (AUC). AUC values > 0.75 was appraised as satisfactory, AUC values > 0.8 was appraised as well, and AUC values > 0.9 was appraised as very good. The Statistical Package for Social Sciences (SPSS-IBM Corp., Armonk, NY, USA) 20.0 was the software used for the statistical analyses.

## RESULTS

A total of 806 patients admitted to the Gastroenterological Surgical ICU were included in the study between March 2016 and March 2017. Patients older than 18 years of age, who stayed 24 h or more in the ICU, were included. Forty- nine patients' records were excluded due to incompleteness or the unavailability of significant values. 4 patients were younger than 18 years of age. Those patients were not included in the study, leaving 753 (93.4%) patients for analysis. The data used to derive SAPS 3 scores and probabilities of death were collected in all these patients. Patients' characteristics are presented in Table 1. Apart from basic and observational admission (n = 128/753, 17%), the main reasons for ICU admission were as follows: cardiovascular, respiratory, infectious and neurological. These reasons encountered for 81% of the ICU admissions. The mean age of the patients was 59.01 years, with a standard deviation of 14.68 years and the representatives of both sexes were relatively proportional (58.6% males versus 41.4% females). Their average SAPS 3 score was 36.73 with a standard deviation of 14.093. The total mortality at discharge was 11 % (83 patients). CRP levels were ranged 1 to 450 and mean level was calculated as high as 128.33 probably due to the fact that 56.83 % (n = 428) of the patients had either infectious or oncologic component at the time of admission. This expected condition was tested with reliability statistic and Cronbach's Alpha level was 0.23 and Cronbach's Alpha if CRP Item Deleted level was 0.68. So we decided not to take CRP levels as a part of prognostic index just to find out any relation to SAPS 3 and outcomes of patients. Besides that One-Sample Kolmogorov Smirnov test showed that our variables were not homogenous and the results showed that Asymp. Sig. (2-tailed) levels ≤ 0.05 so we decided to use non-parametric tests. Spearman's rho test showed that the relation between mortality rate, length of stay in ICU and SAPS 3 score was significant statistically (age factor was used as a control variable). The relation of CRP levels with SAPS 3 scores and mortality rate was found significant statistically, but it is not significant with length of stay in the ICU. Kruskal Wallis Test and Mann-Whitney U test showed that mortality factor was affected with the SAPS 3

**Table 1.** Patients' characteristics and data

| | Mean/ total number | Standard deviation/ percent | *p** value |
|---|---|---|---|
| Age (years) | 59.01 | 14.686 | **0.007** |
| Length of stay in ICU (days) | 10.36 | 16.975 | **< 0.001** |
| In-hospital mortality | 83 | 11% | NA |
| CRP levels | 128.33 | 93.58 | **0.001** |
| SAPS 3 scores | 36.73 | 14.093 | **< 0.001** |

CRP = C-reactive protein, SAPS 3 = Simplified Acute Physiology Score 3, ICU = intensive care unit, NA = not applicable, p* = according to mortality variable.

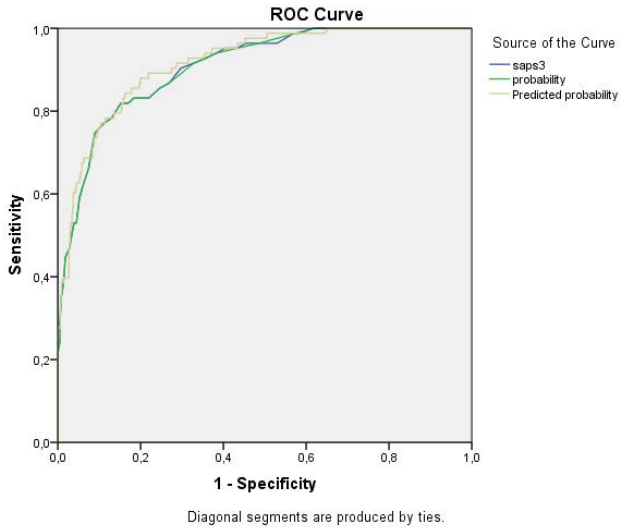


**Figure 1**. Receiver operating characteristic (ROC) curves of SAPS 3, probability of death and predicted probability with mortality dependent factor.

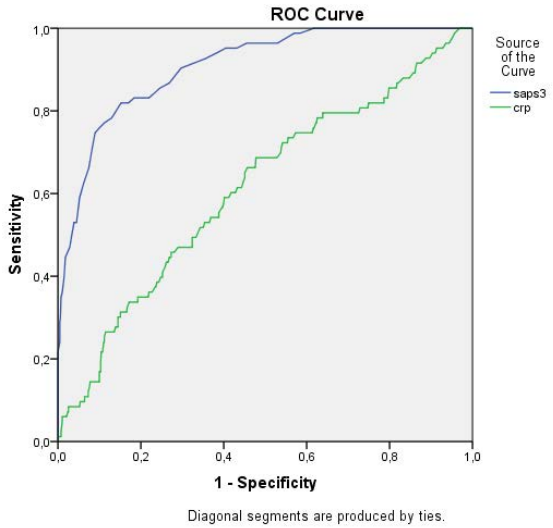


**Figure 2**. Receiver operating characteristic (ROC) curves of SAPS 3 and CRP.

**Table 2**. Area under the curve levels with SAPS 3, probability of death and predicted probability by SPSS

| Test Result Variable(s) | Area | Std. Error | Asymptomatic 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| SAPS-3 scores | 0.908 | 0.016 | 0.876 | 0.940 |
| Probability of death by SAPS 3 | 0.908 | 0.016 | 0.876 | 0.940 |
| Predicted probability by SPSS program | 0.916 | 0.015 | 0.887 | 0.946 |

