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Original Article

Comparison of scoring systems: SOFA, APACHE-II, LODS, MODS, and SAPS-II in critically ill elderly sepsis patients

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Abstract

Introduction: The elderly population is unique and the prognostic scoring systems developed for the adult population need to be validated. We evaluated the predictive value of frequently used scoring systems on mortality in critically ill elderly sepsis patients.

Methodology: In this single-center, observational, prospective study, critically ill elderly sepsis patients were evaluated. Sequential organ failure evaluation score (SOFA), acute physiology and chronic health evaluation score-II (APACHE-II), logistic organ dysfunction score (LODS), multiple organ dysfunction score (MODS), and simplified acute physiology score-II (SAPS-II) were calculated. The participants were followed up for 28 days for in-hospital mortality. Prognostic scoring systems, demographic characteristics, comorbid conditions, and baseline laboratory findings were compared between "survivor" and "non-survivor" groups.

Results: 202 patients with a mean age of 79 (interquartile range, IQR: 11) years were included, and 51% (n = 103) were female. The overall mortality was 41% (n = 83). SOFA, APACHE-II, LODS, MODS, and SAPS-II scores were significantly higher in the non-survivor group ($p < 0.001$), and higher scores were correlated with higher mortality. The receiver operator characteristics (ROC) - area under curve (AUC) values were 0.802, 0.784, 0.735, 0.702 and 0.780 for SOFA, APACHE-II, LODS, MODS, and SAPS-II, respectively. All prognostic scoring models had a significant discriminative ability on the prediction of mortality among critically ill elderly sepsis patients ($p < 0.001$).

Conclusions: This study showed that SOFA, APACHE-II, LODS, MODS, and SAPS-II scores are significantly associated with 28-day mortality in critically ill elderly sepsis patients, and can be successfully used for predicting mortality.

Key words: organ dysfunction scores; APACHE; survival; intensive care units; aged; sepsis.

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Introduction

Sepsis is defined as multi-organ dysfunction due to dysregulated host response triggered by systemic infection [1]. It has been demonstrated that the incidence of sepsis increases due to advanced age, immunosuppression, and the existence of multi-resistant infections [2,3].

Around 3% of all hospitalized patients were diagnosed with sepsis, half of them were treated in the intensive care units (ICU), and the mortality rate was slightly over 25% [4]. Among elders, the risk of infections and sepsis is much higher due to their suppressed immune systems [3]. The vast majority of sepsis cases (60-85%) consist of patients over the age of 65, and it is expected to increase further with the increase in the elderly population [5]. The mortality rate associated with severe sepsis was 1.3-1.5 times higher in patients aged 65 and over than in younger patients, and the elder patients tended to die earlier [6].

The frequently used parameter to evaluate the effect of treatment methods in the ICU on the clinical course of the patient is the determination of mortality rate [7]. Several scoring systems have been developed and used widely in ICUs to assess the severity of disease, predict mortality and morbidity, and evaluate the efficacy of treatment methods [8,9]. The most reliable scoring methods may be listed as acute physiology and chronic health assessment score (APACHE-II) [10], simplified acute physiology score (SAPS-II) [11], sequential organ failure assessment (SOFA) [12], multiple organ dysfunction score (MODS) [13], and logistic organ dysfunction score (LODS) [14]. However, the results of

various studies evaluating the power of scoring systems to predict mortality in elderly patients have shown discrepancies [15–17]. A study conducted with elderly sepsis patients revealed that APACHE-II was more successful in the estimation of mortality [15], whereas another study demonstrated that SAPS-II was superior [16]. Also, APACHE II and SOFA together were found to be successful in predicting mortality in elderly critical care patients [17]. In conclusion, the current literature failed to propose the utility of any scoring models in the clinical practice for elderly sepsis patients treated in ICUs to estimate in-hospital prognosis [18].

In this study, we aimed to evaluate the predictive value of the widely used scoring systems on mortality among ICU patients aged 65 years and over with sepsis.

