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The predictive performance of the SAPS II and SAPS 3 scoring systems: A retrospective analysis☆

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ABSTRACT

Purpose: The purpose was to analyze and compare the performance of Simplified Acute Physiology Score (SAPS) II and SAPS 3 (North Europe Logit) in an intensive care unit (ICU) for internal disorders at a German university hospital.

Materials and methods: This retrospective study was conducted at a single-center 12-bed ICU sector for Internal Medicine in Essen, Germany, within an 18-month period. Data for adult ICU patients (N = 548) were evaluated. SAPS II and SAPS 3 scores were assessed along with the predicted mortality rates. Discrimination was evaluated by calculating the area under the receiver operating characteristic curve, and calibration was evaluated using the Hosmer-Lemeshow goodness-of-fit C-test. The ratios of observed-to-expected deaths (standardized mortality ratio, SMR) were calculated along with the 95% confidence intervals (95% CIs).

Results: The in-hospital mortality rate was 22.6%, which provided an SMR of 0.91 (95% CI, 0.77-0.99) for SAPS II and 0.62 (95% CI, 0.52-0.71) for SAPS 3. Both SAPS II and SAPS 3 exhibited acceptable discrimination, with an area under the receiver operating characteristic curve of 0.84 (95% CI, 0.79-0.89) and 0.73 (95% CI, 0.67-0.79), respectively. However, SAPS II demonstrated superior SMR-based discrimination, which was closer to the observed mortality rate, compared with SAPS 3. Calibration curves exhibited similar performance based on the Hosmer-Lemeshow goodness-of-fit C-test results: $\chi^2 = 7.10$ with $P = .525$ for SAPS II and $\chi^2 = 3.10$ with $P = .876$ for SAPS 3. Interestingly, both scores overpredicted mortality.

Conclusions: In this study, SAPS 3 overestimated mortality and therefore appears less suitable for risk evaluation in comparison to SAPS II.

1. Introduction

In modern intensive care units (ICUs), extremely complicated and/or cost-intensive treatments are used to improve outcomes for seriously ill patients. In this context, the assessment of mortality risk (at admission) has been considered crucial to optimizing the clinical management of ICU patients, thus supporting cost containment and limiting medical futility. Standardized scoring systems are being used worldwide by clinicians to evaluate patients' condition, prognosis, and survival, thereby predicting and reducing risk-adjusted hospital mortalities. These tools provide valid medical information that can also help investigators accurately characterize/stratify individuals who are enrolled in clinical studies.

To date, a large amount of evidence attests to the ability of the Simplified Acute Physiology Score (SAPS) II to accurately discriminate between different patient populations [1,2]. However, a trend toward overestimation of mortality among high-risk patients has often been reported in association with a lack of calibration among certain patient subgroups [3,4]. Although numerous clinical studies have reported that SAPS II is capable of accurately assessing illness severity, its performance in predicting mortality has been questioned by many investigators, as it was developed more than 20 years ago [5]. The Simplified Acute Physiology Score 3 (SAPS 3, first introduced in 2002) has exhibited comparable discrimination performance, with the best results reported in northern European patients, although its calibration has varied depending on the geographical area in which it has been tested [6,7]. Since its introduction, customized mortality prediction equations were developed for SAPS 3 for 7 different world areas. Based on this

☆ Conflicts of interest: none.

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background, this study aimed to analyze and compare the performance of SAPS II and SAPS 3 (North Europe Logit) in a conservative ICU for internal disorders at a German clinical center. Using these results, we sought to identify the best tool for calculating the ratios of observed-to-expected deaths (standardized mortality ratio, SMR), thereby improving the quality of evaluation and management of local care.

2. Materials and methods

2.1. Design, setting, and patients

This study was conducted at the University Hospital Essen (Essen, Germany), which is an academic clinical center with a nearly 1300-bed capacity. Study data were obtained from patients who were admitted to the interdisciplinary 22-bed ICU, which covers the neurology clinic (with a total of 10 of 22 beds) and 5 specialized departments for internal medicine. In this ICU, only 12 (of 22) beds are devoted to internal medicine patients, and the present study exclusively evaluated these admissions. Overall, admissions included patients who were coming from the regular care wards, other ICUs (our hospital or another hospital), the emergency department, and occasionally the operative room. The nurse-to-patient ratio was 1:3, and the ICU medical team involved 6 physicians (1 or 2 specialists, and 5 or 4 attending hospitalists) who worked in 8- to 12-hour shifts as critical care physicians. In general, admission and discharge criteria were administered according to published guidelines [8].

All patients who were admitted to the ICU within an 18-month period were considered potential study objects. Patients were excluded from this study if they were younger than 18 years, had undergone arteriovenous coronary bypass surgery within the 2 weeks before admission, or had stayed in the ICU for less than 24 hours. For all analyses, we excluded data that were derived from the readmission(s) of a single patient to the ICU within the study period and data from patients with incomplete medical records. Thus, during the 18-month study period, 548 patients were evaluated, and their data were subjected to statistical analysis.

