SPANDIDOS PUBLICATIONS
ONCOLOGY LETTERS 32: 345, 2026

Lactate-to-albumin ratio as an independent predictor of short- and long-term mortality in ICU patients with malignant tumors: A retrospective cohort study

JINGCHAO BAI[1,2*], YIHAN XU[2*], KE WANG[1] and XIN FU[1]

[1]Department of Gynecologic Oncology, Tianjin Medical University Cancer Institute and Hospital, Tianjin 300060, P.R. China;
[2]Department of Gastrointestinal Cancer Biology, Tianjin Medical University Cancer Institute and Hospital, Tianjin 300060, P.R. China

Received February 22, 2026; Accepted May 20, 2026

DOI: 10.3892/ol.2026.15700

Abstract. Lactate-to-albumin ratio (LAR) may reflect metabolic dysregulation and nutritional status in critically ill patients. However, its association with long-term prognosis in intensive care unit (ICU) patients with malignant tumors requires further elucidation. The present study was conducted to assess the association between LAR and 30-day and 360-day all-cause mortality in ICU patients with malignant tumors and to investigate the potential non-linear associations and subgroup differences. A total of 1,634 ICU patients with malignant tumors were enrolled. Baseline clinical data were collected and LAR was calculated. Survival differences across LAR tertiles were analyzed using Kaplan-Meier curves with the log-rank test. Univariate and multivariate Cox regression models (with stepwise adjustment for confounders) were employed to evaluate the independent predictive value of LAR for all-cause mortality. A restricted cubic spline model was used to analyze the non-linear association and subgroup interaction tests were conducted to verify the stability of the LAR effect. The 30-day mortality rates for the three tertile groups were 23, 31 and 43%, respectively, while the 360-day mortality rates were 51, 56 and 67%. Mortality significantly increased with higher LAR tertiles (P<0.001). Multivariate Cox regression analysis, after adjusting for confounders, identified LAR as an independent risk factor for both 30-day [hazard ratio (HR)=1.13; 95% CI: 1.04-1.22; P=0.004] and 360-day (HR=1.15; 95% CI: 1.07-1.23; P<0.001) all-cause mortality. Restricted cubic spline analysis indicated a linear association between LAR and mortality risk. Subgroup analysis revealed no significant interaction effects. Overall, LAR was identified to be an independent predictor of 30-day and 360-day all-cause mortality in ICU patients with malignant tumors, exhibiting a linear positive association with mortality risk. Its predictive effect remains stable across different subgroups, suggesting its potential as a prognostic indicator in this patient population.

Introduction

Malignant tumors represent one of the leading causes of mortality worldwide, accounting for 9.7 million deaths in 2022 (1). Acute clinical deterioration in patients with cancer, often necessitating admission to the intensive care unit (ICU) for life support and organ replacement therapy, can be triggered by tumor treatment-associated complications (such as myelosuppression and infection) or by disease progression itself (including cachexia, organ metastasis, malignant pleural effusion or ascites) (2,3). The in-ICU mortality rate among these patients is markedly higher compared with that of non-oncological critically ill patients (58.8% vs. 36.5%) (4), constituting a particularly challenging clinical problem in the field of critical care medicine. Consequently, accurately assessing their mortality risk and identifying key prognostic factors are of notable importance for guiding clinical decision-making, optimizing the allocation of medical resources and ultimately improving patient outcomes.

The lactate-to-albumin ratio (LAR) has gained attention in critical care research as a novel biomarker that provides an integrated measure of both tissue hypoxia and inflammation-nutritional status (5,6). Even under oxygen-sufficient conditions, tumor cells preferentially generate energy through high-rate glycolysis, a metabolic process that produces large amounts of lactate as the end product (7), in advanced or bulky tumors, metabolic dysregulation within the body is

---

Correspondence to: Dr Jingchao Bai or Dr Xin Fu, Department of Gynecologic Oncology, Tianjin Medical University Cancer Institute and Hospital, 1 West Huan-Hu Road, Ti Yuan Bei, Hexi, Tianjin 300060, P.R. China
E-mail: jingchaobai@126.com
E-mail: fxhappy@126.com