Methodology

Setting and participants

This prospective, single-center, observational study included patients aged 65 years and over diagnosed with either sepsis or septic shock and admitted to the main ICU of a university hospital between 1 July 2021 and 1 July 2022. We prospectively included ICU patients aged 65 years and over diagnosed with either sepsis or septic shock. Enrollees were diagnosed with sepsis or septic shock according to the "sepsis consensus (sepsis-3) report" [19] and the international sepsis and septic shock management guidelines [20] jointly published by the Society of Critical Care Medicine (SCCM) and the European Society of Intensive Care Medicine (ESICM) in 2016 and 2017, respectively. A written informed consent form was obtained from all participants or their caregivers. Patients under 65 years of age, patients with end-stage cancer, end-stage heart failure, cirrhosis, requiring urgent surgical intervention, a history of recent trauma or advanced dementia, and those who or their caregivers were hesitant to give written informed consent were excluded from the study. The institutional Clinical Research Ethics Committee approved the study protocol (Code:2021/36). All procedures were performed following the Turkish Medicine and Medical Devices Agency Good Clinical Practices Guidelines and the Declaration of Helsinki.

Patient characteristics and procedures

Demographic characteristics including age and gender, and anthropometric variables including height, and weight were noted, and body mass index (BMI) was calculated for all participants. Existing comorbid conditions such as diabetes mellitus, dyslipidemia, hypertension, congestive heart disease, coronary artery disease, chronic kidney disease, and chronic obstructive pulmonary disease (COPD) were retrieved from the electronic health records of the participants. In addition, baseline laboratory findings including white blood cell count, hemoglobin, platelets, glucose, urea, creatinine, aspartate aminotransferase (AST), alanine aminotransferase (ALT), total bilirubin, potassium, sodium, procalcitonin, C-reactive protein were recorded.

SOFA, APACHE-II, LODS, MODS, and SAPS-II scores and associated predictive mortality rates (PMR) were calculated for each scoring model within the first 24 hours of ICU admission. The primary outcome of the study was mortality from any cause, and the follow-up period was 28 days. We divided the patients into "survivors" and "non-survivors" groups according to death records at the end of the follow-up period.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) (version 26.0, Chicago, Illinois) was used for statistical analysis. The distribution of the data was assessed by the Shapiro-Wilk test. In the case of continuous variables, results were expressed as the mean ± standard deviation and expressed as the percentage of the total for categorical variables. Skewed variables were presented as median (interquartile range, IQR). According to the distribution of variables, the differences between the continuous variables in the survivor and non-survivor groups were compared with either the Student's *t*-test or the Mann-Whitney U test. The Chi square test was used to compare categorical variables. Point biserial correlation was calculated to evaluate the potential correlation of scoring models with mortality. The power of all scoring models in the prediction of the 28-day mortality rate was tested with the receiver operator characteristics (ROC) - area under curve (AUC) analysis. ROC analysis was also used to state cut-off values and their sensitivity and specificity to estimate the risk of mortality in the ICU. The ROC-AUC values of scoring models were compared pairwise with the method defined by DeLong *et al*. [21]. Statistical significance was accepted at the level *of* $p < 0.05$.

Results

A total of 202 patients with a mean age of 79 (IQR: 11) years were included, and 51% (n = 103) of them were female. 40.6% (n = 82) of the participants were diagnosed with septic shock and received vasopressors. 38.1% (n = 77) of them were receiving invasive mechanical ventilation therapy.

Table 1. General characteristics, comorbid conditions, and baseline laboratory findings of patients.

