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Original Article

Comparing the APACHE II, SOFA, LOD, and SAPS II scores in patients who have developed a nosocomial infection

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Background:*There have been numerous scores intended to evaluate the severity of patients' condition upon admission and during their intensive care unit (ICU) stay. However, to our knowledge, no study has ever evaluated the predictive abilities of these scores among nosocomial patients during their ICU stay. The aim of our study is to compare the predictive performances of the Acute Physiology, and, Chronic Health Evaluation (APACHE II) score, Simplified Acute Physiologic Score (SAPS II), Logistic Organ Dysfunction (LOD), and Sequential Organ Failure Assessment (SOFA) scores among intensive care patients who have developed a nosocomial infection.*

Methods: *The study is monocentric and retrospective. The APACHE II, SAPS II, LOD, and SOFA scores were reported from the third day of the patient's hospital stay, preceding the diagnosis of the first nosocomial event up to the third post diagnosis day.*

Results: *Out of 46 patients contracting at least one ICU-acquired infection, the multiple analyses indicated that on the day of diagnosis, the SOFA score is the most predictive (odds ratio [OR]: 12.3; 95% confidence interval [CI]: 2.33–64.91). The second most predictive was the APACHE II score (OR: 8.29; 95% CI: 1.43–48.14). The third and fourth most predictive were the LOD score (OR: 4.06; 95% CI: 0.81–20.26) and the SAPS II score (OR: 2.26; 95% CI: 0.55–9.24), respectively.*

Conclusion: *The analysis of the receiver operating characteristic areas under the curve of the reported scores in the present study showed that the best predictive performance is in favor of the SOFA score.*

Keywords: *intensive care, risk factors, nosocomial infections, ICU mortality, severity scores*

Introduction

Whatever their specialty (surgical, medical, or both), intensive care units (ICUs) have to take care of patients with life-threatening conditions as a result of one or even several organ failures. These departments register the highest mortality rates[1] and the highest amounts of nosocomial infections.[2]According to several studies,[3,4] this high rate of nosocomial infections is matched with an increase in therapeutic activity and high severity scores. Indeed, these high severity scores give an evaluation of the seriousness of each case due to comorbidities and due to severe illness; they are also a good indication of the patient's response to therapy.[5-9] The use of these measures during admission or during the ICU stay is a common practice; these measures are also frequently used in most of the reviews that have studied nosocomial risk.[10,11]

Among the severity scores most frequently used among patients in intensive care, we must point out the following points. First, the Acute Physiology, And, Chronic Health Evaluation (APACHE II) score's calculation is only based on 12 physiological variables associated with the patient's age, and it pertains to a certain number of comorbidities. Calculated on the most pejorative values during the first 24 hours in intensive care, these 12 physiological variables, taken apart, constitute the Acute Physiologic Score (APS).Use of the APACHE II score is still a bit difficult and quite empirical; however, its prognostic capacity during the first 24 hours of stay in intensive care is evident.[12]Second, the Simplified Acute Physiologic Score (SAPS II) is a simplified system that evaluates severity. It is based on a critical overview of the first APACHE system.[13] Third, the Logistic Organ Dysfunction (LOD) score was developed by Le Gall et al,[13]using the same database that was used to develop the framework of the SAPS II score. Finally, the SOFA score is different from the others because of its sequential capacity in evaluating the incidence and the severity of the organ dysfunction.[14-16] However, it can be noted that these four scores have numerous similarities, as they evaluate the same organs.[17-20]

There is a huge range of scores when evaluating the severity of patients during admission or during their stay in intensive care. However, as far as we know, no study has ever compared the predictive performance of these scores among a population of nosocomial patients and during their stay in intensive care. The aim of this study is to evaluate the performance of the APACHE II, LOD, SOFA, and SAPS II scores for their prediction of mortality in nosocomial patients during the patients' stay in intensive care.

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Materials and methods

This study is monocentric and retrospective in nature. It took place at Timone University Hospital's ICU, which is one of the most important hospitals in Southeast France. Equipped with 1,069 beds (793 for adults and 276 for children), it is Europe's third-largest hospital.The ICU contains nine beds. Admissions are processed directly by the emergency unit or by the Mobile Emergency Unit. Patients can be transferred from other hospitals either by internal admissions or through the specific request of another service. The approval of the ethics committees was unnecessary when conducting this study; all information related to the identity of the patients will remain confidential.