CRP = C-reactive protein, SAPS 3 = Simplified Acute Physiology Score 3, ICU = intensive care unit

score, length of stay in the ICU and CRP levels significantly as a statistical manner (Asymp. Sig. (2-tailed) < 0.01). The discriminative power, assessed using the AUC, was high enough with SAPS-3 scores and the probability of death estimation (AUC 0.908) while predicted probability obtained by SPSS program was higher (AUC 0.916). (Figure 1 and Table 2) Although we decided not to take CRP levels as a prognostic index due to the factors mentioned above, to test the accuracy of our decision we compare discriminative power of SAPS-3 and CRP by using AUC. As expected, AUC level found < 0, 75 for CRP. (Figure 2 and Table 3) The Hosmer–Lemeshow goodness-of-fit test revealed a good calibration for the SAPS 3 global model as shown in Table 4 and Table 5 with sig. level 0.817 and overall percentage 92.

**Table 3.** Area under the curve levels with SAPS 3 and CRP

| Area Under the Curve | |
|---|---|
| Test Result Variable(s) | Area |
| SAPS 3 | 0.908 |
| CRP | 0.613 |

CRP = C-reactive protein, SAPS 3 = Simplified Acute Physiology Score 3

**Table 4.** Hosmer and Lemeshow Test for SAPS 3

| Step | Chi-square | df | Sig. |
|---|---|---|---|
| 1 | 4,426 | 8 | ,817 |

**Table 5.** Overall correct percentage value with SAPS 3

| Classification Table[a] | | | | | |
|---|---|---|---|---|---|
| Observed | | | Predicted | | |
| | | | Mortality | | Percentage Corrected |
| | | | 0 | 1 | |
| **Step 1** | Mortality | 0 | 660 | 10 | 98.5 |
| | | 1 | 50 | 33 | 39.8 |
| | Overall Percentage | | | | 92.0 |

[a]The cut value is 0.500

## DISCUSSION

The aim of describing and quantifying the severity of the conditions of selected groups of critically ill patients necessitates prognostic scoring system development and these systems allow for the relatively objective assessments of the workloads required by intensive care units and comparison of the effectiveness of the care between these facilities. There are so many studies in the literature about scoring systems and the results are conflicting [12]. It is indispensable to contemplate that surgical patients have different physiological and functional characteristics than other patients, which may influence prognosis. The SAPS 3 system is one of the main scoring systems which has a convenient calibration and discriminative performance in general population admitted to an ICU [13]. It is demonstrated that SAPS 3 usage is valid for surgical patients as well with good discrimination and calibration power. Unlike the other scoring systems the SAPS 3 model prediction based on data within the first hours and it includes variables specific to the surgical procedures. SAPS 3' simplicity and requirement of non-sophisticated data makes it distinct from other prognostic scores [14]. Besides that, values above 24 hours often represent the standard of care more than the actual clinical state of the patient so it can be concluded that SAPS 3 is superior to other scoring systems like the SOFA or APACHE scores which fall to show actual clinical state. It has been known that CRP levels used to assist in management in conjunction with clinical findings and other investigations and many studies have shown that serum CRP levels correspond to the severity of the illness [15]. The present study aimed to assess SAPS 3 as a third generation scoring system and CRP levels with standard care of surgical patients and uses regression curve analysis. The discriminative power of SAPS 3 was very good, close to the one published in the original publication, and the calibration was appropriate. Moreover, this model showed the relation of SAPS 3 scores and CRP levels with mortality and length of stay in the ICU. So the SAPS 3 score system may be revised by using CRP levels with a good calibration and a perfect cut off value obtained from prospective studies.

### Limitations

There are some limitations in this study that should be taken account like being a retrospective study. Relatively small sample size is limiting the power of the analysis of goodness-of-fit Hosmer and Lemeshow test which is poor to assess. Another potential limitation is being a single-center study with a different patients' case mix as compared to the original SAPS 3 hospital outcome cohort. So it can be questionable either these results may be generalized to other ICUs or not.

## CONCLUSION

Finally, one could criticize the data collector reliability in the present study. Even though this is an important topic, we are quite reliant that, in this study, bias related to inadequate data collection was limited, since collection was done by the ICU doctors. In conclusion, in the present study, we found that the SAPS 3 admission score has a good discriminative

power and calibration while CRP levels are related to SAPS 3 score and mortality and not related to the length of stay.

*Conflict of interest*

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

*Financing*

The authors disclosed that they did not receive any grant during conduction or writing of this study.

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