

# Prognostic Scores in a Gastroenterology Intensive Care Unit

P. Freire, J. M. Romãozinho, P. Amaro, M. Ferreira and C. Sofia

*Department of Gastroenterology, Coimbra University Hospital. Coimbra, Portugal*

## ABSTRACT

**Background:** several prognostic systems have been developed and validated in general Intensive Care Units (ICUs). No assessment of these scores was performed in specialized Gastroenterology Intensive Care Units (GICUs).

**Aim:** to assess the prognostic accuracy of Acute Physiology and Chronic Health Evaluation (APACHE) II, Simplified Acute Physiology Score (SAPS) II and Sequential Organ Failure Assessment (SOFA) scores systems to predict mortality in a GICU.

**Methods:** retrospective study of 300 consecutively admissions in a GICU. Demographics, indication for admission, APACHE II, SAPS II and SOFA scores and survival at GICU discharge were recorded. Discrimination was evaluated using receiver operations characteristic (ROC) curves and area under a ROC curve (AUC). Calibration was estimated using the Hosmer-Lemeshow goodness-of-fit test.

**Results:** overall GICU mortality was 5.3%. APACHE II, SAPS II and SOFA mean scores of nonsurvivors (21.9, 46.2 and 9.3, respectively) were found to be significantly higher than those of survivors (11.9, 26.7 and 2.2, respectively) ( $p < 0.001$ ). Discrimination was excellent for all the prognostic systems, with AUC = 0.900, 0.903 and 0.965 for APACHE II, SAPS II and SOFA, respectively. Similarly, APACHE II, SAPS II and SOFA scores achieved good calibration, with  $p = 0.671$ ,  $0.928$  and  $0.775$ , respectively. Among the three scores, SOFA showed the best performance, with overall correctness of prediction of 94.0%, while it was 86.2% for APACHE II and 82.7% for SAPS II.

**Conclusions:** in GICU, APACHE II, SAPS II and SOFA scores have excellent prognostic accuracy and, among the three scores, SOFA has the greatest overall correctness of prediction.

**Key words:** Gastroenterology Intensive Care Unit, APACHE II, SAPS II, SOFA, prognostic scores.

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## INTRODUCTION

Several predictive scoring systems have been developed and validated in general Intensive Care Unit (ICU) populations to evaluate the severity of illness and prognosis (1-6). However, to our knowledge, no reports are available on validation of these prognostic models in specialized Gastroenterology Intensive Care Units (GICUs).

Prognostic models can also be used for comparison and quality assessment between different ICUs and within the same ICU over time (7,8), for audit and clinical research (9), as well for evaluating therapeutic effectiveness and guiding communication between clinicians and families (10-12).

There are two main categories of general prognostic models)first, those evaluating the severity of illness, namely Acute Physiology and Chronic Health Evaluation (APACHE) II (13) and Simplified Acute Physiology Score (SAPS) II (14); secondly, models quantifying organ dysfunction and failure, of which the most used is the Sequential Organ Failure Assessment (SOFA) (6,15). Most prognostic models evaluate survival on discharge from ICU, using data collected within the first 24h in ICU (1-4,16,17).

The aim of this study was to assess the prognostic accuracy of APACHE II, SAPS II and SOFA scores systems in predicting mortality of patients admitted to a GICU.

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*Correspondencia:* Paulo André Vinagreiro Freire. Department of Gastroenterology, Coimbra University Hospital. Av. Bissaya Barreto - Praceta Prof. Mota Pinto- 3000-075 Coimbra, Portugal. e-mail: pauloavfreire@gmail.com

## METHODS

### Patients

This is a retrospective study of 300 consecutively admissions (288 patients) in a 4-bed specialized GICU at a 1200-bed university hospital in Portugal, between February 2005 and October 2006. In this unit patients with hepatic and/or gastrointestinal severe medical diseases are admitted. Surgical patients, including post-transplant, are not admitted in this GICU, since there are specific units in our hospital for these patients. Hospitalizations with GICU stay < 24 hours were excluded from the study. For the purposes of this study, each admission was considered a separate patient.