Out of a total of 565 patients hospitalized from January 1, 2011 to June 30, 2012, 291 patients, aged ≥16 years and staying in the ICU for at least 3 days were included in the study. Among the 291 selected patients, 41 were not included due to missing data. Amongst the 250 remaining patients, 46 developed at least one nosocomial episode. Infected cases were determined based on bacteriological samples. It was decided that the day of collection would be designated as the first day of infection, and we only took into account the first nosocomial episode. The collection of data was performed according to a standard format. We systematically recorded each patient's age, sex, dates of ICU admission and discharge, number of days spent at the ICU before the start of the first nosocomial infection, total number of days spent in hospital, clinical settings (comorbities, reasonsfor hospitalization), origins of the patient, type of pathology, type of infection, and pathogenic causal agents. We reported every invasive procedure (intubation, tracheotomy, urinary catheter, central catheter, or sedation), and the duration of the use of antibiotics before and after the nosocomial incident occurred. The LOD score, the SAPS II score, and the SOFA score were calculated in advance, 3 days before the day of the infection diagnosis and 3 days afterwards.

Statistical analysis

To identify which of the four scores best predicts a fatal issue among our study group, we calculated the odds ratios (OR) and 95% confidence intervals (95% CI) for variables associated with mortality. All of the significant risk factors studied during the univariate analysis with *P*-value <0.20 were introduced in the four univariate logistic regression models.

For each measure, APACHE II, LOD, SOFA, and SAPS II scores were calculated on days D–3, D–2, D–1, D+1, D+2, D+3;in addition, the specificity, sensitivity, the global predictive accuracy, the positive predictive value (PPV), and the negative predictive value (NPV) were determined. The cut-off point for mortality prediction during the ICU stay was determined for each score once the Youden index (sensitivity + specificity–1) was maximal (under the constraint that specificity does not equal one, and that the sensitivity is not zero, to avoid over fitting). It should be noted that the Youden index evaluates the efficacy of the performance of a test diagnosis. It is lowered to 0 for a very weak performance and is close to 1 for a high performance. A calculation of the area within the receiver operating characteristics (ROC) curve was performed 3 days before the day of diagnosis of the nosocomial infection, and up to the third day after the date of the diagnosis (D–3, D–2, D–1, D0, D+1, D+2, and D+3). All analyses were performed using R statistical software (Wirtschafts University, Vienna, Austria), and a 5% statistical significance level was chosen.

Results

The data from our study were based on a total of 46 patients, aged 18 years and over, with a minimum stay in the ICU of 3 days, from July 1, 2011 to June 30, 2012.It can be noted that, among the top-ranking community-acquired infections in intensive care, the number one infection is pneumonia, which is contracted under mechanical ventilation at a rate of 47.82%, and this is followed by lung infections (21.73%). Bacteriemias and urinary infections rate 17.39% and 10.87%, respectively. All of the infected patients (100%) were given antibiotics. The overall morbidity rate was 23.91%. The demographic and clinical data are reported in Table 1 and Table 2.The objective values of the SAPSS II, APACHE II, SOFA, and LOD scores measured on days D–3, D–2, D–1, D+1, D+2, D+3, and D0 (which is the day of nosocomial infection diagnosis) are reported in Tables 3, 4, 5, and 6.

Table 1:
Description of the exogenous quantitative variables

	N	Minimum	Average	Std Deviation	Median	Maximum
Age	46	18	56.09	14.73	56.00	84
LOS	46	3	19.11	12.40	17.00	69
D.ICU-AI	46	3	6.63	4.30	6.00	27
MV	46	0	15.00	11.28	12.00	63

Abbreviations:D.ICU-AI, diagnosis day of intensive care unit acquired infection; LOS, length of stay; MV: mechanical ventilation.