[*]Contributed equally

Abbreviations: LAR, lactate-to-albumin ratio; RCS, restricted cubic spline; MIMIC-IV, Medical Information Mart for Intensive Care IV; SOFA, Sequential Organ Failure Assessment; LODS, Logistic Organ Dysfunction System; IQR, interquartile range; CCI, Charlson Comorbidity Index; INR, international normalized ratio

Key words: lactate-to-albumin ratio, intensive care unit patients with malignant tumors, all-cause mortality, Cox regression analysis, prognostic assessment

exacerbated, leading to a marked increase in lactate production. Furthermore, the onset of severe complications such as sepsis can induce systemic hypoperfusion and hypoxia, which impairs lactate clearance and further augments its generation (8,9). In critically ill patients with cancer admitted to the ICU, this dysregulated lactate metabolism often signals a poor prognosis (10,11). The LAR is a prognostic biomarker in conditions including sepsis, heart failure and acute respiratory failure (12-15). For instance, in critically ill patients with cirrhosis and sepsis, LAR has exhibited an L-shaped nonlinear association with mortality (inflection point at LAR=1.05) and has demonstrated an improved predictive performance compared with albumin alone (16,17). In community-acquired pneumonia, LAR has shown comparable efficacy to traditional scoring systems (such as the pneumonia severity index or confusion, uremia, respiratory rate, blood pressure, age ≥ 65 years score) in predicting the need for ICU admission and in-hospital mortality (18). However, it remains unclear whether LAR holds prognostic value specifically in critically ill patients with malignancy. Therefore, the present study investigated the association between the LAR index and prognosis in critically ill patients with cancer.

Materials and methods

Data source and study population. Data from the Medical Information Mart for Intensive Care IV (MIMIC-IV) database(mimic.mit.edu/) was utilized in the present study, developed by Beth Israel Deaconess Medical Center (19). The MIMIC-IV database contains de-identified clinical data from >400,000 ICU admissions, encompassing comprehensive records such as patient demographics, diagnoses, treatments and medications. All data is rigorously anonymized in compliance with privacy regulations to ensure patient confidentiality. The present authors completed the required training course for MIMIC-IV and were granted access to the database. As the database contains only de-identified information, the requirement for informed consent was waived for the present analysis.

Study population. A total of 65,346 patients with their first ICU admission were initially identified. From this cohort, 8,451 patients with a diagnosis of malignancy were selected based on the Charlson Comorbidity Index (CCI) (20,21). The following exclusion criteria were subsequently applied: i) Patients aged under 18 years (n=0); ii) those with an ICU length of stay <24 h (n=1,710); and iii) patients lacking lactate or albumin measurements on the first day of ICU admission (n=5,107). This resulted in the exclusion of 6,817 patients. Consequently, a final cohort of 1,634 critically ill patients with malignancy was included in the analysis. These patients were further stratified into three groups according to their LAR values: Tertile 1 (T1; n=539), tertile 2 (T2; n=556) and tertile 3 (T3; n=539; Fig. 1).

Data extraction. All data for the present study were extracted from the MIMIC-IV database using PostgreSQL software (version 17.4, postgresql.org/). The extracted data pertained to the first 24 h of ICU admission and included: i) Baseline demographic information; ii) vital signs; iii) severity-of-illness scores, including the Sequential Organ Failure Assessment (SOFA) and Logistic Organ Dysfunction System (LODS) score; iv) history of chronic comorbidities (such as coronary artery disease, congestive heart failure, cerebrovascular disease, chronic lung disease, liver disease, diabetes or hypertension); v) laboratory parameters measured within 24 h of ICU admission (including red blood cell count, white blood cell count, platelet count, sodium, potassium, calcium, glucose, lactate, albumin, anion gap, blood urea nitrogen (BUN), creatinine, international normalized ratio (INR), prothrombin time (PT), activated partial thromboplastin time (APTT) and urine output); and vi) details regarding medication administration and treatment regimens (such as epinephrine, norepinephrine, mechanical ventilation and continuous renal replacement therapy). Data regarding hospitalization-associated outcomes were also collected, encompassing hospital and ICU length of stay, as well as 30-day and 360-day all-cause in-hospital mortality. Baseline laboratory data were defined as the first measurements obtained within 24 h of ICU admission (rather than the highest or lowest values) to reflect the initial physiological status and minimize the influence of subsequent therapeutic interventions.