	Total (n = 202)	Survivors (n = 119)	Non-Survivors (n = 83)	*p*
Age, median (IQR)	79 (11)	79 (12)	78 (10)	0.998
Gender, n (%) -- Female	103 (51.0)	63 (31.2)	40 (19.8)	0.507
Body mass index, median (IQR)	25.35 (3.12)	25.39 (3.12)	24.97 (3.33)	0.598
Diabetes mellitus, n (%)	97 (48.0)	63 (31.2)	34 (16.8)	0.094
Dyslipidemia, n (%)	17 (8.4)	11 (5.4)	6 (3.0)	0.612
Hypertension, n (%)	142 (70.3)	89 (44.1)	53 (26.2)	0.094
Congestive heart disease, n (%)	64 (31.7)	36 (17.8)	28 (13.9)	0.601
Coronary artery disease n, (%)	69 (34.2)	40 (19.8)	29 (14.4)	0.845
Chronic kidney disease, n (%)	47 (23.3)	27 (13.4)	20 (9.9)	0.816
COPD, n (%)	39 (19.3)	23 (11.4)	16 (7.9)	0.993
WBC (cells/uL), median (IQR)	12100 (8930)	11600 (7200)	13500 (11300)	0.244
Hemoglobin (g/dL), median (IQR)	10.40 (3.40)	10.80 (3.30)	10.00 (3.60)	0.054
Platelets (cellsx10^3/uL), median (IQR)	195 (157.25)	201 (146)	173 (170)	0.910
Glucose (mg/dL), median (IQR)	120 (86.75)	125 (109)	105 (79)	0.002
Urea (mg/dL), median (IQR)	108 (84.25)	97 (96)	118 (76)	0.002
Creatinine (mg/dL), median (IQR)	1.81 (1.82)	1.62 (1.54)	2.09 (2.52)	0.002
AST (U/L), median (IQR)	36 (54.25)	29 (38)	49 (155)	0.001
ALT (U/L), median (IQR)	23 (39)	19 (26)	29 (112)	0.035
Total bilirubin(mg/dL), median (IQR)	1 (1)	0.8 (0.8)	1.2 (1.9)	< 0.001
Potassium (mmol/L), median (IQR)	4.23 (1.19)	4.07 (1.16)	4.40 (1.11)	0.125
Sodium (mmol/L), median (IQR)	137 (9.25)	137 (9.00)	139 (11.00)	0.241
Procalcitonin, (ng/ml) median (IQR)	1.79 (9.98)	1.72 (8.70)	2.34 (13.00)	0.238
CRP (mg/L), median (IQR)	116.5 (140.4)	116.0 (125.7)	121.2 (180.0)	0.992

IQR: inter quantile range; n: absolute number; COPD: chronic obstructive pulmonary disease; WBC: white blood count; AST: aspartate aminotransferase; ALT: alanine aminotransferase; CRP: C-reactive protein. p values < 0.05 were significant.

Table 2. Study parameters and their comparisons.

	Total (n = 202)	Survivors (n = 119)	Non-survivors (n = 83)	*p*
SOFA, median (IQR)	8 (6)	6 (4)	11 (5)	< 0.001
PMR – SOFA (%), median (IQR)	33.0 (29.8)	21.5 (13.1)	50.0 (62.2)	< 0.001
APACHE–II, median (IQR)	23.5 (10.0)	21.0 (9.0)	28.0 (10.0)	< 0.001
PMR–APACHE–II(%),median (IQR)	40 (30)	40 (30)	55 (33)	< 0.001
LODS, median (IQR)	7 (5)	6 (3)	9 (5)	< 0.001
PMR – LODS (%), median (IQR)	38.2 (47.2)	28.9 (27.4)	58.7 (45.1)	< 0.001
MODS, median (IQR)	8 (5)	6 (4)	9 (4)	< 0.001
PMR – MODS (%), median (IQR)	16 (34)	16 (34)	50 (34)	< 0.001
SAPS-II, median (IQR)	49 (28)	42 (16)	62 (30)	< 0.001
PMR – SAPS-II (%), median (IQR)	43.8 (57.2)	28.5 (32.6)	71.9 (50.4)	< 0.001

SOFA: sequential organ failure assessment; IQR: inter quantile range; PMR: predicted mortality rate; APACHE-II: acute physiology and chronic health evaluation; LODS: logistic organ dysfunction score; MODS: multiple organ dysfunction score; SAPS-II: simplified acute physiology score; n: absolute number. *p* values < 0.05 were significant.