Data collected included demographics, indication for admission, APACHE II, SAPS II and SOFA scores and survival at GICU discharge. The scores were computed for each patient using data collected within the first 24h in GICU, selecting, for each variable, the worst (most abnormal) value during this period.

The main study outcome was GICU mortality.

### Ethical approval

Ethical approval for this research was given by the local Ethics Committee.

### Statistical Analysis

Categorical variables were expressed as frequency and percentage, and the corresponding contingency tables were analyzed with Pearson's chi-square test or Fisher's exact test, as appropriate. Odds ratios (OR) were determined with 95% confidence intervals (95% CI).

Continuous variables were summarized using means and standard deviation (and range). These variables were tested for normal distributions using Kolmogorov-Smirnov test. Student's t test was employed to compare the means of continuous variables and normally distributed data; otherwise, the Mann-Whitney U test was employed. A p value less than 0.05 was considered statistically significant.

The model performance is usually evaluated statistically by measuring calibration and discriminative ability (1,18).

Calibration (i.e., the degree of correspondence between predicted and observed mortality over the entire range of risks) was described by the goodness-of-fit testing using the Hosmer-Lemeshow test. As usually, a p value > 0.2 was considered good (19).

Discrimination (i.e., the model's ability to differentiate between patients who died and those who survived) was examined with receiver operation characteristic (ROC) curves, using area under the curve (AUC), which is a plot

of true positive rate (sensitivity) vs false positive rate (1-specificity) (19). The AUC ranges from 0 to 1, with 0.5 corresponding to what is expected by chance alone and 1.0 to perfect discrimination. In general, an AUC > 0.7 indicates a useful test (20). AUC between 0.7 and 0.8 were classified as "acceptable" and > 0.8 as "excellent" discrimination (21).

Finally, cut-off points were calculated by obtaining the best Youden index (sensitivity + specificity - 1) (22). Positive predictive value, negative predictive value, sensitivity, specificity, overall correctness of prediction and odds ratio for GICU mortality were then calculated using the obtained cut-off values.

The data was analyzed with the Statistical Package for Social Sciences-SPSS (SPSS Inc., Chicago, Illinois, USA) computer software for Windows (version 17.0).

## RESULTS

A total of 288 patients represented 300 cases (admissions). Of the 300 cases, 199 were male (66%) and 101 were female (34%). The mean age was  $63.9 \pm 17.6$  (range 17-97 years) and all patients were white. This sample included 124 (41.3%) admissions of patients with history of liver cirrhosis, mostly (80.6%, n = 100) alcoholic liver cirrhosis.

Upper gastrointestinal bleeding (68%, n = 204) was the most common reason for GICU admission, including 123 (41.0%) patients with bleeding peptic ulcers and 81 (27.0%) with variceal bleeding. The 123 patients admitted with bleeding peptic ulcers included 74 (60.2%) duodenal ulcers, 46 (37.4%) gastric ulcers and 3 (2.4%) anastomotic ulcers. The endoscopic stigmata of these ulcers were as following: 7 (5.7%) - Forrest Ia; 32 (26.0%) - Forrest Ib; 49 (39.9%) - Forrest IIa; 26 (21.1%) - Forrest IIb; 6 (4.9%) - Forrest IIc; 3 (2.4%) - Forrest III. Of the 81 patients admitted with variceal bleeding, 69 patients had esophageal variceal bleeding and 12 gastric variceal bleeding. The primary treatment for esophageal variceal bleeding was elastic band ligation, sclerosis (with absolute alcohol) and Sengstaken Blackmore balloon tamponade in 30 (43.5%), 21 (30.4%) and 18 (26.1%) patients, respectively. In the 12 patients admitted with gastric variceal bleeding the primary treatment was Histoacryl® + Lipiodol in 11 (91.7%) patients and Sengstaken Blackmore balloon tamponade in 1 (8.3%) patient. Table I lists the reasons for GICU admission.

Acute renal failure or acute-on-chronic renal failure was found in 62 (20.7%) patients, requiring dialysis in 11 patients (3.7%). Twenty-three patients (7.7%) required endotracheal intubation, including 15 (5.0%) with mechanical ventilation.

