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ORIGINAL RESEARCH

Prognostic Models Using the Lactate-to-Albumin Ratio for 28-Day Mortality in ICU Sepsis Patients: A Bayesian Model Averaging Approach

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Purpose: The lactate-to-albumin ratio (LAR) has recently emerged as a significant predictor of 28-day mortality in sepsis. This study aims to determine the prognostic value of LAR for 28-day mortality and identify prognostic models for sepsis patients.

Patients and Methods: A prospective study was conducted on patients admitted to the Intensive Care Unit at Thong Nhat Hospital, Vietnam. The study included patients aged 16 years and older diagnosed with sepsis according to the Sepsis-3 consensus guidelines. The primary outcome was all-cause mortality within 28 days from the time of sepsis diagnosis. Multivariable logistic regression estimated odds ratios (ORs). Bayesian model averaging (BMA) was used to identify candidate models. Discrimination was evaluated by the area under the curve (AUC), and calibration was assessed.

Results: This study included 170 participants with a median age of 73 years and a male predominance (54.1%). The overall 28-day mortality rate was 57.6%. The median LAR was 2.2, with a statistically significant difference between the survival and mortality groups ($p < 0.001$). Multivariate logistic regression analysis revealed that LAR was independently associated with 28-day mortality (OR, 2.74; 95% CI, 1.09–6.86; $p = 0.017$). The AUC for LAR was 0.81 (95% CI 0.75–0.87; $p < 0.001$) with a cut-off point of 1.2 (sensitivity 91%, specificity 57%). BMA identified three clinically applicable models: LAR combined with age and respiratory infection (AUC 0.855), LAR combined with respiratory infection (AUC 0.839), and LAR combined with age and respiratory infection and SOFA score (AUC 0.864). Internal validation also represented the stability and reproducibility of these models with AUC 0.848, 0.836, and 0.854, respectively.

Conclusion: In this single-center cohort, higher LAR was independently associated with 28-day mortality, and BMA identified simple LAR-based models with good internal discrimination and calibration. These findings require further external validation before routine clinical implementation.

Keywords: sepsis, lactate-to-albumin ratio, prognosis, intensive care unit, mortality

Introduction

Sepsis is defined as a life-threatening organ dysfunction caused by a dysregulated host response to infection.[1] The complex pathophysiology of sepsis involves excessive inflammation, microvascular dysfunction, and metabolic derangements, which ultimately impair tissue oxygenation and contribute to multi-organ failure.[2] The rising incidence and complex nature of sepsis and septic shock present major challenges for clinicians.[1–3] A meta-analysis of 29 studies reported mortality rates of 29% in sepsis and 37.9% in septic shock.[4]

Biomarkers play an important role in the diagnosis, risk stratification, and prognostication of sepsis.[5] Among them, serum lactate is a key indicator of tissue hypoperfusion and is incorporated into the Sepsis-3 diagnostic framework.[1] Elevated lactate reflects impaired cellular metabolism and is associated with poor prognosis in critically ill patients, though it may be confounded by factors such as adrenergic stimulation, liver or renal dysfunction, and comorbidities.[5,6] Besides, Serum albumin also has

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prognostic value, with hypoalbuminemia (often defined as below 35 g/L) common in critically ill patients and associated with worse outcomes, especially in sepsis and sepsis shock.[7,8] However, albumin levels are influenced by comorbidities, nutritional status, and aging, especially in the elderly.[9]

To overcome the limitations of individual biomarkers, the lactate-to-albumin ratio (LAR) has recently been proposed as a composite index integrating the acute metabolic stress reflected by lactate with the chronic nutritional and inflammatory status captured by albumin.[9] Several studies have demonstrated that LAR outperforms lactate or albumin alone in predicting short-term mortality in sepsis patients. For instance, Shin et al reported that LAR was independently associated with 28-day mortality, with superior discriminative ability compared to lactate alone.[10] Li et al and Hu et al further confirmed the prognostic relevance of LAR across diverse ICU populations.[11,12]

Despite these promising findings, there remains a paucity of evidence on the clinical utility of LAR in sepsis patients from low- and middle-income countries, where the burden of sepsis is particularly high and resources are limited. Additionally, while individual studies have reported the prognostic role of LAR, few have attempted to integrate LAR into multivariable prognostic models alongside established clinical predictors. Given the heterogeneity of sepsis and the urgent need for reliable, practical tools for early risk stratification, the development of robust prognostic models incorporating LAR may provide important clinical value.

Therefore, this study aimed to (1) evaluate the prognostic value of LAR for predicting 28-day mortality in sepsis patients admitted to the ICU, and (2) establish and internally validate prognostic models integrating LAR with other key clinical variables for practical application in critical care settings.

Materials and Methods

Study Design

This prospective study was conducted from January 2023 to December 2024 at the Intensive Care Unit (ICU) of Thong Nhat Hospital, a tertiary care facility in Ho Chi Minh City, Vietnam. The study enrolled 170 patients aged 16 years and older, all of whom were diagnosed with sepsis based on the Sepsis-3 criteria and admitted to the ICU.[1] Patients were excluded if they had received albumin infusion within the previous three weeks, had nephrotic syndrome or cirrhosis, were pregnant, or were lactating.