Table 2:
Description of the exogenous qualitative variables

	Modalities	Percentage (in%)
Gender	Female	37.0
	Male	63.0
Death	No	76.1
	yes	23.9
Origins	Other	67.4
	Medical	32.6
Med/Chir	Medical	87.0
	Chirurgical	13.0

Table 3:
Description of the SAPS II score

	N	Minimum	Average	Std Deviation	Median	Maximum
SAPSII D-3	34	26	44.24	11.57	42.00	69
SAPSII D-2	46	21	43.67	13.13	42.00	73
SAPSII D-1	46	22	44.15	11.51	44.00	70
SAPSII D0	46	22	44.46	12.51	44.00	73
SAPSII D+1	43	22	43.44	11.81	42.00	73
SAPSII D+2	43	22	40.91	12.57	38.00	73
SAPSII D+3	40	16	39.10	11.84	38.00	73

Table 4:
Description of the LOD score

	N	Minimum	Average	Deviation	Median	Maximum
Lods D-3	34	2	5.56	2.44	6.00	11
Lods D-2	46	2	5.54	2.56	5.00	11
Lods D-1	46	1	5.72	2.46	5.50	11
Lods D0	46	2	6.13	2.22	6.00	12
Lods D+1	42	2	5.62	2.39	5.50	12
Lods D+2	42	2	5.43	2.38	5.00	11
Lods D+3	40	2	5.18	2.41	5.00	11

Table 5:
Description of the APACHE II score

	N	Minimum	Average	Deviation	Median	Maximum
APACHEII D-3	35	11	22.09	8.00	22.00	50
APACHEII D-2	46	1	22.07	8.77	21.50	49
APACHEII D-1	46	4	22.50	8.56	22.00	47
APACHEII D0	46	4	23.35	9.01	23.00	45
APACHEII D+1	42	3	23.45	9.45	23.50	50
APACHEII D+2	41	3	23.29	10.31	21.00	56
APACHEII D+3	39	3	23.03	9.71	21.00	48

Table 6:
Description of the SOFA score

	N	Minimum	Average	Deviation	Median	Maximum
SOFA D-3	34	4	6.50	2.12	6.00	11
SOFA D-2	46	3	6.50	2.14	6.00	11
SOFA D-1	46	2	6.96	2.21	6.00	12
SOFA D0	46	2	7.17	2.35	6.00	13
SOFA D+1	43	2	6.74	2.34	6.00	12
SOFA D+2	41	2	6.51	2.24	6.00	12
SOFA D+3	39	3	8.28	9.06	5.00	48

The results of the calculation of the area under the ROC curve for the APACHE II, SAPS II, SOFA and LOD scores – which were calculated from the third day before the diagnosis of the nosocomial event, and up to the third post diagnostic day – are described in Table 7 and Figure 1.

Table 7:
Confidence interval (95%) for the AUC ROC

Score	Day	Lower bound 95%	AUC	upper bound 95 %
	-3	0.321	0.536	0.750
	-2	0.257	0.458	0.660
	-1	0.313	0.509	0.705
SAPS II	0	0.361	0.560	0.758
	1	0.384	0.577	0.770
	2	0.449	0.634	0.818
	3	0.354	0.563	0.771
	-3	0.329	0.558	0.786
	-2	0.383	0.596	0.809
	-1	0.356	0.575	0.794
LODS	0	0.399	0.603	0.807
	1	0.491	0.674	0.858
	2	0.452	0.635	0.818
	3	0.386	0.586	0.786
	-3	0.419	0.632	0.846
	-2	0.443	0.630	0.817
	-1	0.489	0.674	0.859
APACHE II	0	0.489	0.679	0.869
	1	0.527	0.704	0.881
	2	0.546	0.726	0.906
	3	0.526	0.711	0.896
	-3	0.489	0.713	0.938
	-2	0.542	0.729	0.915
	-1	0.519	0.719	0.920
SOFA	0	0.613	0.766	0.919
	1	0.519	0.714	0.910
	2	0.455	0.661	0.866
	3	0.519	0.718	0.916

