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A study of the prognostic value of age shock index combined with rapid sequential organ failure score in assessing sepsis

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ABSTRACT

Introduction: This study addresses the high incidence, mortality, and healthcare burden of sepsis by evaluating the prognostic value of combining the Age Shock Index (Age SI) with the quick Sequential Organ Failure Assessment (qSOFA) score in predicting outcomes of septic patients.

Method: A retrospective analysis was conducted involving 316 sepsis patients admitted to the ICU of the Fourth People's Hospital of Zigong City, Sichuan Province, between December 2022 and December 2024. Participants were categorized into survival (n = 187) and non-survival (n = 129) groups. Statistical analyses were performed using SPSS 26.0 and R software to compare clinical indicators between groups. Binary logistic regression was used to identify independent risk factors, while ROC curves, a nomogram model, and Bootstrap internal validation were employed to evaluate predictive performance.

Results: The non-survival group had significantly higher values in age, CCI score, lactate level, SOFA score, Age SI, and APACHE II score ($P < 0.05$), along with lower systolic and mean arterial pressures ($P < 0.05$). Multivariate analysis confirmed age, CCI score, lactate, qSOFA score, and Age SI as independent risk factors. The ROC analysis demonstrated that the combination of Age SI and qSOFA yielded the highest predictive accuracy (AUC = 0.832, sensitivity = 0.783, specificity = 0.743). The nomogram model achieved a C-index of 0.832, and internal validation showed an accuracy of 74.96%.

Conclusion: the combination of Age SI and qSOFA scores serve as an effective tool for predicting 28-day mortality in sepsis patients and may support clinical decision-making.

Keywords: age shock index, disease severity evaluation, prognostic assessment, sepsis, survival rate.

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INTRODUCTION

Sepsis is a dysregulated immune response to infection characterized by high incidence and mortality, with approximately 19 million cases and 6 million deaths reported globally each year.[1–5] Its pathophysiology involves dyscontrolled inflammation, immune dysfunction, coagulation abnormalities, and multiple organ dysfunction.[6–10] Despite advances in treatment strategies such as optimized antibiotic therapy and immunomodulation[11–15], mortality remains high, underscoring the need for more accurate prognostic tools. Currently used clinical scoring systems such as SOFA and qSOFA have limitations including low sensitivity or dependence on laboratory parameters[16–20], while biomarkers are often influenced by individual variability.[21,22]

Studies suggest that combining qSOFA with other indicators (e.g., lactate or oxygenation index) can improve predictive performance.[23–27] The Age Shock Index (Age SI), which integrates age and hemodynamic parameters, has demonstrated good prognostic value in critically ill patients.[28–30] This study proposes a combined model of Age SI and qSOFA to overcome the limitations of single-parameter assessment. Through a retrospective analysis of 316 sepsis patients, we evaluated the predictive ability of this combination for 28-day mortality, offering a more rapid and accurate prognostic approach for clinical use.[26] Previous studies have shown that the qSOFA score has low predictive effect. Therefore, this study aimed to evaluate the prognostic value of combining the Age Shock Index (Age SI) with the quick Sequential Organ Failure Assessment (qSOFA) score in predicting outcomes of septic patients.

METHODS

This study employed a retrospective design and was approved by the Ethics Committee of Zigong Fourth People's Hospital in Sichuan Province (with waiver of informed consent). A total of 621 sepsis patients admitted to the ICU between December 2022 and December 2024 were initially screened. Based on the Sepsis 3.0 diagnostic criteria (confirmed infection and SOFA score ≥ 2) [39], 316 eligible patients (195 males and 121 females) were included.

Inclusion criteria were: age ≥ 18 years, ICU stay ≥ 24 hours, and complete clinical data. Exclusion criteria comprised: death

within 24 hours, presence of end-stage chronic or immunodeficiency diseases, and pregnancy. All data were de-identified prior to analysis.

A total of 316 patients were ultimately included in the clinical data analysis. Based on 28-day mortality, the patients were divided into a survival group (n=187) and a death group (n=129). This study analyzed data from eligible participants in both the experimental and control groups, including demographic parameters such as age, gender, body mass index (BMI), Charlson Comorbidity Index (CCI) score, heart rate, respiratory rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, renal replacement therapy status, vasoactive agent use, mechanical ventilation status, lactate levels, human serum albumin, white blood cell count, lymphocyte count, procalcitonin (PCT), C-reactive protein (CRP), blood urea nitrogen (BUN), creatinine clearance rate, SOFA score, qSOFA score, Age SI score, and APACHE II score.