Sample Size Calculation

The sample size was calculated using the formula for the area under the curve (AUC), following the equations:[13]

$$n_{Patients} = n_{Controls} \geq \frac{Z^2_{1-\frac{\alpha}{2}} \cdot V_{AUC}}{d^2}$$

$$V_{AUC} = \left(0.0099.e^{\frac{-a^2}{2}}\right).\left(6a^2 + 16\right)$$

$$a = 1.414.Z_{AUC}$$

$$Z_{AUC} = \phi^{-1}(AUC)$$

Based on the study by Jikyoung Shin et al,[10] which reported an AUC of 0.69 for LAR for predicting 28-day mortality, with an allowable error margin (d) of 0.09 and a type I error rate (α) of 0.05. Accordingly, the standard normal deviate was set at $Z_{(1-\alpha/2)} = 1.96$. The inverse cumulative normal distribution function of the AUC was used to determine the value of Z_{AUC}. Based on these parameters, the minimum required sample size was estimated as n (patient) = n (control) ≥ 70. Therefore, at least 70 cases and 70 controls were necessary to ensure the desired precision in estimating the AUC. After adjusting for a 10% sample loss in prospective studies, the minimum required sample size was 154 patients.

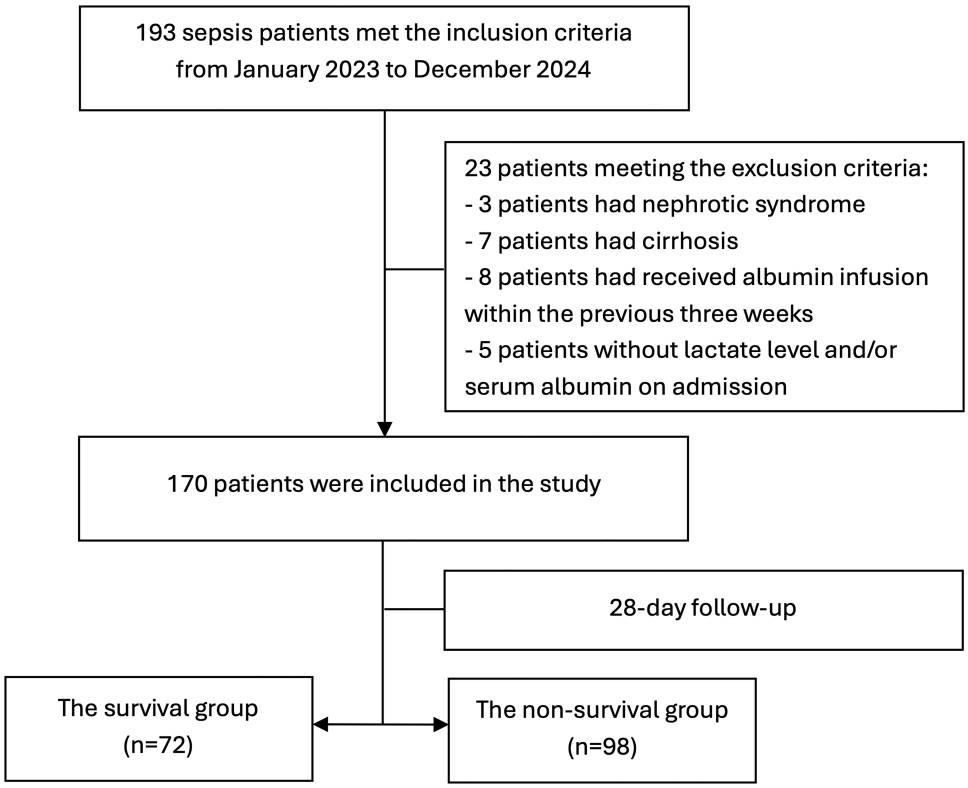

Figure 1 Recruitment flowchart.

Data Collection

For eligible patients, data collection involved recording information from medical history, hospital records, and previous discharge papers. Attending physicians completed a data collection form for each patient.

Blood samples were obtained at admission to measure lactate and albumin levels. These samples were processed within one hour at the Biochemistry Department: serum lactate was analyzed using the AU5800 analyzer (expressed in mmol/L), and serum albumin was measured using the Cobaspro analyzer (expressed in g/dL). Patients were followed for 28 days to assess outcomes, categorized as either survival or non-survival. Mortality was defined as death within 28 days after the diagnosis of sepsis was established according to Sepsis-3 criteria, both in-hospital and post-discharge deaths. The sampling procedure of the study is presented in Figure 1.

Definition of Main Variables

Comorbid conditions were defined based on standardized criteria. Hypertension was diagnosed if systolic blood pressure was ≥ 140 mmHg and/or diastolic blood pressure was ≥ 90 mmHg or if patients had a documented diagnosis in medical records and were prescribed antihypertensive medication.[14] Diabetes Mellitus was identified based on medical records, prescriptions, and ongoing antihyperglycemic treatment, or by following the 2023 standards of the American Diabetes Association.[15] Cardiovascular diseases included chronic coronary artery disease, heart failure, or atrial fibrillation documented in medical records and/or requiring ongoing treatment. Coronary artery disease was defined as ischemic heart disease, a history of acute coronary syndrome, or previous coronary revascularization. Heart failure or atrial fibrillation was diagnosed according to European Society of Cardiology guidelines or based on ongoing treatment.[16,17] Stroke included ischemic or hemorrhagic strokes diagnosed based on medical records, prescriptions, or prior healthcare evaluations. Chronic obstructive pulmonary disease (COPD) or bronchiectasis was identified through medical records or prescriptions, with COPD specifically documented through medical records, prescriptions, or spirometry results. Chronic kidney disease (CKD) was defined as a diagnosis of CKD based on KDIGO criteria for at least three months prior to admission, an estimated glomerular filtration rate < 60 mL/min/1.73 m^2

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(measured at least three months before admission), or imaging or abnormal urinary findings persisting for three months prior to admission.[18] Chronic liver disease referred to liver dysfunction lasting longer than six months, as recorded in medical records or ongoing treatments. Finally, cancer was defined as any diagnosis of malignancy documented in medical records or requiring active treatment.