Table 3. Survival rates of patients with above and below median values.

	Median values	Samples value	Survivors (n = 119)	Non-survivors (n = 83)	*p*
SOFA, n (%)	8	Above median	44 (21.8)	68 (33.7)	**< 0.001**
		Below median	75 (37.1)	15 (7.4)	
APACHE-II, n (%)	23.5	Above median	37 (18.3)	64 (31.7)	**< 0.001**
		Below median	82 (40.6)	19 (9.4)	
LODS, n (%)	7	Above median	55 (27.2)	64 (31.7)	**< 0.001**
		Below median	64 (31.7)	19 (9.4)	
MODS, n (%)	8	Above median	67 (33.2)	23 (11.4)	**< 0.001**
		Below median	52 (25.7)	60 (29.7)	
SAPS–II, n (%)	49	Above median	40 (19.8)	62 (30.7)	**< 0.001**
		Below median	79 (39.1)	21 (10.4)	

SOFA: sequential organ failure assessment; APACHE-II: acute physiology and chronic health evaluation; LODS: logistic organ dysfunction score; MODS: multiple organ dysfunction score; SAPS-II: simplified acute physiology score; n: absolute number. *p* values < 0.05 were significant.

Table 4. Point biserial correlation and ROC analyses of patient survival across SOFA, APACHE–II, LODS, MODS and SAPS-II.

	Point biserial correlation			Sensitivity (%)	Specificity (%)	AUC, CI
	r	*p*	Cutoff			
SOFA	0.522	**< 0.001**	8.5	66.3	73.9	0.802, 0.740 – 0.865
APACHE–II	0.494	**< 0.001**	23.5	77.1	68.9	0.784, 0.718 – 0.850
LODS	0.411	**< 0.001**	7.5	62.7	71.4	0.735, 0.665 – 0.805
MODS	0.352	**< 0.001**	8.5	59.0	66.4	0.702, 0.627 – 0.776
SAPS-II	0.499	**< 0.001**	50.5	72.3	72.3	0.780, 0.714 – 0.847

ROC: receiver operator characteristics; SOFA: sequential organ failure assessment; APACHE-II: acute physiology and chronic health evaluation; LODS: logistic organ dysfunction score; MODS: multiple organ dysfunction score; SAPS-II: simplified acute physiology score; AUC: area under curve; CI: confidence internal; n: Absolute number; AUC, CI values that do not cross 1 were significant.

The most common site of infection was the lungs (40.6%, n = 82) and followed by the urinary tract (27.7%, n = 56).