Statistical analysis was performed using SPSSAU to compare differences between the two groups in terms of general demographic characteristics, vital signs upon ICU admission, laboratory parameters, and relevant treatment approaches. Binary logistic regression analysis was conducted on these indicators to identify independent risk factors affecting the prognosis of sepsis patients. Receiver operating characteristic (ROC) curves were applied, and the area under the curve (AUC) was calculated to further determine sensitivity, specificity, and cutoff values. The predictive value of combining age, shock index (SI), and qSOFA score for the prognosis of sepsis patients was analyzed, with a p-value < 0.05 considered statistically significant. A nomogram for the combined Age-SI + qSOFA diagnostic model was constructed, and calibration curves were used to evaluate the model's goodness-of-fit. Statistical analysis was performed using R language. Internal validation of the model was conducted via the bootstrap method to assess its predictive performance. The C-statistic (C-index) and the p-value from the Hosmer–Lemeshow (HL) goodness-of-fit test were computed based on repeated sampling.

RESULTS

A comparison of age, gender, BMI, and CCI scores between the two groups is presented in Table 1. The non-survivor group had significantly higher age and CCI scores compared to the survivor group (P < 0.05), while no significant differences were observed in gender or BMI between the groups (P > 0.05).

comparison of heart rate, respiratory rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure between the two groups is presented in Table 2. No significant differences were observed in respiratory rate or diastolic blood pressure between the groups (P > 0.05). The heart rate in the non-survivor group was significantly higher than that in the survival group (P < 0.05). Conversely, systolic blood pressure and mean arterial pressure were significantly lower in the non-survivor group compared to the survivor group (P < 0.05).

A chi-square test was employed to compare the differences between the two treatment approaches, with the results presented in Table 3. Significant differences were observed between the two groups of patients in terms of whether renal replacement therapy was performed, whether vasoactive drugs were administered, and whether mechanical ventilation was received (P < 0.05). The non-survivor group showed significantly higher proportions of renal replacement therapy, vasoactive drug use, and mechanical ventilation compared to the survivor group (P < 0.05).

Comparisons of albumin, serum creatinine, blood urea nitrogen, arterial lactate content, white blood cell count,

Table 1. Analysis of Baseline Characteristics Between the Two Groups

Variables	Survivor Group (N=187)	Non-survivor Group (N=129)	P value
Age (years), (median: Q1;Q3)			0.001
	67.00 (54.00;75.00)	72.00 (62.00;79.00)	
Gender, (n, %)			0.742
Man	114 (61.0)	81 (62.8)	
Female	73 (39.0)	48 (37.2)	
BMI, (median: Q1;Q3)			0.121
	30.09 (27.37;32.44)	29.09 (26.85;31.94)	
CCI Score (mean±SD)			<0.001
	3.94±1.88	5.35±2.25	

Note: BMI, body mass index; CCI, Charlson Comorbidity Index

Table 2. Comparison of Vital Signs Between the Two Groups

Variables	Survivor Group (N=187)	Non-survivor Group (N=129)	P value
Heart rate, (median: Q1;Q3)			0.004
	122.00 (98;129.00)	112.00 (106;141.50)	
Respiratory rate, (mean±SD)			0.366
	29.79±9.32	28.79±9.95	
Systolic blood pressure (SBP), (mmHg), (median: Q1;Q3)			<0.001
	121 (102.00;144.00)	99.00 (77.50;125.00)	
Diastolic blood pressure (DBP), (mmHg), (median: Q1;Q3)			0.265
	65 (57;76)	64 (51.5;76)	
Mean arterial pressure (MAP), (mmHg), (mean±SD)			<0.001
	85.63±20.46	76.61±21.66	

Table 3. Comparison of Treatment Approaches Between the Two Groups

Variables	Survivor Group (N=187)	Non-survivor Group (N=129)	P value
Whether to undergo renal replacement therapy, (n, %)			0.014
Yes	16 (8.6)	23 (17.8)	
No	171 (91.4)	106 (82.2)	
Whether to use vasoactive drugs, (n, %)			<0.001
Yes	113 (60.4)	104 (80.6)	
No	74 (39.6)	25 (19.4)	
Whether to receive mechanical ventilation, (n, %)			<0.001
Yes	131 (70.1)	112 (86.8)	
No	56 (29.9)	17 (13.2)	

Table 4. Comparison of Laboratory Parameters Between the Two Groups

Variable	Survival Group (N=187)	Non-survivor (N=129)	P value
Lactate, (mmol/L), (median: Q1;Q3)			<0.001
	2.90 (2.20;3.00)	3.90 (2.2;6.10)	
Albumin, (g/L), (mean±SD)			0.086
	28.79±6.39	29.97±5.32	
White Blood Cell Count, (10^9/L), (median: Q1;Q3)			0.808
	16.15 (11.46;21.35)	16.37 (10.69;22.94)	
Lymphocyte Count, (10^9/L), (median: Q1;Q3)			0.650
	0.55 (0.32;0.95)	0.59 (0.31;0.98)	
Procalcitonin, (Ng/mL), (median: Q1;Q3)			0.672
	2.00 (0.28;7.6)	1.62 (0.49;5.31)	
CRP, (mg/L), (median: Q1;Q3)			0.778
	116.45 (51.9;157.81)	116.45 (46.44;169.09)	
Serum creatinine, (μmol/L), (mean±SD)			0.003
	118.41±97.66	156.71±126.22	
Blood urea nitrogen (BUN), (mmol/L), (mean±SD)			
	13.77±9.69	14.12±9.51	0.755