Statistical Analysis

Data were compiled using Microsoft Excel and analyzed with R 2023 software. Quantitative variables were assessed for normality using graphical methods, comparisons of means and medians, and the Shapiro–Wilk test. Normally distributed variables were reported as mean ± standard deviation and compared using the *t*-test. Non-normally distributed variables were expressed as medians with interquartile ranges (IQR) and analyzed using the Mann–Whitney *U*-test. Qualitative variables were compared between groups by Fisher's exact or chi-square tests.

All data were collected completely; cases with missing information were excluded from the analysis. The predictive value of LAR was assessed using a receiver operating characteristic (ROC) curve, which plots sensitivity against the false positive rate. The accuracy of LAR was determined by the AUC, with thresholds defined as ≥ 0.70 for acceptable accuracy, ≥ 0.80 for good accuracy, and ≥ 0.90 for excellent accuracy. The optimal cut-off value was selected based on the highest Youden index (J = sensitivity + specificity - 1). To identify potential predictors of 28-day mortality, we first performed univariate logistic regression. Variables with a significance level of $p < 0.20$ were subsequently included in the multivariable logistic regression model. Multicollinearity was assessed by calculating variance inflation factors and further examined using least absolute shrinkage and selection operator (LASSO) regression to avoid overfitting.

Variables retained after this step were subjected to Bayesian model averaging (BMA), which evaluates the entire set of possible models and assigns posterior probabilities to identify those with the highest likelihood of being optimal. This approach allowed us to capture model uncertainty and select candidate prognostic models that combined both statistical robustness and clinical interpretability. By evaluating the full model space and weighting by posterior probabilities, BMA reduces overfitting and yields more robust estimates, enabling assessment of LAR's independent contribution alongside other potential factors. Model performance was assessed on two domains. Discrimination was quantified using the AUC with 95% confidence interval (CI). Calibration was evaluated by calibration plots, Brier score, and R^2 to assess the agreement between predicted and observed outcomes. Finally, internal validation was performed using bootstrap resampling with 1,000 iterations to examine the stability and reproducibility of model performance.

Ethical Considerations

This study was approved by the Ethics Committee in Biomedical Research at Thong Nhat Hospital (Approval number: 01/2023/BVTN-HDYD). Written informed consent was obtained from all participants or their legally authorized representatives before enrollment in the study. For patients who were unable to provide consent due to their medical condition, consent was obtained from their family members or legal guardians following the hospital's ethical guidelines. All procedures were conducted following the principles of the Declaration of Helsinki.

Results

A total of 170 patients diagnosed with sepsis in the ICU were included in the study and analyzed. The demographic and clinical characteristics of the study population are detailed in Table 1. The 28-day mortality rate among these patients was 57.6% (98/170). The median SOFA score within 24 hours was 8 (IQR 5–10), significantly higher in non-survivors than survivors ($p < 0.001$). The median APACHE II score was 18 (IQR 14–24), also higher in non-survivors ($p < 0.001$). Median serum lactate concentration was 4.95 mmol/L, approximately twice as high in non-survivors as in survivors ($p < 0.001$). Mean serum albumin was 2.59 ± 0.59 g/dL, lower in non-survivors than survivors (2.50 ± 0.62 vs 2.71 ± 0.50 g/dL, $p = 0.009$). LAR had a median of 2.2, and was markedly elevated in non-survivors compared to the survival group (2.9 vs 1.1, $p < 0.001$).

Multivariable logistic regression identified LAR as independently associated with mortality (OR 2.74, 95% CI 1.09–6.86, $p = 0.017$), along with respiratory infection (OR 2.96, 95% CI 1.29–6.79, $p = 0.009$) and age (OR 1.03, 95% CI 1.01–1.06, $p = 0.016$) (Table 2).

Table 1 Baseline Characteristics of Participants

Variables	Overall (n = 170)	Survival (n = 72)	Non-Survival (n = 98)	p-value
Age (years)	73 (62–85)	68.5 (56–78)	77.5 (66–86)	<0.001[a]
Sex (Male)	92 (54.1)	43 (59.7)	49 (50.0)	0.209[b]
SOFA score	8 (5–10)	6.5 (4–9)	9 (6–11)	<0.001[a]
APACHE II score	18 (14–24)	17 (12–21)	19 (15–25)	<0.001[a]
Comorbidities				
Diabetes	59 (34.7)	23 (31.9)	36 (36.7)	0.517[b]
Hypertention	105 (61.8)	43 (59.7)	62 (63.3)	0.639[b]
Cardiac diseases	49 (28.8)	24 (33.3)	25 (25.5)	0.266[b]
Cerebrovascular disease	25 (14.7	7 (9.7)	18 (18.4)	0.116[b]
Chronic lung disease	8 (4.7)	6 (8.3)	2 (2.0)	0.072[c]
Chronic renal disease	13 (7.6)	3 (4.2)	10 (10.2)	0.143[c]
Chronic liver disease	4 (2.4)	2 (2.8)	2 (2.0)	1.000[c]
Cancer	12 (7.1)	5 (6.9)	7 (7.1)	0.960[c]
Suspected infection focus				
Respiratory infection	87 (51.2)	26 (36.1)	61 (62.2)	<0.001[b]
Urinary tract infection	34 (20.0)	11 (15.3)	23 (23.5)	0.187[b]
Intra-abdominal infection	44 (25.9)	24 (33.3)	20 (20.4)	0.057[b]
Skin and soft tissue infection	16 (9.4)	11 (15.3)	5 (5.1)	0.025[c]
Other or unknown	16 (9.4)	9 (12.5)	7 (7.1)	0.237[b]
Initial vital signs				
Glasgow score	14 (9–15)	15 (14 −15)	12 (8–15)	<0.001[a]
Heart rate (per minute)	105.5 (93–124)	106.5 (94–124)	105 (93–126)	0.975[a]
Body temperature (°C)	37.0 (36.7–38.3)	37.6 (37.0–38.5)	37.0 (36.6–38.1)	0.061[a]
Respiratory rate (per minute)	25 (20–30)	24 (21–28)	26 (20–30)	0.446[a]
Mean arterial pressure (mmHg)	83 (70–103)	87 (73–104)	80 (70–100)	0.155[a]
SpO_2 (%)	93 (86–95)	93 (90–95)	90 (85–96)	0.203[a]
Laboratory and microbiology test				
White blood cell (K/uL)	14.4 (9.4–21.5)	15.1 (11.0–20.7)	14.0 (8.7–21.8)	0.292[a]
Hematocrit (%)	33.76 ± 7.82	33.92 ± 6.67	33.65 ± 8.59	0.868[d]
Platelets (K/uL)	175.5 (119.0–252.5)	193.5 (135.5–237.0)	173.0 (104.5–262.0)	0.454[a]
Total bilirubin (μmol/l)	16.5 (11.4 −31.4)	14.9 (10.4–27.7)	18.0 (11.8–31.8)	0.327[a]
AST (IU/l)	62.0 (33.5–124.0)	67.0 (35.0–123.0)	58.0 (33.0–122.5)	0.930[a]
ALT (IU/l)	38.0 (21.0–83.0)	42.0 (24.5–90.5)	37.5 (19.5–75.0)	0.406[a]