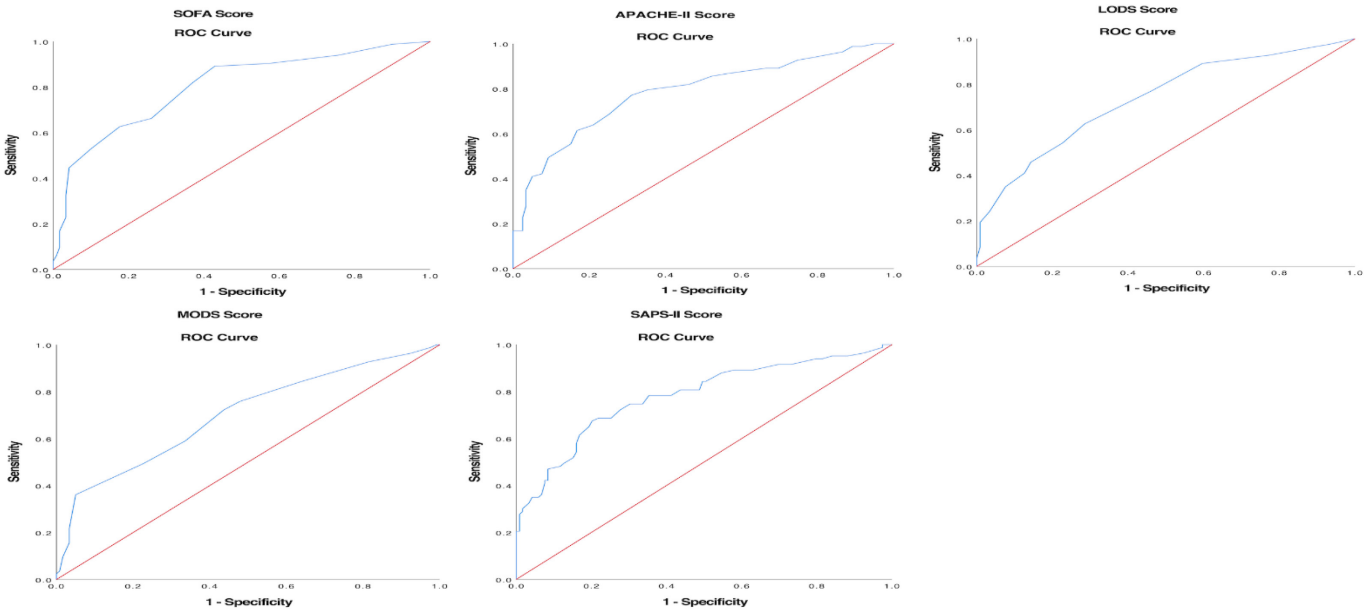
The age, gender, BMI, and comorbid conditions including diabetes mellitus, dyslipidemia, hypertension, congestive heart disease, coronary artery disease, chronic kidney disease, and COPD showed no significant difference between the survivor and non-survivor groups (Table 1). Baseline laboratory findings including white blood cell count, hemoglobin, platelet count, potassium, sodium, procalcitonin, and C-reactive protein were similar between survivors and non-survivors (Table 1). However, urea, creatinine, AST, ALT, and total bilirubin levels were significantly higher and glucose level was significantly lower among non-survivors ($p < 0.05$ for all) (Table 1).

The overall mortality rate during the 28-day follow-up period was 41% (n = 83). Mortality rates of very elderly (≥ 80 years) and elderly (65-79 years) patients showed no significant difference (38.5% vs. 43.4%; $p = 0.484$). As shown in Table 2, all SOFA, APACHE-II, LODS, MODS, and SAPS-II score medians and associated PMRs were significantly higher in the non-survivor group ($p < 0.001$ for all).

The median values of SOFA, APACHE-II, LODS, MODS, and SAPS-II scores are presented in Table 3. It was found that the mortality rate of patients with the above-median values of all scoring models on the day of admission was associated with higher mortality rates ($p < 0.001$ for all). Also, higher SOFA, APACHE-II, LODS, MODS, and SAPS-II scores showed a remarkable correlation with mortality rates ($p < 0.001$ for all) (Table 4).

As reported in Table 4, the areas under the curve were calculated as 0.802 for SOFA, 0.784 for APACHE-II, 0.735 for LODS, 0.702 for MODS, and 0.780 for SAPS-II. ROC-AUC analysis revealed that all prognostic scoring models had a significant discriminative ability on the prediction of mortality among elderly patients with sepsis in the ICU ($p < 0.001$ for all). Cut-off values for each scoring model are listed

Figure 1. ROC curves of patient survival across SOFA, APACHE – II, LODS, MODS and SAPS-II.



ROC: receiver operator characteristics; SOFA: sequential organ failure assessment; APACHE-II: acute physiology and chronic health evaluation; LODS: logistic organ dysfunction score; MODS: multiple organ dysfunction score; SAPS-II: simplified acute physiology score.

in Table 4. In addition, ROC curve diagrams are presented in Figure 1.