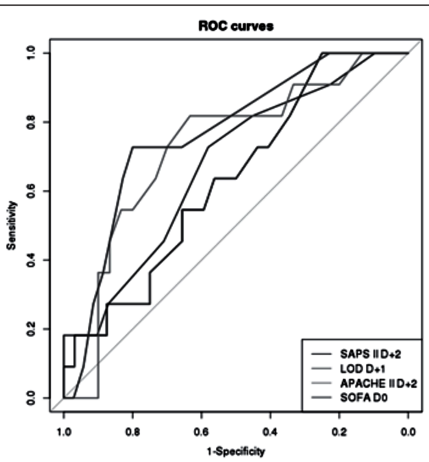

Figure 1: ROC curve for APACHE II, SOFA, and SAPSII scores

The multiple logistic regression analysis, which controlled for the predictive factors of a fatal issue (death), shows that the SOFA score on the day of diagnosis is the most predictive of mortality (OR: 12.3; 95% CI: 2.33–64.91), followed by the APACHE II score (OR: 8.29; 95% CI: 1.43–48.14). The next most predictive are the LOD score and the SAPAS II score, respectively (LOD OR: 4.06; 95% CI: 0.81–20.26; SAPS II OR: 2.26; 95% CI: 0.55–9.24).It was evident that the area under the ROC curve is higher for the SOFA score on the day of diagnosis. The area under the ROC curve was highest for the LODS score on the day after the diagnosis was made, and it was highest 2 days after the diagnosis was made for the SAPS II and APACHE II scores. Conversely, the results of the analysis show that the best value of the Youden index (0.527), the best specificity (80%), the best global prediction rate (78.3%), as well as the best negative and positive predictions (53.3% and 90.3%, respectively) were established by the SOFA score on the day of diagnosis. The APACHE II score yields the highest sensitivity (Table 8).

Table 8: Death prediction on the very best day as far as discriminating power is concerned.

Score	Daily scores with the best discriminating power	cut off point	Youden index	Sensitivity (in %)	Specificity (in %)	global prediction	positive prediction (in %)	negative prediction (in %)
SAPS II	+2	42.5	0.201	54.5	65.6	62.8	35.3	80.8
LODS	+1	5.5	0.308	72.7	58.1	61.9	38.1	85.7
APACHE II	+2	22	0.451	81.8	63.3	68.3	45	90.5
SOFA	0	7.5	0.527	72.7	80	78.3	53.3	90.3

The multiple logistic regression analysis, which controlled for the predictive factors of a fatal issue (death), shows that the SOFA score on the day of diagnosis is the most predictive of mortality (OR: 12.3; 95% CI: 2.33–64.91), followed by the APACHE II score (OR: 8.29; 95% CI: 1.43–48.14). The next most predictive are the LOD score and the SAPAS II score, respectively (LOD OR: 4.06; 95% CI: 0.81–20.26; SAPS II OR: 2.26; 95% CI: 0.55–9.24).

Discussion

Nosocomial infections in intensive care remain a major public health problem, and there are some fatal cases. To limit this problem, one needs to share resources and engage in multi-level actions (upstream and downstream) to continually assess the severity of the disease. Indeed, evaluating a complex clinical and physiological state such as multi-trauma and/or multi-deficient patients in intensive care in a nosocomial context, and with simplified evaluation tools, may help with developing a more proactive response and more suitable therapeutic actions.

The aim of the present study was to compare the predictive performances of four scores (SAPS II, SOFA, APACHE II, and LOD) when assessing the level of gravity in nosocomial patients during their ICU stay from the third day preceding the diagnosis of a nosocomial event to the third day after the diagnosis. However, it is important to remember that the aim and the calculation techniques used for the aforementioned scores are slightly different. Indeed, the SOFA score is used to describe the level of morbidity, whereas the LOD score was designed to be a tool that evaluates the mortality probability due to malfunctioning organ(s) on the day of admission.[13]

To our knowledge, no study has ever compared the capacity of the SAPS II, SOFA, APACHE II, and LOD scores to predict mortality in nosocomial patients that are infected during their stay in intensive care. It is thus difficult to compare our results to another study. However, Peres Bota et al's[21] results comparing SOFA scores to the Multiple Organ Dysfunction Score (MODS), which was calculated every 2 days using patients in intensive care who were not specifically nosocomial, showed that the SOFA score has very good discriminatory ability to determine a patient's outcomes. The authors indicated that the SOFA score truly sets itself apart from the other scores in terms of its better sensitivity. The results of Khwannimit's[22] study– which was conducted on a population comparable to that noted in Peres Bota et al's[21] study – reported the excellent discriminatory ability of SOFA and LOD scores with respect to the SOFA score's area under the curve(AUC) (initial: 0.879; maximum: 0.907)when compared to that of the LOD score (initial: 0.88; maximum: 0.92). The authors also indicated that the AUC of the different scores were much higher than the one calculated in Peres Bota et al's[21] study.