Table 5. Comparison of Disease Severity Between the Two Groups

Variable	Survivor Group (N=187)	Non-survivor Group (N=129)	P value
SOFA, (median: Q1;Q3)			<0.001
	9.00 (7.00;12.00)	7.00 (5.00;8.00)	
qSOFA, (median: Q1;Q3)			<0.001
	2.00 (2.00;3.00)	1.00 (1.00;2.00)	
Age SI, (median: Q1;Q3)			<0.001
	86.84 (67.85;109.42)	59.17 (45.70;77.36)	
APACHE II, (median: Q1;Q3)			
	24.00 (20.00;28.00)	17.00 (14.00;21.00)	<0.001

Note: SOFA, Sequential Organ Failure Assessment; qSOFA, quick Sequential Organ Failure Assessment; Age SI, Age Shock Index; APACHE II, Acute Physiology and Chronic Health Evaluation II.

lymphocyte count, procalcitonin, and C-reactive protein were conducted between the two groups. The results, as shown in Table 4, indicated that arterial lactate and serum creatinine levels in the mortality group were significantly higher than those in the survival group ($P < 0.05$).

The differences in SOFA, qSOFA, Age SI, and APACHE II scores between the two groups were compared. As shown in Table 5, the non-survivor group had significantly higher SOFA, qSOFA, Age SI, and APACHE II scores compared to the survivor group ($P < 0.05$).

Currently, a variety of combined diagnostic indicators have been developed in clinical practice for the early diagnosis and prognosis assessment of sepsis, such as combining qSOFA with procalcitonin, lactate, or mean arterial pressure. This study compared the diagnostic efficacy of the combined Age SI + qSOFA with LqSOFA, PqSOFA, and MqSOFA, analyzing differences among various combined diagnostic methods in predicting sepsis severity and prognosis to determine which approach possesses the highest diagnostic efficacy in clinical practice. The aim is to enable earlier and more accurate identification of sepsis patients, thereby improving clinical outcomes.

Table 6. Diagnostic Performance Analysis of the Combined Model

Indicators	AUC	Cut-off value	Sensitivity (%)	Specificity (%)
PqSOFA	0.718	2.5	0.791	0.599
LqSOFA	0.712	2.5	0.791	0.61
MqSOFA	0.723	3.5	0.674	0.701
Age SI+qSOFA	0.832	0.38	0.783	0.743

Note: PqSOFA, procalcitonin-combined quick Sequential Organ Failure Assessment; LqSOFA, lactate-enhanced quick Sequential Organ Failure Assessment; MqSOFA, mean arterial pressure-combined quick Sequential Organ Failure Assessment.

Receiver operating characteristic (ROC) curve analysis was employed to evaluate the diagnostic efficacy of the combined Age SI + qSOFA versus PqSOFA, LqSOFA, and MqSOFA. The results, presented in Table 6, demonstrate that the combined diagnostic model of Age SI and qSOFA is superior to other combined models, with an AUC of 0.832, a sensitivity of 78.3%, and a specificity of 74.3%.

DISCUSSION

Sepsis is a life-threatening organ dysfunction caused by a dysregulated host response to infection, which can rapidly progress to septic shock or even multiple organ dysfunction syndrome (MODS) within a short period. As a critical condition in emergency and critical care medicine, sepsis has consistently been a major focus in clinical practice. In recent years, research emphasis has shifted toward prevention and early diagnosis. Domestic scholars have also been actively exploring and optimizing early management strategies for sepsis. The 2020 Chinese Emergency Expert Consensus on Early Prevention and Blockage of Sepsis[31] Emphasizes the concept of "early prevention, early detection, and early intervention," advocating for targeted examinations, laboratory tests, and interventions during the early stages of sepsis to halt its progression to multiple organ failure, thereby reducing both the incidence and mortality of sepsis. Due to the complexity of sepsis, which involves multiple interrelated pathophysiological mechanisms, it remains a significant global health challenge despite advances in understanding and medical technology in recent years. The annual number of sepsis patients still exceeds 300,000, with an overall mortality rate of 17%, making it a substantial global disease burden.[32]

