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RESEARCH ARTICLE

Assessment and Comparison of Scoring Systems—SAPS III, APACHE II, and SOFA for Prediction of Mortality in Patients with Sepsis in a Mixed Medical and Surgical Indian ICU

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ABSTRACT

Background: Sepsis is a leading cause of intensive care unit (ICU) morbidity and mortality. Severity-of-illness scoring systems aid risk stratification, but most were derived from Western cohorts and require validation in Indian ICU settings.

Aim: To assess and compare the accuracy of the Simplified Acute Physiology Score (SAPS) III, Acute Physiology and Chronic Health Evaluation (APACHE) II, and Sequential Organ Failure Assessment (SOFA) scores for predicting mortality in patients with sepsis admitted to a mixed medical–surgical Indian ICU.

Methods: This prospective, single-centre, observational study enrolled 118 adults with sepsis admitted to a 40-bed mixed medical–surgical ICU over 18 months. SAPS III, APACHE II and SOFA scores were calculated within 24 hours of admission. Discrimination was assessed using the area under the receiver operating characteristic curve (AUROC), and sensitivity, specificity, positive and negative predictive values (PPV, NPV) and accuracy were computed at the optimal Youden's index cut-off for each score.

Results: Overall in-hospital mortality was 39.8% (47/118). Mean SAPS III, APACHE II and SOFA scores were significantly higher among non-survivors than survivors (61.68 vs 49.23, 21.98 vs 16.39, and 7.91 vs 5.39 respectively; $p<0.001$ for SAPS III and SOFA, $p=0.001$ for APACHE II). The AUROC for SAPS III (0.73) was higher than that of APACHE II (0.66) and SOFA (0.66). At the optimal cut-off (≥60), SAPS III showed sensitivity 51.06%, specificity 85.92%, PPV 70.59%, NPV 72.62% and accuracy 72%. Presence of comorbidity was significantly associated with mortality ($p=0.023$), and lower Glasgow Coma Scale, higher serum creatinine and higher bilirubin were significantly associated with death.

Conclusion: SAPS III demonstrated better discriminatory ability than APACHE II and SOFA for predicting mortality in this mixed medical–surgical Indian ICU cohort of septic patients, though its sensitivity remained modest. A combination of scores, along with clinical judgement, is recommended for prognostication in resource-limited ICU settings.

Keywords: Sepsis; Intensive care unit; SAPS III; APACHE II; SOFA; Mortality prediction; India.

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Introduction

Sepsis is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection, and it remains one of the leading causes of in-hospital morbidity and mortality among medical and surgical patients admitted to intensive care units (ICUs). Epidemiological data indicate that the incidence of severe sepsis has been rising over time, with an estimated increase of approximately 1.5% per year and hospital mortality historically reported between 17% and 26% for sepsis and severe sepsis, respectively. Compared with high-income countries, hospital-based epidemiological data on sepsis from India remain relatively limited, though available single-centre experience suggests a substantial associated mortality burden[1-3].

The ICU is a specialised area in which medical technology and skilled personnel converge to manage critically ill patients, and because a simple subjective clinical assessment cannot reliably quantify the severity of critical illness, a variety of objective ICU scoring systems have been developed. These scores serve as tools for risk stratification, ICU benchmarking and resource allocation. Landmark first-generation severity models include the Acute Physiology and Chronic Health Evaluation (APACHE) score, the Simplified Acute Physiology Score (SAPS), and the repetitive, organ-dysfunction-based Sequential Organ Failure Assessment (SOFA) score. Most first-day severity scores are calculated using physiological derangement within the first 24 hours of ICU admission and do not account for factors influencing outcome beyond this window, whereas SOFA is designed for serial, day-wise assessment of organ dysfunction. Among

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contemporary models, SAPS III has been reported to show the best discrimination capacity for 28-day mortality when compared with several other severity scores[4-8].