Mean  $\pm$  standard deviation (and range) of APACHE II, SAPS II and SOFA scores were  $12.4 \pm 6.7$  (0-44),  $27.8 \pm 11.2$  (6-72) and  $2.6 \pm 2.9$  (0-16), respectively. The GICU

**Table I. Indication for GICU Admission**

Primary GICU admission cause	n (%)
Bleeding peptic ulcer	123 (41.0)
Variceal bleeding	81 (27.0)
Acute pancreatitis	21 (7.0)
Lower gastrointestinal bleeding	15 (5.0)
Hepatic encephalopathy	9 (3.0)
Acute hepatic failure	8 (2.7)
Cholangitis	6 (2.0)
Miscellaneous/other causes	37 (12.3)

GICU, Gastroenterology Intensive Care Unit.

**Table II. Average Values of APACHE II, SAPS II and SOFA Scores According to Survival**

Scoring system	Survivors	Nonsurvivors	p value
APACHE II	11.9 ± 6.3	21.9 ± 5.4	<0.001
SAPS II	26.7 ± 10.1	46.2 ± 12.6	<0.001
SOFA	2.2 ± 2.3	9.3 ± 3.0	<0.001

APACHE, Acute Physiology and Chronic Health Evaluation; SAPS, Simplified Acute Physiology Score; SOFA, Sequential Organ Failure Assessment.

mortality rate was 5.3% (n = 16). Mean APACHE II, SAPS II and SOFA scores were significantly higher in nonsurvivors (Table II).

ROC curves and corresponding AUC are illustrated in Figure 1. The results of Hosmer-Lemeshow goodness-of-fit tests ( $\chi^2$ ), the best Youden index and the resultant cut-off point are shown in table III. The three scores had AUC > 0.90, i.e., they have a good discriminative ability. Additionally, the test of model fit confirmed, for all the scores, that predicted mortality was similar to observed mortality

**Table III. Calibration, Youden Index and Cut-off Values of the Scoring Systems**

Scoring system	Calibration goodness-of-fit ( $\chi^2$ )	Youden index	Cut-off point
APACHE II	0.671	0.78	16
SAPS II	0.928	0.78	34
SOFA	0.775	0.88	5

APACHE, Acute Physiology and Chronic Health Evaluation; SAPS, Simplified Acute Physiology Score; SOFA, Sequential Organ Failure Assessment.

(good calibration).

To assess the prognostic value of the obtained cut-off points for predicting GICU mortality, the positive predictive value, negative predictive value, sensitivity, specificity and overall correctness of prediction were determined (Table IV). GICU mortality rates above and below the cut-off points and the corresponding odds ratio for GICU mortality were detailed in table V.

## DISCUSSION

Accurate prognostic indicators for patient survival in ICUs aid clinical decision, assist communication with families of patients and allow comparison between units (7,12,21).

The APACHE II, SAPS II and SOFA are ICU-specific prognostic scores widely used. Several past studies analyze the predictive abilities of these prognostic sys-

**Table IV. Prediction of GICU Mortality**

Scoring system	PPV (%)	NPV (%)	Sensitivity (%)	Specificity (%)	Overall correctness of prediction (%)
APACHE II	19.7	99.6	93.8	78.5	86.2
SAPS II	18.2	99.1	87.5	77.8	82.7
SOFA	32.0	100	100	88.0	94.0

GICU, Gastroenterology Intensive Care Unit; APACHE, Acute Physiology and Chronic Health Evaluation; SAPS, Simplified Acute Physiology Score; SOFA, Sequential Organ Failure Assessment; PPV, Positive Predictive Value; NPV, Negative Predictive Value.