The pairwise comparison of AUC values of scoring models are listed in Table 5. According to the comparison of ROC-AUC values, while SOFA was similar to APACHE-II and SAPS-II, it was significantly different from LODS and MODS ($p < 0.05$ for all). No significant difference was observed between APACHE-II and LODS or SAPS-II scores ($p > 0.05$ for all). MODS was significantly different from all scoring models other than LODS ($p = 0.0236$). The pairwise comparison of LODS and SAPS-II were also significantly different ($p < 0.05$).

Discussion

Despite significant advances in treatment modalities for sepsis, the mortality rates are still far from the desired level and ranging between 20-80% in various studies [22]. As the average age of the population increases, the rate of geriatric patients with sepsis is expected to increase as well. As expected, the incidence of elderly patients admitted to ICUs has increased all over the world in recent years [23]. Recently several scoring models developed to predict mortality in ICU patients, and their accuracy has been demonstrated in various studies [10–14]. However, the efficacy of such scoring systems in elderly ICU patients has not been fully determined, and there is still a debate about the results [15–18]. So, the determination of the reliability of mortality and prognosis prediction tools to be used in elderly patients with sepsis is crucial. In this study, we evaluated the efficacy of the prognostic scoring models SOFA, APACHE-II, LODS, MODS, and SAPS-II on 28-day mortality among ICU sepsis patients aged 65 years and over. We concluded that all these scoring models could be consistently used in the prediction of mortality among elderly sepsis ICU patients, and higher scores were associated with higher mortality rates. In addition, while lower glucose and higher urea, creatinine, ALT, and AST values at the time of admission were associated with higher mortality rates, comorbid conditions and higher leucocyte count, C-reactive protein (CRP) and procalcitonin levels were inconsequent with mortality.

In our study, the overall mortality rate was 41%. Similarly, a recent prospective multicenter study reported a 40% in-hospital 28-day mortality rate in critically ill elderly sepsis patients [15]. However, in some studies, mortality rates can vary between 10% and 70%, considering several differences of the cohorts such as the mean age of the enrollees [24], severity of sepsis [25], duration of follow-up period [26], frequency of comorbid conditions [27], and the country that study was conducted [28]. In a meta-analysis published in 2020, ICU mortality was found to be 24.4%, but unlike our study, this study was conducted not only with elderly patients but also with adult patients [24]. In another study published in 2018, mortality rates were 55.7% in severe sepsis patients and 70.4% in septic shock patients [26]. In a study conducted on geriatric sepsis patients in 2021, the total mortality was found to be 11% [27]. However, only 11% of patients in this study had septic shock and the mechanical ventilation rate was around 21%. We believe that the high mortality rate in our study was associated with the high number of patients diagnosed with septic shock, the high number of patients who need mechanical ventilators, and the fact that the participants were elderly with higher comorbidity rates.

Scoring models can be classified into two main groups as prognostic scoring models and organ function scores. While prognostic scoring models assess the severity of the disease at the time of admission [29], organ function scores provide information about the clinical course of the patient and the progression of the disease by re-evaluating patients repeatedly [30]. While mostly used validated prognostic scoring models can be listed as APACHE-II and SAPS-II, organ function scores can be listed as SOFA, MODS, and LODS. Even though, the primary aim of organ function scores is not prognostication, as a descriptor of organ dysfunction, higher values of such scores consistently correlate with mortality [30]. As far as we know, in the current literature, there is no study comparing the predictive

Table 5. Pairwise comparison AUC values of SOFA, APACHE–II, LODS, MODS and SAPS-II.