From the included patients' records, we prospectively collected information for retrospective analysis regarding patient demographics, medical history, origin and reason for acute admission, physiological parameters at the time of admission and over the first 24 hours of the ICU stay, laboratory parameters, and end-of-treatment outcomes (eg, survival to hospital discharge vs in-hospital mortality). The SAPS II and/or SAPS 3 scores were calculated (along with their predicted mortality rates) based on data that were collected within the first hour or the first 24 hours after the ICU admission, respectively, as described previously [1,7].

2.2. Statistical analysis

Statistical analysis was performed using SPSS (version 21.0; SPSS Inc, Chicago, IL). Calculation of the median (MD) and the first quartile (Q1) and the third quartile (Q3) was performed for all continuous variables. Spearman rank correlation coefficient was used for a nonparametric measure of correlation. Categorical parameters were recorded, frequency percentages were calculated, and the χ^2 test was used for these analyses. Each tool's discrimination power was assessed by calculating the area under the receiver operating characteristic curve (AUROC), and calibration was evaluated using the Hosmer-Lemeshow goodness-of-fit C-test [9]. In that test, P value of more than .05 ($P > .05$) suggests good calibration. Calibration curves were constructed by plotting the predicted mortality rates (x-axis) vs the observed mortality rates (y-axis). Ratios of observed-to-expected deaths (reported here as SMR) were calculated with the 95% confidence intervals (95% CIs).

2.3. Ethics

This noninterventional study was performed in agreement with the ethical principles and standards that were formulated in the second Helsinki declaration and its later amendments. The requirement for informed consent was waived by the institutional review board of the University Hospital Essen, as our retrospective analysis of the data precluded any possible interference between this prospective observational study and the decisions regarding the patients' clinical management.

3. Results

3.1. Patient characteristics

The patients' demographic and clinical characteristics are listed in Tables 1 to 1C. The mean patient age was 60.2 years, and 62% of the patients were men. Sources of patients' admission included the regular internal medicine wards (76.8%) of the University Hospital Essen, the emergency department (6.9%), ICUs for other clinical departments (3.8%), other hospital wards (7.8%), and the operating room (4.6%; of these admissions, only one half had undergone acute surgical procedures). Of note, 95.4% of the admissions to the ICU were related to internal medical disorders, which were treated in the clinic of cardiology (58.6%), gastroenterology (16.1%), nephrology (10.2%), hematology/oncology (6.4%), endocrinology (0.9%), or other departments (infectious disease, angiology, and radiotherapy) (7.7%). Among the acute conditions, 20.6% were caused by acute coronary syndrome, 9.1% by respiratory failure, 6.8% by decompensated heart failure, 6.6% by acute aortic syndrome, 5.5% by sepsis, 4.7% by acute liver failure, and 4% by cardiac arrhythmias (Table 2). Furthermore, 38 patients (6.9%) were admitted to the ICU after successful cardiopulmonary resuscitation. The mean stay in the ICU was 6.6 days. Notably, 65 patients (11.9%) stayed 24 to 36 hours in our ICU and were then transferred to other ICUs attached to 6 different clinics (Anesthesiology: 12, Surgery: 13, Bone Marrow Transplantation: 10, Traumatology: 14, Neurosurgery: 1, and Thorax Surgery: 15). As these patients did not suffer from internal conditions and were only time-bridged in our ICU, the authors classified them as "Rest."

3.2. Performance of SAPS II vs SAPS 3

The SAPS II and SAPS 3 scores (MD [Q1; Q3]) were 33.00 [22.00; 47.00] and 58.00 [46.25; 70.50], respectively. Based on these scores, the predicted mortality for SAPS II was 24.00% [4.60%; 39.10]% compared with 31.00% [12.25%; 57.75%] for SAPS 3. Among 548 patients, a total of 124 in-hospital deaths (22.6%) were observed, which included 69 men (12.8%) and 55 women (10.2%). These results provided an SMR of 0.91 (95% CI, 0.77-0.99) for SAPS II and 0.62 (95% CI, 0.52-0.71) for SAPS 3 (Table 3). Both SAPS II and SAPS 3 exhibited acceptable discrimination performances, with an AUROC of 0.84 (95% CI, 0.79-0.89) and 0.73 (95% CI, 0.67-0.79), respectively (Fig. 1), although there was no significant difference between the 2 tools. However, SAPS II

Table 1A
Patients admission characteristics (N = 548)

Source of admission		
Regular care ward	421	76.8%
Emergency department	38	6.9%
Operating room	25	4.6%
Other hospital	43	7.8%
Other ICU	21	3.8%
Type of admission in SAPS II		
Unplanned surgery	12	2.2%
Planned surgery	13	2.4%
Medical	523	94.5%
Comorbidities in SAPS 3		
Immunosuppression	179	32.7%
Metastatic cancer	59	10.8%
Hematological cancer	10	1.8%
Cirrhosis	108	19.7%
Chronic heart failure NYHA IV	187	34.1%
In-hospital mortality	124	22.6%

NYHA indicates New York Heart Association classification.