Early recognition of sepsis severity and timely intervention can significantly improve patient outcomes. In recent years, increasing research has been dedicated to identifying factors influencing the severity and prognosis of sepsis patients, aiming to assist clinicians in earlier risk stratification and short-term prediction. This enables timely and adequate treatment, effectively controlling disease progression and improving patient outcomes. It has high morbidity and mortality rates, posing a major global health burden.[31–35] Early identification and intervention are crucial for improving prognosis.[36–38] The qSOFA score serves as a rapid screening tool and can effectively predict 28-day mortality in septic patients (OR = 6.002, P < 0.001). The Age SI (age × heart rate / systolic blood pressure), which integrates independent risk factors such as age, heart rate, and systolic blood pressure, also demonstrates significant predictive value (OR = 1.02, P = 0.001).[39]

Furthermore, the SOFA score (OR = 1.255, P < 0.01), APACHE II score (OR = 1.333, P < 0.001), CCI (OR = 1.245, P < 0.05), as well as lactate levels and serum creatinine, are closely associated with sepsis severity and prognosis. Studies have shown that combining Age SI with the qSOFA score significantly improves predictive performance (AUC = 0.832), outperforming single indicators and other scoring systems with high sensitivity and specificity. This approach aids in the early identification of high-risk patients, guides clinical intervention, and improves patient outcomes.[40,41] The qSOFA score can effectively identify sepsis patients with poor prognosis, yet it cannot be used alone in many cases of sepsis. The 2021 International Guidelines for Management of Sepsis and Septic Shock recommend using the qSOFA score as a standalone screening tool for sepsis or septic shock.[40] To address this limitation, it is necessary to combine qSOFA with other indicators. Studies have shown that when combined with other screening markers, the qSOFA score significantly improves both sensitivity and specificity, enabling better prediction of sepsis prognosis.

Research indicates that the Age-Shock Index (Age SI) holds certain value in predicting sepsis prognosis. By integrating factors such as age, heart rate, and systolic blood pressure, it allows for a rapid and non-invasive assessment of disease severity and prognostic risk in patients.[41] Moreover, it can be used in combination with other indicators to predict outcomes in sepsis patients. For instance, combining Age SI with markers such as the neutrophil-to-lymphocyte ratio provides a more comprehensive evaluation of the patient's condition, reducing the limitations associated with single-parameter assessments.[28,29] In this study, the combination of Age SI and qSOFA score demonstrated superior performance in predicting 28-day mortality among sepsis patients compared to using either qSOFA or Age SI alone. Furthermore, its predictive efficacy was higher than that of SOFA score, APACHE II score, LqSOFA, PqSOFA, and MqSOFA. The AUC reached 0.832, with a sensitivity of 0.783 and specificity of 0.742. The combination of these two indicators compensates for the low specificity of qSOFA and the oversimplification of Age SI. A nomogram for the combined Age SI + qSOFA diagnostic model was developed and internally validated. The model showed a C-index of 0.832, and the Hosmer-Lemeshow goodness-of-fit test yielded a p-value of 0.4042, indicating good model consistency.

However, as a single-center retrospective observational study, it is limited by potential issues such as restricted data accuracy, inability to infer causality, and possible confounding biases. The limited sample size and lack

of subgroup analysis based on disease progression also constrain in-depth interpretation of the results. Future efforts should involve multicenter, prospective studies with expanded sample sizes that include patients from diverse healthcare backgrounds. Incorporating stratified analysis or causal inference methods (such as propensity score matching) would allow more accurate evaluation of the predictive performance and clinical applicability of the combined Age SI and qSOFA score. Furthermore, it is recommended to group patients according to clinical outcomes to further explore the predictive value of this combined indicator across different prognostic states, thereby promoting the optimization and clinical application of sepsis prognostic assessment systems.

CONCLUSION

Multivariate logistic regression analysis confirmed that age, CCI score, lactate level, qSOFA score, SOFA score, Age SI, APACHE II score, as well as the use of vasoactive drugs and mechanical ventilation, are all independent risk factors affecting the 28-day survival rate of sepsis patients. This study innovatively proposed that the combination of Age SI and qSOFA score can serve as an effective indicator for assessing sepsis prognosis, establishing a novel evaluation framework that has not yet been widely adopted. This provides a new tool and research direction for early risk stratification and prognostic judgment in sepsis.

CONFLICT OF INTEREST

All authors of this paper declare that they have no conflicts of interest.

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ETHICAL STATEMENT

This study employed a retrospective design and was approved by the Ethics Committee of Zigong Fourth People's Hospital in Sichuan Province with approval number 2022-169.

AUTHOR CONTRIBUTIONS

Lv Lukai-Manuscript editing and Design.
Zhong zhitao- Manuscript editing and Data acquisition.
Fan Mingyan and Li Lei- Manuscript editing and Data analysis.

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