Because the major severity-of-illness scoring systems were derived and validated predominantly in North American and European ICU cohorts, their performance characteristics may not be directly transportable to Indian medical–surgical ICUs, where case-mix, infection profile, nutritional status and resource availability differ substantially. Local validation is therefore essential before any of these scores can be applied with confidence for prognostication or ICU benchmarking in Indian critical care practice. The present study was undertaken to assess and compare the validity of SAPS III, APACHE II and SOFA scores for predicting mortality in patients with sepsis admitted to a mixed medical and surgical ICU in northern India.

Aim

To assess and compare the accuracy of three scoring systems—SAPS III, APACHE II and SOFA—for predicting mortality in patients with sepsis in a mixed medical and surgical Indian ICU.

Primary Objective

To evaluate the sensitivity and specificity of SAPS III, APACHE II and SOFA scores for predicting mortality in patients with sepsis in a mixed medical and surgical Indian ICU.

Secondary Objectives

- To evaluate the positive and negative predictive values of SAPS III, APACHE II and SOFA scores for predicting mortality in patients with sepsis.
- To compare the overall diagnostic accuracy of SAPS III, APACHE II and SOFA scores for predicting mortality in patients with sepsis.

Materials and Methods

Study Design and Setting

This was a hospital-based, single-centre, prospective observational study conducted in the 40-bed mixed medical and surgical ICU of the Department of Critical Care Medicine over a period of 18 months.

Study population

A total of 118 adult patients admitted to the ICU with a diagnosis of sepsis were recruited consecutively after applying the eligibility criteria below.

Inclusion Criteria

Adults fulfilling at least 2 of the following criteria—core temperature >38°C or <36°C, heart rate >90 beats/min, respiratory rate >20/min or PaCO2 <32 mmHg, and white cell count >12,000/µL or <4,000/µL or >10% immature forms—together with at least one feature of organ dysfunction (altered mental status, hypoxaemia with PaO2 <72 mmHg, oliguria, coagulopathy with INR >1.5, or hypotension/lactate >2 mmol/L) were included.

Exclusion criteria

Age <18 years, burns, pancreatitis, and polytrauma.

Data Collection

After institutional ethics committee approval and written informed consent, demographic and clinical data (age, sex, comorbidities, vital signs, Glasgow Coma Scale), arterial blood gas analysis, complete blood count, renal and liver function tests were recorded at admission using a pre-designed proforma. SAPS III, APACHE II and SOFA scores were calculated within 24 hours of ICU admission using standard published worksheets, and patients were followed up to hospital discharge or death.

Sample Size

The sample size was calculated using MedCalc software, based on comparison of the AUROCs reported for APACHE II, SAPS III and SOFA in an external validation study[16] (AUROC: APACHE II 0.772, SAPS III 0.790, SOFA 0.742),

with type I error (α) of 0.05 and power of 80%. The largest of the pairwise-calculated sample sizes (118) was adopted for the study.

Statistical Analysis

Data were entered in Microsoft Excel and analysed using SPSS v25.0 and Jamovi v2.3.12. Normality was assessed with the Kolmogorov–Smirnov test. Quantitative variables were compared using the unpaired t-test or Mann–Whitney U test as appropriate, and qualitative variables using the chi-square or Fisher's exact test. Discriminative ability of each score was assessed using AUROC analysis, with pairwise comparison by the DeLong test. The optimal cut-off for each score was identified using the maximum Youden's index, and sensitivity, specificity, PPV, NPV and overall accuracy were calculated at this cut-off. A two-tailed p-value <0.05 was considered statistically significant.

Ethical Considerations

The study protocol, informed consent form and data collection instruments were reviewed and approved by the Institutional Scientific Research Committee and Ethics Committee prior to initiation of the study.

Results

A total of 118 patients with sepsis admitted to the mixed medical–surgical ICU were enrolled after applying the eligibility criteria. Overall in-hospital mortality was 39.8% (47/118), while 60.2% (71/118) were discharged. The mean age of the study population was 62.25 ± 14.99 years, and 76 (64.4%) patients were male; neither age nor sex was significantly associated with mortality (p=0.417 and p=0.372, respectively).