	SOFA		APACHE-II		LODS		MODS		SAPS-II	
	DBA (SE)	*p*	DBA (SE)	*p*	DBA (SE)	*p*	DBA (SE)	*p*	DBA (SE)	*p*
SOFA			0.018 (0.025)	0.470	0.067 (0.022)	< 0.05	0.100 (0.025)	< 0.001	0.022 (0.023)	0.342
APACHE–II	0.018 (0.025)	0.470			0.049 (0.025)	0.052	0.083 (0.029)	< 0.05	0.004 (0.024)	0.873
LODS	0.067 (0.022)	< 0.05	0.049 (0.025)	0.052			0.034 (0.028)	0.236	0.045 (0.021)	< 0.05
MODS	0.100 (0.025)	< 0.001	0.083 (0.029)	< 0.05	0.034 (0.028)	0.236			0.079 (0.030)	< 0.05
SAPS-II	0.022 (0.023)	0.342	0.004 (0.024)	0.873	0.045 (0.021)	< 0.05	0.079 (0.030)	< 0.05		

AUC: area under curve; SOFA: sequential organ failure assessment; APACHE-II: acute physiology and chronic health evaluation; LODS: logistic organ dysfunction score; MODS: multiple organ dysfunction score; SAPS - II: simplified acute physiology score; DBA: difference between areas; SE: standard error. *p* values < 0.05 were significant.

value of SOFA, APACHE-II, LODS, MODS, and SAPS-II scores on mortality among elderly ICU sepsis patients.

One study demonstrated that the APACHE-II score was significantly associated with mortality in approximately 1500 elderly sepsis patients [15]. In another study with a smaller group of 150 elderly sepsis patients, APACHE-II and SOFA scores on the day of admission to the ICU were found to be quite reliable in predicting mortality ($p < 0.001$) [31]. Qiao *et al.* assessed the performance of APACHE-II and SOFA scores on the day of admission, and SOFA scores during the follow-up period in predicting mortality among critically ill elderly patients and reported that all scores were accurately associated with mortality [17]. Additionally, they have found that the AUC of maximum SOFA scores and the difference between the maximum and initial SOFA scores were higher than the baseline SOFA and APACHE-II scores and had better discriminatory power on mortality [17]. On the contrary, various studies have reported that the APACHE II score at presentation was not reliable in predicting the mortality rate [32,33] and suggested the use of serial measurements of SOFA score instead [33]. In our study, the higher values of both APACHE-II and SOFA scores in the first 24 hours were strongly associated with higher mortality rates without any superiority between them.

In our study, it has been revealed that all prognostic scoring models have a significant discriminative ability on the prediction of mortality among elderly patients with sepsis in the ICU ($p < 0.001$ for all). According to the pairwise comparison neither SOFA nor APACHE-II demonstrated superior predictive ability. Similarly, in a study conducted with critically ill elder sepsis patients, while both APACHE-II and SOFA scores were efficient in predicting mortality, there was no significant difference in the pairwise comparison of them [34].

The organ dysfunction scores SOFA, MODS, and LODS have many similarities including the evaluated organ systems and score range, and have proven power in predicting ICU mortality in critically ill patients [35]. The MODS score uses the worst value during ICU stay for evaluating organ dysfunction, while the SOFA and LODS scores use the worst values for each day [36–38]. In a study that compared SOFA, MODS, and LODS scores for predicting in-hospital mortality among severe sepsis adult patients, it has been demonstrated that all SOFA, MODS, and LODS scores had a reliable discrimination power on mortality, and according to AUC values, LODS had the highest accuracy to predict the outcome of patients with severe sepsis [39]. In our study, likewise, all three organ dysfunction scores had predictive power for mortality, but the highest AUC value was observed in SOFA and significantly differed from MODS and LODS.

Colussi *et al.* evaluated the predictive power of APACHE-II, SAPS-II, and SOFA scores on in-hospital mortality among mostly geriatric (82%) patients diagnosed with sepsis using the systemic inflammatory response syndrome (SIRS) criteria and reported that the highest AUC value was obtained by the SAPS-II score [36]. Our study cohort consists of only elderly patients, and we used the criteria specified in the sepsis-3 consensus instead of SIRS criteria for the diagnosis of sepsis, and we achieved the highest AUC value by APACHE-II score. A study from Thailand validating SOFA, APACHE-II, LODS, MODS, and SAPS-II scores on mortality in adult (non-elderly) ICU patients reported that AUC values of the scores were SOFA (0.879), LOD (0.880), MODS (0.861), APACHE-II (0.913) and SAPS-II (0.895), and similarly, they achieved highest value by APACHE-II score [35].