(*Continued*)

Table 1 (Continued).

Variables	Overall (n = 170)	Survival (n = 72)	Non-Survival (n = 98)	p-value
Ure (mmol/l)	12.2 (8.0–17.1)	11.7 (7.3–18.7)	12.4 (8.5–16.9)	0.569[a]
Creatinine (μmol/l)	154.5 (106.3–240.5)	163.5 (111.5–275.3)	154.0 (106.3–224.3)	0.263[a]
Lactate (mmol/l)	4.9 (3.1–8.1)	3.16 (2.1–5.5)	7.1 (4.1–10.1)	<0.001[a]
Albumin (g/dl)	2.59 ± 0.59	2.71 ± 0.50	2.50 ± 0.62	0.009[d]
Lactate/albumin ratio	2.2 (1.1–3.4)	1.1 (0.8–2.2)	2.9 (1.7–4.1)	<0.001[a]
Procalcitonin (ng/mL)	10.7 (2.2–63.1)	14.9 (2.4–75.4)	10.1 (2.0–54.4)	0.723[a]
Blood culture-positive	44 (25.9)	17 (23.6)	27 (27.6)	0.562[b]
Outcomes				
Invasive mechanical ventilation	103 (60.6)	20 (27.7)	83 (84.7)	<0.001[b]
Renal replacement therapy	41 (24.1)	11 (15.3)	30 (30.6)	0.021[b]
Days in ICU	6 (2–14)	7 (3–15.5)	5 (2–13)	0.027[a]

Notes: Data were shown as the median (interquartile range) or frequencies (percentages), except Albumin and Hematocrit were shown as the mean ± standard deviation. [a]Mann–Whitney *U*-test, [b]chi-square test, [c]Fisher's exact test, and [d]t-test.
Abbreviations: ALT, alanine transaminase; APACHE, acute physiology and chronic health evaluation; AST, aspartate transaminase; ICU, intensive care unit; SOFA, sequential organ failure assessment.

Table 2 Multivariate Logistic Regression Analysis

Risk Factors	OR	95% CI	p-value
Age	1.03	1.01–1.06	0.018
Respiratory infection	2.96	1.29–6.79	0.011
Lactate	1.01	0.70–1.45	0.956
LAR	2.74	1.09–6.86	0.032
SOFA	1.13	0.98–1.30	0.099
APACHE II	1.01	0.93–1.08	0.888

Abbreviations: APACHE, acute physiology and chronic health evaluation; CI, confidence interval; LAR, lactate-to-albumin ratio; OR, odds ratio; SOFA, sequential organ failure assessment.

The ROC curve analysis indicated that LAR alone predicted 28-day mortality with an AUC of 0.81 (95% CI 0.75–0.87; $p < 0.001$) (Figure 2). The optimal cut-off point was 1.2, with a sensitivity of 91% and specificity of 57%. The positive predictive value was 74%, and the negative predictive value was 82% (Supplemental table).

BMA confirmed the consistent prognostic contribution of LAR, respiratory infection, and age. Three optimal models were identified: (i) LAR + age + respiratory infection, (ii) LAR + respiratory infection, and (iii) LAR + age + respiratory infection + SOFA score (Figure 3). The LAR + age + respiratory infection model showed favorable performance (AUC 0.855) with good calibration (Table 3, Figure 4). Similarly, for the model that combines LAR with the respiratory infection variable and the model that combines LAR with age, the respiratory infection, and SOFA score variables, the AUCs were 0.839 and 0.864, respectively.