**Table V. Cut-off Points, Mortality Rate and Odds Ratio for GICU Mortality**

Scoring system	Mortality rate (%)	p value	Odds ratio for GICU mortality (95% CI)
APACHE II			
≥ 16	19.7	<0.001	54.84 (7.10 – 423.39)
< 16	0.4		
SAPS II			
≥ 34	18.2	<0.001	24.56 (5.44–110.91)
< 34	0.9		
SOFA			
≥ 5	32.0	<0.001	Infinite
< 5	0		

GICU, Gastroenterology Intensive Care Unit; APACHE, Acute Physiology and Chronic Health Evaluation; SAPS, Simplified Acute Physiology Score; SOFA, Sequential Organ Failure Assessment; CI, Confidence Interval.

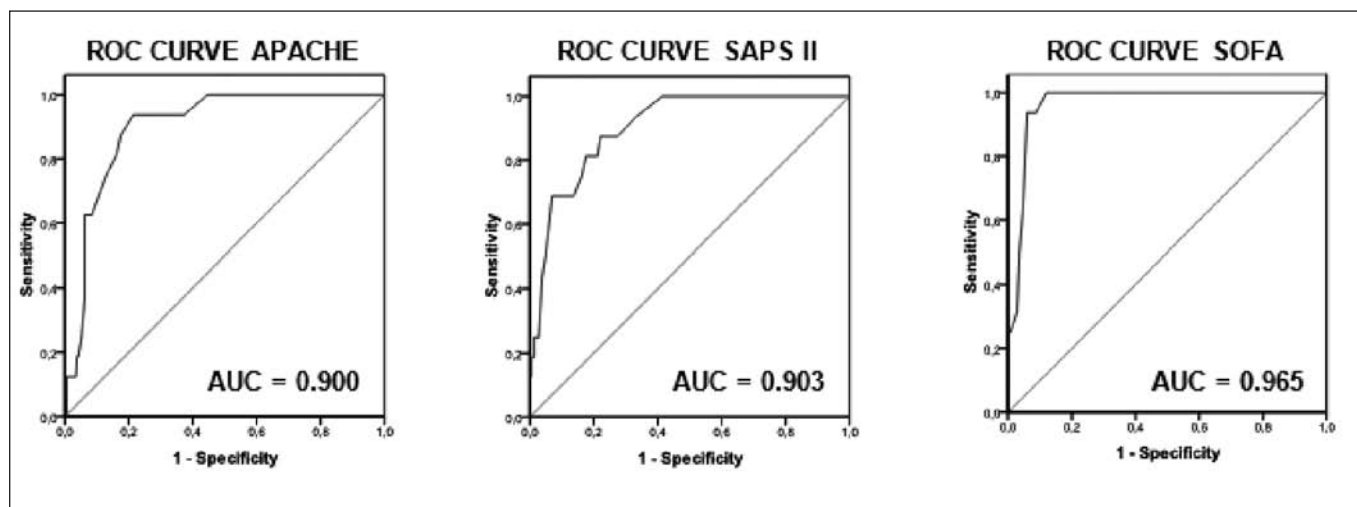


Fig. 1. Receiver operation characteristic (ROC) curves and corresponding area under the curve (AUC) for Acute Physiology and Chronic Health Evaluation (APACHE) II, Simplified Acute Physiology Score (SAPS) II and Sequential Organ Failure Assessment (SOFA) in 300 consecutive admissions to a Gastroenterology Intensive Care Unit.

tems in ICU populations and sub-populations (1-4,17,23-25). However, to our knowledge, no assessment of these scores was developed in specialized GICU.

APACHE II, a measure of severity of disease (13), has previously been used to risk stratify patients with upper gastrointestinal bleeding (26,27), acute pancreatitis (28-31) and abdominal sepsis (32). Thus, it is expected that APACHE II and, by extrapolation, probably the other scores, may have prognostic ability in GICU.

Our study assessed, to our knowledge for the first time, the accuracy of prognostic scores in patients admitted to a GICU. In our series, discrimination and calibration was excellent for all the scores (Fig. 1 and Table III). This means that the scores have very good ability to classify patients correctly as survivors or nonsurvivors and that model predicted mortality was similar to observed mortality. The high sensitivity, specificity, overall correctness of prediction and negative predictive value confirm the excellent right classification rates of the tested scoring systems in GICU (Table IV). The low positive predictive values are an unsurprising and somewhat inevitable consequence of the low mortality rate (Table IV). Nevertheless, these relatively low positive predictive values are strong enough to justify a significantly higher mortality in patients with score values above the cut-off points (Table V).