Discussion

Severe sepsis and septic shock remain major reasons for ICU admission and leading causes of mortality outside coronary care settings. Because the standard severity-of-illness scores were developed in large Western cohorts, validation in Indian ICU populations remains important before their routine clinical or benchmarking use[20]. In the present study of 118 patients with sepsis admitted to a mixed medical–surgical ICU, overall mortality was 39.8%, comparable to the 34% reported by Sharma *et al*[15] and higher than the 16.3% reported by Zhu *et al* in a Sepsis-3–defined cohort[8], but lower than the 87.5% mortality

Table 1: Baseline clinical characteristics and outcome-associated parameters

Parameter	*Discharged (n=71)*	*Death (n=47)*	*Total (n=118)*	*p-value*
Mean age (years)	61.34 ± 15.59	63.64 ± 14.09	62.25 ± 14.99	0.417
Male sex, n (%)	48 (67.6%)	28 (59.6%)	76 (64.4%)	0.372
Mean GCS	13.11 ± 3.03	10.51 ± 4.70	12.08 ± 3.98	<0.001
Serum creatinine (mg/dL)	1.81 ± 1.20	2.43 ± 1.79	2.06 ± 1.48	0.03
Serum bilirubin (mg/dL)	0.96 ± 1.00	3.09 ± 5.10	1.80 ± 3.43	0.001
Comorbidity present, n (%)	49 (69%)	41 (87%)	90 (76.3%)	0.023

Mean Glasgow Coma Scale was significantly lower among non-survivors than survivors (10.51 vs 13.11; p<0.001). Among biochemical parameters, serum creatinine and bilirubin were significantly higher among non-survivors, while serum sodium and potassium did not differ significantly between groups. The presence of one or more comorbidities was significantly associated with mortality (87% vs 69%; p=0.023); hypertension (20%), diabetes mellitus (17%), chronic kidney disease (11%) and chronic liver disease (11%) were the most prevalent comorbidities.

Table 2: Comparison of SAPS III, APACHE II and SOFA scores between survivors and non-survivors

Score	*Discharged (Mean ± SD)*	*Death (Mean ± SD)*	*Total (Mean ± SD)*	*p-value*
SAPS III	49.23 ± 12.12	61.68 ± 16.43	54.19 ± 15.22	<0.001
APACHE II	16.39 ± 7.47	21.98 ± 9.99	18.62 ± 8.95	0.001
SOFA	5.39 ± 2.93	7.91 ± 4.63	6.40 ± 3.89	<0.001

Mean values of all three scores were significantly higher among patients who died compared with those who were discharged, confirming their construct validity as markers of illness severity in this cohort.

Table 3: Diagnostic accuracy of SAPS III, APACHE II and SOFA scores for prediction of mortality (at optimal Youden's index cut-off)

Parameter	*SAPS III*	*APACHE II*	*SOFA*
Optimal cut-off	≥60	≥20	≥11
Youden's index (max.)	0.37	0.24	0.26
Sensitivity (%)	51.06	53.19	31.91
Specificity (%)	85.92	70.42	94.37
PPV (%)	70.59	54.35	78.95
NPV (%)	72.62	69.44	67.68
Accuracy (%)	72	64	66
AUROC	0.73	0.66	0.66

On receiver operating characteristic analysis, the area under the curve was 0.73 for SAPS III, 0.66 for APACHE II and 0.66 for SOFA, indicating that SAPS III had the best overall discriminative ability among the three scores in this cohort, although its sensitivity (51.06%) remained modest. SOFA showed the highest specificity (94.37%) and PPV (78.95%) but the lowest sensitivity (31.91%), reflecting a trade-off in performance characteristics across the three models.