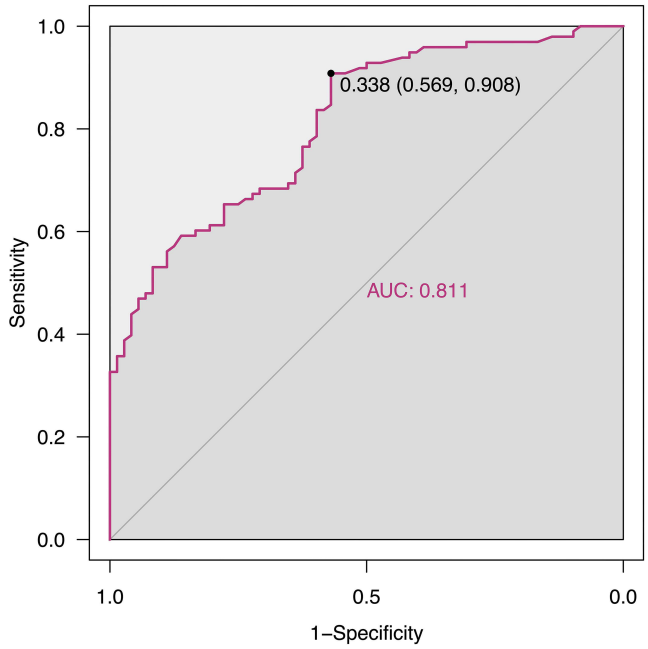

Figure 2 Receiver operating characteristic curve analysis of lactate-to-albumin ratio.
Abbreviations: AUC, area under the curve.

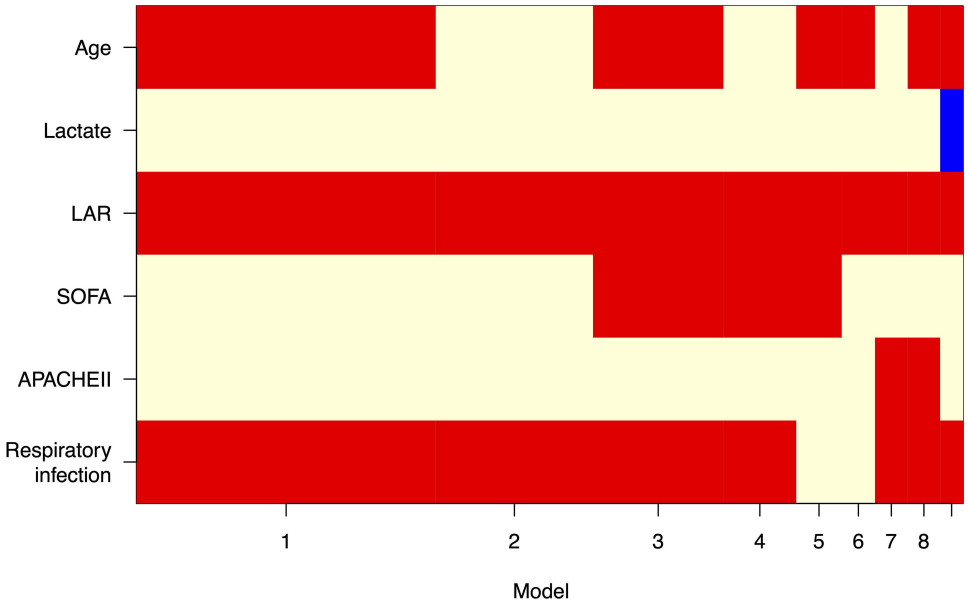

Figure 3 Bayesian model averaging for selection of 28-day mortality prognostic models in patients with sepsis.
Abbreviations: APACHE, acute physiology and chronic health evaluation; LAR, lactate-to-albumin ratio; SOFA, sequential organ failure assessment.

To further evaluate the stability of model performance, we conducted internal validation. The three candidate models (LAR + age + respiratory infection, LAR + respiratory infection, and LAR + age + respiratory infection + SOFA) all retained good discrimination after internal validation, with AUCs of 0.848, 0.836, and 0.854, respectively. Calibration slopes remained close to 1 (0.956–0.983), suggesting no substantial overfitting. The Brier scores (0.158–0.167) indicated acceptable overall accuracy. These results support the robustness of the identified LAR-based models (Table 3). Based on the results, a prognostic nomogram incorporating LAR, age, and respiratory infection was developed (Figure 5).

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Table 3 Comparison of Prognostic Models

	Apparent Performance				Internal Validation			
	R^2	AUC	Brier	Slope	R^2	AUC	Brier	Slope
LAR and age, respiratory infection	0.480	0.855	0.153	1.000	0.484	0.848	0.161	0.956
LAR and respiratory infection	0.446	0.839	0.161	1.000	0.451	0.836	0.167	0.983
LAR and age, respiratory infection, SOFA	0.497	0.864	0.148	1.000	0.502	0.854	0.158	0.936

Abbreviations: AUC, area under the curve; LAR, lactate-to-albumin ratio; SOFA, sequential organ failure assessment.

Discussion

Sepsis-related mortality rates remain high, ranging from 30% to 60%, despite advancements in the diagnosis and treatment of sepsis, such as the development of new antibiotics and continuous renal replacement therapy.[4,6] Additionally, many biomarkers have been studied and utilized to identify patients for treatment, assess disease severity, and predict outcomes.[5] Currently, serum lactate concentration is considered a critical parameter for evaluating tissue perfusion and infection status.[1] Serum lactate is included in the Sepsis-3 consensus recommendations and is widely applied in clinical practice.[1] In addition to lactate, serum albumin is also recognized as an indicator for predicting mortality in sepsis patients.[19] Serum albumin concentrations below 35 g/L in adults indicate hypoalbuminemia, a condition frequently observed in sepsis patients, which worsens the disease and increases mortality.[19] Recent studies have shown that LAR offers superior prognostic value compared to lactate or serum albumin alone.[9,11,20] This ratio appears promising for early detection and risk stratification in sepsis, but its clinical role requires further validation before routine use.