Among the three scores, SOFA showed the best performance, with overall correctness of prediction 7.8% and 11.3% greater than that of APACHE II and SAPS II scores, respectively (Table IV). Although the SOFA was not developed to predict outcome but to describe the degree of organ dysfunction in critically ill patients, several studies showed its predictive ability in patients admitted to ICUs (16,33-36). Additionally, the variables needed to record the SOFA are derived from standard monitoring of

critically ill patients and calculation at the bedside takes only 3 minutes (36). These elements are important because for any predictive model to be clinically useful, it must show ease of use, accuracy and reproducibility (37, 38). However, there are some limitations of the SOFA that should be addressed. Diagnosis, age and co-morbid conditions are ignored. Glasgow Coma Scale is the neurological variable assessed, but its clinical evaluation is subjective and it is affected by sedative and analgesic drugs frequently used in critically ill patients. The liver function was evaluated with serum bilirubin although it has limited ability to reflect the full spectrum of liver dysfunction in critical illness and it cannot differentiate acute liver dysfunctions from the effects of pre-existing chronic disease. This may be mostly important in GICU where a significant proportion of patients have liver disease.

Established prognostic models are usually estimated after the first 24 h of ICU admission (1-4,16,17). Thus, current models may not be suitable to decide on the appropriateness of admission to ICU, as clinical status may improve over the first 24h with therapy or deteriorate due to complications (39). Other limitations are that they were not designed to predict prognosis for long stays or after ICU discharge and do not evaluate end-points other than mortality, such as cost-effectiveness, recovery, physical activity or quality of life (19,40-42).

The evaluated scores were calibrated to predict the outcome in the original development samples, that were extracted from general ICUs where the mortality rate is significantly higher than in our unit (13,14,16). In addition, it is well known fact that mortality prediction model performance usually deteriorates when models are applied to different population samples, i.e. less sick patients. Indeed, although APACHE II works well for severely ill cirrhotic patients admitted to ICUs (17,43-47),



this is not the case when its predictive value is assessed in a population of cirrhotic patients with mortality rate of only 11.5% (48). Thus, our results are somewhat surprising, because the mortality rate in our sample was only 5.3% and nevertheless the scores showed an excellent performance.

Potential limitations of our study should be mentioned. Firstly, it is a retrospective study. Secondly, this work was performed in an academic referral hospital; therefore our results may not be applicable to institutions with different populations. Finally, patients with GICU stay < 24 hours were excluded, resulting in a mortality rate of only 5.3%. It could be stated that the rational of excluding these patients weakens our study, because the most likely is that these patients have died. However, this problem is shared by all the other works in this area, as the tested scores, by definition, must be calculated with the worst value for each variable obtained during the first 24h of admission.

Despite the excellent performance of the tested scores in our study, its structure has some limitations in the prognostic assessment of patients admitted in a GICU. Indeed, prothrombin time and blood units transfused are not measured by the scores, and they are presumably important prognostic variables in a population with high incidence of cirrhosis and in which the principal reason for admission was upper gastrointestinal bleeding. Therefore, in the future, it would be interesting to develop studies to identify independent risk factors in patients admitted to a GICU and, based on them, develop a specific score for this context.

Objective prognostic estimates can be useful as an important tool in the decision making process. However, probability models can never predict whether a patient will live or die with 100% accuracy (49-51). Thus, these probabilities should be used to complement and enhance, not as a substitute for clinical judgment.

In conclusion, our data showed that APACHEII, SAPS II and SOFA scores have excellent discrimination and calibration in GICU and, therefore, are clinically useful in this context. Furthermore, our results indicate that among the three scores, SOFA has the greatest overall correctness of prediction. Nevertheless, a validation of our results is required in others GICU, preferably prospectively. Prognostic scoring systems cannot replace the clinical evaluation of the patients. However, we believe that these scores may improve the physician's estimate of prognosis and, hence, be useful in clinical decision making.

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