It is well known that sepsis-associated mortality rates are higher among elderly individuals than younger adults [6]. However, several studies conducted only in elderly sepsis patients have been explicit that age has no considerable role in the prediction of mortality [40–42]. Likewise, the median ages of survivors and non-survivors were similar in our study. However, the results of a study performed with sepsis patients over 65 years of age revealed that the 28-day ICU mortality was approximately 50% and was significantly higher in very elderly (≥ 80 years) patients than in elderly (65-79 years) patients (54.2% vs. 47.4%; $p = 0.02$) [15]. We assume that this difference originated from a remarkably lower mortality rate in our study among very elderly patients.

Comorbid conditions increase the risk of sepsis in elderly individuals [3,6], and in a recent study, the authors demonstrated that COPD and end-stage renal disease were associated with higher mortality rates in adult sepsis patients, while hypertension, diabetes mellitus, and coronary artery disease were unrelated [43]. Besides, a study evaluating mortality-related conditions among ICU patients revealed that more frequent comorbid conditions among the non-survivor group were end-stage heart failure, metastatic carcinoma, hematological malignancy, liver cirrhosis, and chronic kidney disease, but not COPD [35]. In this study, we included patients in relatively better conditions by excluding patients with end-stage organ failure or terminal cancer to avoid possible confounder

effects of such comorbid conditions and found that the mortality rates of elderly ICU sepsis patients were independent of any comorbid condition. Similarly, Boumendil *et al*. elicited that both comorbid conditions and functional status are associated with long-term outcomes for elderly ICU patients but not with in-hospital mortality [44].

Both CRP and procalcitonin levels are frequently found to be high at presentation in sepsis patients, but their predictive values on mortality are negligible [45,46]. Besides, both CRP and procalcitonin levels begin to gain importance at 72 hours of follow-up, and higher values can discriminate between survivors and non-survivors [45,46]. Similarly, we found that both CRP and procalcitonin levels at the time of admission were unrelated to mortality. Moreover, due to the study design, we did not follow the changes in CRP and procalcitonin values during the follow-up period.

There are some limitations in our research. First, our study is a single-center study carried out with a relatively small number of participants, which imposes limitations in terms of case diversity and differences in the quality of ICU care and has an inability of reflecting the general population. Second, because of the study setting, only elderly critically ill sepsis patients were included, and geriatric outcomes were not compared with the younger group or with critically ill patients without a diagnosis of sepsis. Third, despite we only included geriatric patients in the study, we cannot evaluate the functionality of the participants due to their recently deteriorated conditions. Finally, our study did not evaluate whether the source of sepsis was community-based or hospital, and the long-term outcomes of septic ICU patients were not examined.

Conclusions

The present study showed that all the scoring models of SOFA, APACHE-II, LODS, MODS, and SAPS-II scores were significantly associated with 28-day mortality in critically ill elderly sepsis patients, and higher scores were correlated with higher mortality rates. The AUC scores calculated by ROC curve analysis for these scoring models were 0.802 for SOFA, 0.784 for APACHE-II, 0.735 for LODS, 0.702 for MODS, and 0.780 for SAPS-II. Considering the increase in the elderly population and the increased risk of sepsis in the elders, increase in the burden of elderly septic patients in ICUs is inevitable. Due to the specific conditions of this population, methods used in the evaluation of clinical conditions and management of patients in this group should be specified or validated. For this reason, future studies are warranted to confirm the current findings, validate the use of scoring systems, and determine the scoring model of choice among advanced age patients.

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