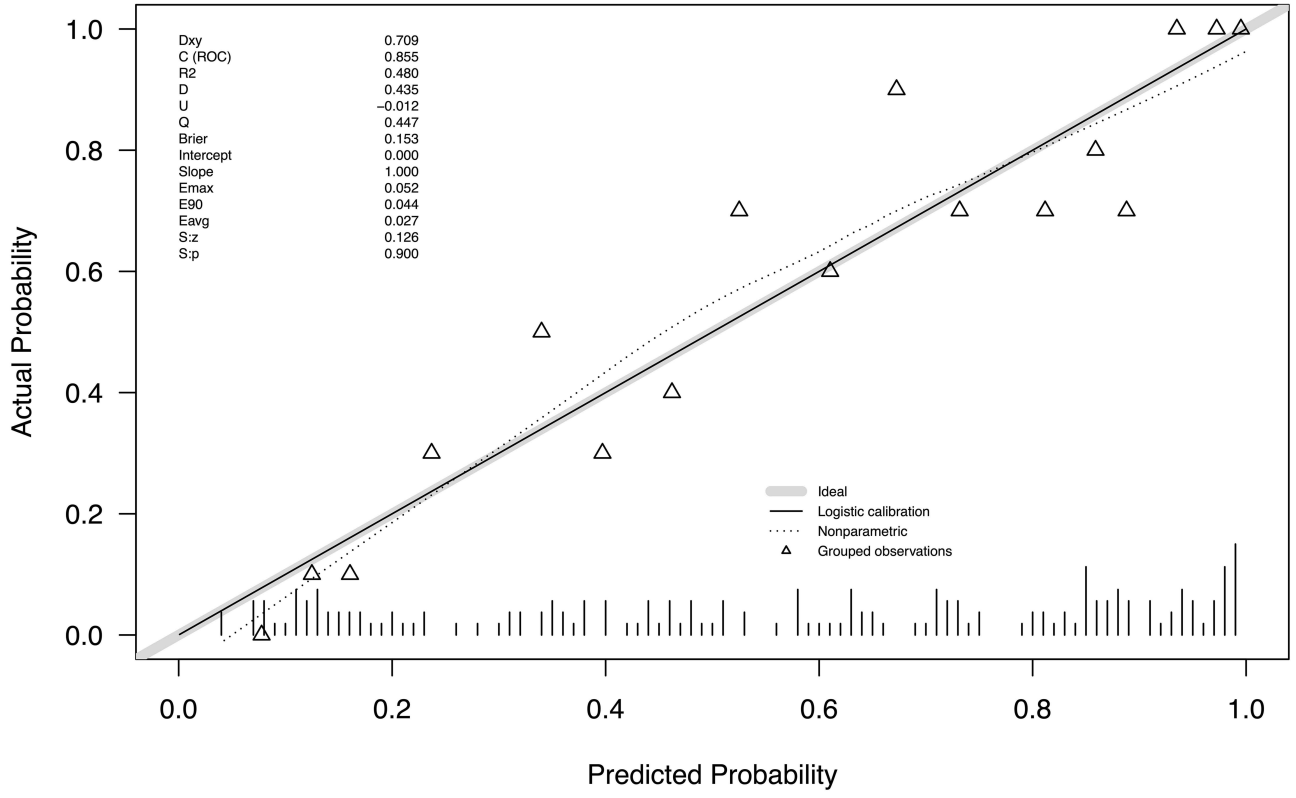

Figure 4 Calibration plot in evaluating the actual probability of the lactate-to-albumin ratio combined age and respiratory infection model.