Also, even if the outcome considered does not specifically pertain to mortality in the ICU, but rather to the overall hospital's mortality rates, then the results of the following respective studies (Timsit et al[23] and Pettilä et al[24]) describe good predictive performance for both the SOFA score and the LOD score. For instance, in the study by Pettilä et al,[24] the AUC of the initial SOFA and LOD scoreswere as follows: 0.73 and 0.73, respectively. However, it should be noted that the discriminatory ability of the SOFA score tends to be weaker according to the findings from Zygun et al's study.[25]The AUC of the initial value of the SOFA score is 0.67 and the maximum value is 0.69.

According to Khwannimit,[22] the disparity of the results might be due to the different calculation methodologies used for the scores, and it may also be due to different treatment policies adopted in each ICU. On the other hand, Livingston et al's[26] study – which was conducted in 22 different ICUs in Scotland, and which was based on the evaluation of the performance of the APACHE and SAPS scores –reported good to excellent discriminatory capacities of these measures. The AUC of the APACHE and SAPS scores are 0.78 and 0.85, respectively.

The results of other studies[27,28] also reported that the APACHE II score's discrimination capacity is better than the one established by the SOFA score calculated at admission. On the other hand, though the results of additional studies[26,27] objectify that the SAPS score and SOFA score have the same discrimination capacity; however, when it is calculated during admission, Janssens et al[29]reported the opposite result- indeed, the SOFA score's AUC during admission was 0.82 and the SAPS II score's AUC was 0.77.In our study, the multiple analyses, which controlled for other predictive factors associated with a fatal complication (death), revealed that on the very day of diagnosis, the SOFA score was the most predictive (OR: 12.3; 95% CI: 2.33–64.91), followed by the APACHE II score (OR: 8.29; 95% CI: 1.43–48.14).Moreover, the calculation of the ROC AUC of the APACHE II, SAPS II, SOFA, and LOD scores performed on days –3 –2, –1, 0, 1, 2, and 3 of the nosocomial event (Table 9) showed that the highest ROC AUC is the one used for the SOFA score on the day of diagnosis. On the day after diagnosis, the highest AUC are the ones of the LODS and SOFA scores. On the second day after diagnosis, the highest AUC were those associated with the SAPS II and APACHE II scores.

According to these results, it appears that only the SOFA score AUC calculated on days (–3,–2, –1, 0, 1, 2, and 3) count >0.5 values (reference line). The rate lies between (0.66 and –0.76). As the discrimination capacity of a score is considered as excellent with a AUC >0.9 and good with an AUC >0.8, it appears that (according to our study) only the SOFA score is distinct from the other scores in terms of predictive performance, as it was considered to be correct to good. The lack of predictive performance observed in the other scores could mostly be explained by a possible inadequacy of the gravity scores across the population we studied.

Indeed, it was reported[24] that the scores were often applied to a population of patients where most of them (over half) had stayed in the ICU no longer than 3 days; however, the median length of stay in the population we studied was 6 days. According to Timsit et al,[23]the discrimination capacity of these scores' abilities to predict patients' outcomes is affected as the length of stay grows longer; their predictive ability is also affected by the intricacy of the organ dysfunction and by the infectious process itself. Indeed, in the process, several intrinsic variables (underlying disease, age, and sex) are implied, but intervention variables such as antibiotic treatment (which is appropriate in the beginning[13]), the prompt removal of unnecessary lines responsible for the spread of infection,[14] and the optimizing of the hemodynamic condition by the provision of artificial hydratation or vasopressor drugs[15,16] could determine the evolution of the process or alter the scores' predictions.

In this study, several limits should be mentioned, including the retrospective and monocentric nature, as well as the size of our sample.

Conclusion

Among the documented scores in our study, the SOFA score was the only one that stood out as having good predictive performance in terms of the patients' outcomes. The contribution of these types of markers is very useful for a sequential estimation of each patient's state, and it could serve as a tool to assist in the decision of choosing among proposed therapeutic projects. In addition, our study could help other research teams in their approaches.

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Conflicts of interest

There are no conflicts of interest.

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