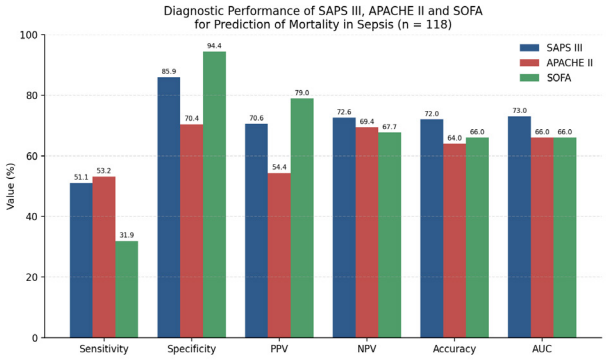

Figure 1: Comparative diagnostic performance (sensitivity, specificity, PPV, NPV, accuracy and AUROC) of SAPS III, APACHE II and SOFA scores for prediction of mortality in sepsis (n=118).

reported by Thakur et al in a surgical sepsis cohort[18]. Variation in reported mortality across studies likely reflects differences in case-mix, ICU bed availability, and nutritional and referral patterns, all of which influence the severity of illness at the time of ICU admission.

The AUROC values obtained in this study (SAPS III 0.73, APACHE II 0.66, SOFA 0.66) indicate acceptable but not excellent discrimination, and were lower than the near-excellent discrimination reported by Sharma *et al* (AUROC 0.981 for SAPS III/SAPS II, 0.978 for APACHE II, 0.911 for SOFA)[15] and by Mbongo *et al*, who reported an AUROC of 0.916 for SAPS III, comparable to APACHE II (0.893) and SOFA (0.846), with good calibration for SAPS III but insufficient calibration for APACHE II[10]. Similarly, Falcão *et al* reported AUROCs in the range of 0.74–0.82 for these scores in a surgical ICU population with fair calibration[16], and Basile-Filho *et al* found that APACHE II, SOFA and, to a lesser extent, SAPS III could discriminate 24-hour ICU survivors from non-survivors among postoperative surgical patients[17]. Other reported AUROC values for APACHE II and SAPS-based scores range from approximately 0.62 to 0.88 across different populations and settings[11-14], underscoring substantial heterogeneity in performance depending on case-mix and the timing of score calculation.

In the present cohort, SAPS III showed the best discrimination among the three scores, consistent with several previous reports favouring SAPS-based models over APACHE II and SOFA[8,10,15]. Halim et al, in contrast, found SOFA and modified SOFA to outperform APACHE II in a surgical ICU population, particularly when scores were measured serially rather than only at admission[9], a finding also echoed by Thakur *et al*, who noted that APACHE II and SOFA had broadly similar discriminative power on day 1 but that SOFA's sensitivity exceeded that of APACHE II at the cost of lower specificity[18]. Similarly, Mehta and Patil reported comparable performance of APACHE II and SOFA in a western Indian tertiary-care ICU[19]. These discrepancies highlight that no single first-day severity score is uniformly superior across all ICU case-mixes, and that serial or repeated scoring—particularly with SOFA—may improve predictive accuracy compared with a single admission-day value[9].

In this study, lower GCS and higher serum creatinine and bilirubin were significantly associated with mortality, consistent with the physiological derangements captured within all three scoring systems, and the presence of comorbidity was independently associated with a higher risk of death. This mirrors the observation that host factors and pre-existing organ reserve, and not physiological derangement alone, materially influence ICU outcome[4]. The relatively modest sensitivity of SAPS III in the present cohort (51.06%) suggests that reliance on a single score at a single time point may under-detect a proportion of patients ultimately destined to die, reinforcing recommendations that a combination of scores—together with clinical judgement—be used for prognostication rather than any single score in isolation[16].

Conclusion

In this prospective study of patients with sepsis admitted to a mixed medical and surgical Indian ICU, SAPS III

demonstrated better discriminatory ability (AUROC 0.73) than APACHE II and SOFA (AUROC 0.66 each) for prediction of in-hospital mortality, with good specificity but modest sensitivity at its optimal cut-off. Higher SAPS III, APACHE II and SOFA scores, lower GCS, higher creatinine and bilirubin, and presence of comorbidity were all significantly associated with mortality. While SAPS III appears to be the most useful single score for prognostication in this setting, no single scoring system offered excellent discrimination in isolation, and a combination of scoring systems together with clinical assessment is recommended for mortality risk stratification in resource-limited Indian ICUs.

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