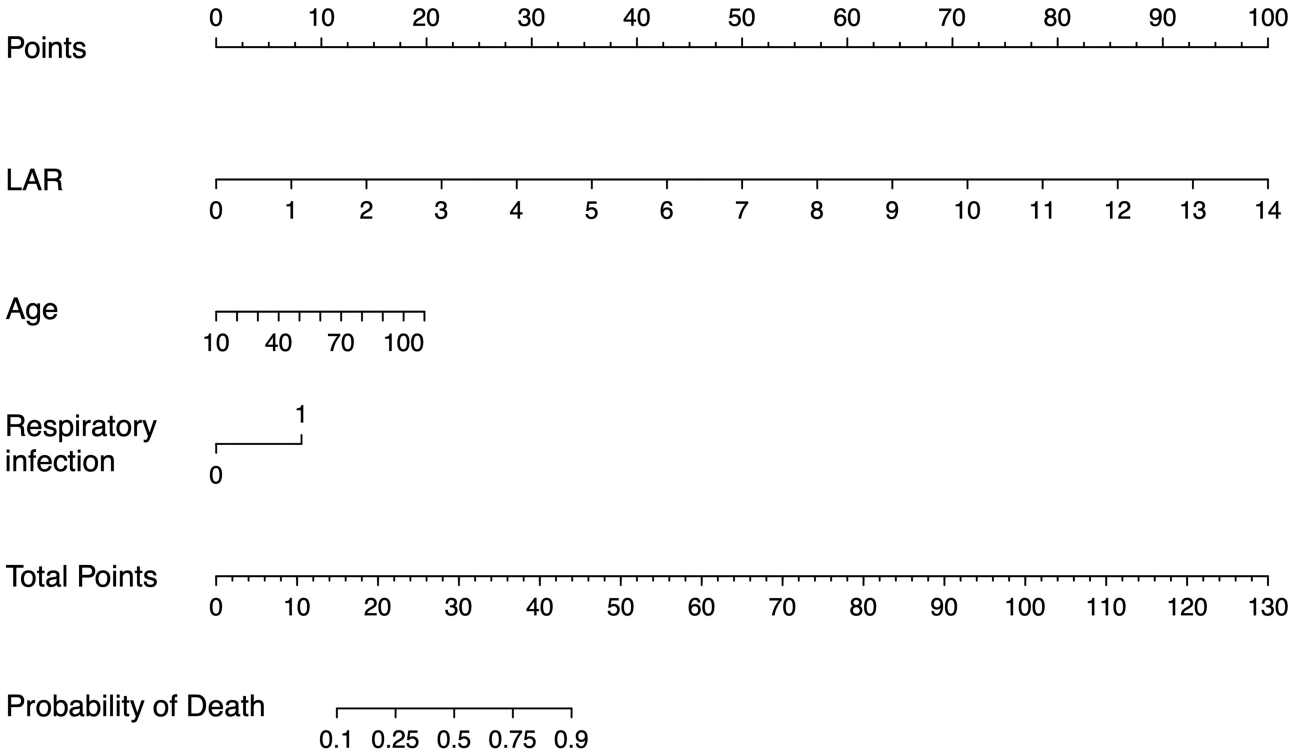

Figure 5 Nomogram for predicting 28-day mortality based on the lactate-to-albumin ratio combined age and respiratory infection model.
Abbreviations: LAR, lactate-to-albumin ratio.

Regarding LAR, our study found that the median LAR was 2.2, higher than that reported in other studies. For example, Fuxing Li's study[11] reported a median LAR of 0.59, and Jikyoung Shin's study[10] reported a median of 1.2. The higher LAR in this study can be explained by the predominantly elderly population, which had a high prevalence of underlying conditions such as respiratory and cardiovascular diseases. These factors contributed to more severe cases of sepsis, likely resulting in higher lactate levels and lower serum albumin levels due to increased senility and malnutrition. When comparing the LAR between the mortality and survival groups, the mortality group had a significantly higher LAR (2.9 vs 1.1, $p < 0.001$). This finding is consistent with other studies. For instance, Jikyoung Shin reported a median LAR of 1.7 in the mortality group compared to 1.0 in the survival group ($p < 0.01$), and Jianhua Hu found that LAR in the mortality group was twice as high as in the survival group (2.0 vs 0.9, $p < 0.001$).[10,12] Fuxing Li's study reported lower LAR values overall, with a median LAR of 0.8 in the mortality group compared to 0.5 in the survival group.[11] Although the absolute values of LAR reported across studies vary due to potential influences from multiple factors, higher LAR consistently showed prognostic significance in distinguishing the mortality group from the survival group, which was consistent with the findings of this study.

In the multivariate logistic regression analysis, we found that LAR was an independent predictor of 28-day mortality in sepsis patients, with an OR of 2.74 (95% CI 1.09–6.86, $p = 0.017$). This finding aligns with other studies. For example, Jikyoung Shin reported an OR of 1.51 (95% CI 1.33–1.72, $p < 0.01$) for LAR as a predictor of mortality.[10] Zhijie Xia found that LAR > 1.6 doubled the mortality rate in sepsis patients.[21] Similarly, Fuxing Li's study found that LAR increased the risk of 28-day mortality with an OR of 1.64 (95% CI 1.31–2.94, $p = 0.025$) when analyzed alongside other variables like procalcitonin/albumin ratio (PAR) and SOFA score.[11]

Based on the AUC of LAR, we calculated a cut-off point of 1.2, with a sensitivity of 91% and a specificity of 57%. The positive predictive value was 74%, and the negative predictive value was 82%. Jikyoung Shin's study reported a LAR cut-off point of 1.32 with a sensitivity of 66% and a specificity of 62%.[10] Fuxing Li's study had a LAR cut-off point of 0.79 with a sensitivity of 53.9% and a specificity of 74.4%.[11] Jianhua Hu's study reported a cut-off point of 1.7, with a sensitivity of 56.21% and a specificity of 94.18%.[12] While our discrimination estimates were good (AUC = 0.81),

the uncertainty around performance was reflected in the 95% CI for the AUC (0.75–0.87) should be considered when interpreting.

When analyzing the best prognostic model for predicting 28-day mortality in sepsis patients, we applied the BMA method and identified three models as the best predictors. These included: (1) LAR combined with age and respiratory infection; (2) LAR and respiratory infection; (3) LAR combined with age and respiratory infection and SOFA score. Comparing these models based on the AUC and clinical accuracy, we found that the LAR model alone had an AUC of 0.81. When combined with age and respiratory infection, the AUC increased to 0.855. Our Calibration results demonstrated that the predicted probabilities of LAR combined with age and respiratory infection model is similar to the actual probabilities. In addition to apparent performance, our internal validation results demonstrated that the prognostic models maintained consistent discrimination and calibration. The LAR + age + respiratory infection model showed an internally validated AUC of 0.848, only slightly lower than its apparent AUC of 0.855, with a calibration slope close to 1.0 and an acceptable Brier score. Similar findings were observed for the other models, indicating that the identified predictors were stable within our dataset.

Our study has several limitations. First, serum lactate and albumin were only measured at admission, and subsequent values during treatment were not recorded. As a result, LAR was only assessed at a single time point. Second, the LAR may be significantly affected in populations with chronic kidney or liver disease. Although we excluded patients with nephrotic syndrome or cirrhosis, we did not analyze these groups due to the very low proportion of such patients in our sample. Third, potential factors such as malnutrition and aging were not recorded, which may be considered a limitation of this study. A further limitation is that while our analysis relied on BMA to address potential model overfitting and included internal validation through bootstrapping, this approach cannot fully replace external validation. Therefore, confirmation in larger multicenter cohorts remains necessary.

Conclusion

In this single-center cohort, LAR had been demonstrated to be a promising prognostic indicator of 28-day mortality in ICU patient population. Moreover, when combined with factors such as age and respiratory infection, the LAR enhances the predictive accuracy, forming a robust prognostic model that shows potential for future clinical application, pending external validation.

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Disclosure

No conflicts of interest declared.

References

1. Singer M, Deutschman CS, Seymour CW, et al. The third international consensus definitions for sepsis and septic shock (sepsis-3). *JAMA*. 2016;315(8):801–810. doi:10.1001/jama.2016.0287
2. Evans L, Rhodes A, Alhazzani W, et al. Surviving sepsis campaign: international guidelines for management of sepsis and septic shock 2021. *Intensive Care Med*. 2021;47(11):1181–1247. doi:10.1007/s00134-021-06506-y
3. Gauer R, Forbes D, Boyer N. Sepsis: diagnosis and management. *Am Fam Physician*. 2020;101(7):409–418.
4. Liu Y-C, Yao Y, Yu -M-M, et al. Frequency and mortality of sepsis and septic shock in China: a systematic review and meta-analysis. *BMC Infect Dis*. 2022;22(1):564. doi:10.1186/s12879-022-07543-8
5. Pierrakos C, Velissaris D, Bisdorff M, Marshall JC, Vincent J-L. Biomarkers of sepsis: time for a reappraisal. *Crit Care*. 2020;24(1):287. doi:10.1186/s13054-020-02993-5
6. Bou Chebl R, Jamali S, Sabra M, et al. Lactate/albumin ratio as a predictor of in-hospital mortality in septic patients presenting to the emergency department. *Origin Res Front Med*. 2020;7. doi:10.3389/fmed.2020.550182
7. Yin M, Si L, Qin W, et al. Predictive value of serum albumin level for the prognosis of severe sepsis without exogenous human albumin administration: a prospective cohort study. *J Intensive Care Med*. 2018;33(12):687–694. doi:10.1177/0885066616685300
8. Arnau-Barrés I, Güerri-Fernández R, Luque S, Sorli L, Vázquez O, Miralles R. Serum albumin is a strong predictor of sepsis outcome in elderly patients. *Eur J Clin Microbiol Infect Dis*. 2019;38(4):743–746. doi:10.1007/s10096-019-03478-2
9. Cakir E, Turan IO. Lactate/albumin ratio is more effective than lactate or albumin alone in predicting clinical outcomes in intensive care patients with sepsis. *Scand J Clin Lab Invest*. 2021;81(3):225–229. doi:10.1080/00365513.2021.1901306

10. Shin J, Hwang SY, Jo IJ, et al. Prognostic value of the lactate/albumin ratio for predicting 28-day mortality in critically ill sepsis patients. *Shock Augusta Ga*. 2018;50(5):545–550. doi:10.1097/shk.0000000000001128
11. Li F, Ye Z, Zhu J, et al. Early lactate/albumin and procalcitonin/albumin ratios as predictors of 28-day mortality in ICU-admitted sepsis patients: a retrospective cohort study. *Med Sci Monit*. 2023:29:e940654. doi:10.12659/msm.940654
12. Hu J, Jin Q, Fang H, Zhang W. Evaluating the predictive value of initial lactate/albumin ratios in determining prognosis of sepsis patients. *Medicine*. 2024;103(12):e37535. doi:10.1097/md.0000000000037535
13. Hajian-Tilaki K. The choice of methods in determining the optimal cut-off value for quantitative diagnostic test evaluation. *Stat Methods Med Res*. 2018;27(8):2374–2383. doi:10.1177/0962280216680383
14. Chakraborty DS, Lahiry S, Choudhury S. Hypertension clinical practice guidelines (ISH, 2020): what is new? *Med Princ Pract*. 2021;30 (6):579–584. doi:10.1159/000518812
15. ElSayed NA, Aleppo G, Aroda VR, et al. 2. classification and diagnosis of diabetes: standards of care in diabetes-2023. *Diabetes Care*. 2023;46 (Suppl 1):S19–s40. doi:10.2337/dc23-S002
16. McDonagh TA, Metra M, Adamo M, et al. ESC guidelines for the diagnosis and treatment of acute and chronic heart failure. *Eur Heart J*. 2021;42 (36):3599–3726. doi:10.1093/eurheartj/ehab368
17. Hindricks G, Potpara T, Dagres N, et al. 2020 ESC guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European association for cardio-thoracic surgery (EACTS): the task force for the diagnosis and management of atrial fibrillation of the European society of cardiology (ESC) developed with the special contribution of the European heart rhythm association (EHRA) of the ESC. *Eur Heart J*. 2021;42(5):373–498. doi:10.1093/eurheartj/ehaa612
18. Levin A, Stevens PE. Summary of KDIGO 2012 CKD Guideline: behind the scenes, need for guidance, and a framework for moving forward. *Kidney Int*. 2014;85(1):49–61. doi:10.1038/ki.2013.444
19. Sheng S, Zhang Y-H, Ma H-K, Huang Y. Albumin levels predict mortality in sepsis patients with acute kidney injury undergoing continuous renal replacement therapy: a secondary analysis based on a retrospective cohort study. *BMC Nephrol*. 2022;23(1):52. doi:10.1186/s12882-021-02629-y
20. Krispin I, Mahamid M, Goldin E, Fteiha B. Elevated lactate/albumin ratio as a novel predictor of in-hospital mortality in hospitalized cirrhotics. *Ann Hepatol*. 2023;28(3):100897. doi:10.1016/j.aohep.2023.100897
21. Chen X, Zhou X, Zhao H, et al. Clinical value of the lactate/albumin ratio and lactate/albumin ratio × age score in the assessment of prognosis in patients with sepsis. *Front Med Lausanne*. 2021;8:732410. doi:10.3389/fmed.2021.732410