Handling of missing data. In the present study, different strategies were employed to handle missing data. For variables with a percentage of missing values <20%, multiple imputation was applied to fill the gaps. Specifically, the multiple imputation method was used to generate several imputed datasets, thereby reducing the potential bias associated with single imputation and ensuring the accuracy and robustness of the imputed data (22). By contrast, variables with >20% missing values were excluded from the subsequent analysis to prevent their influence on the findings.

Definition of exposure and outcomes. LAR, as the exposure of interest, was calculated using the following formula: LAR=lactate (mmol/l)/albumin (mg/dl). The values for both lactate and albumin were obtained from the first 24 h following ICU admission. The primary outcome of the present study was 30-day all-cause mortality. The secondary outcome was 360-day all-cause mortality. Follow-up for all outcomes commenced from the first day of hospital admission, aiming to assess both in-hospital and post-discharge long-term mortality risk.

Statistical analysis. Normality of all continuous variables was assessed using the Shapiro-Wilk test. Variables conforming to a normal distribution are presented as the mean ± SD and group comparisons were performed using an independent sample t-test. Non-normally distributed variables are summarized as the median with interquartile range (IQR) and the Mann-Whitney U test was employed for group comparisons. Categorical variables are expressed as frequency and percentages (%), and differences were assessed using the χ^2 test, unless any expected cell frequency was less than 5, in which case Fisher's exact test was used.

Survival rates across groups were visualized and compared using Kaplan-Meier curves and the log-rank test, respectively. Kaplan-Meier curves were used to plot survival rates for different groups, allowing a visual comparison of patient survival across groups. Differences between groups were

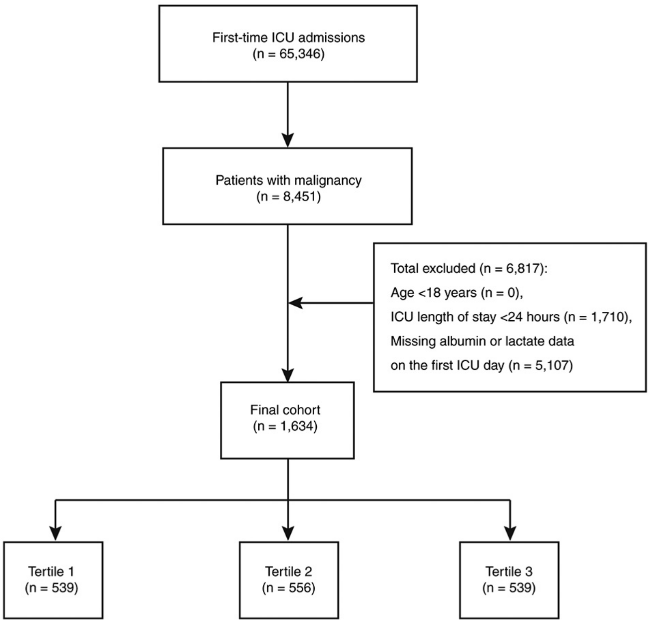


Figure 1. Flowchart of the present study cohort. Distribution of the final cohort of 1,634 critically ill patients with malignancy stratified by LAR tertiles: Tertile 1 (n=539), tertile 2 (n=556) and tertile 3 (n=539). LAR, lactate-to-albumin ratio; ICU, intensive care unit.

assessed using the log-rank test to determine whether significant differences existed among the survival curves. To identify risk factors, univariate Cox proportional hazards regression was initially performed. In the present study, univariate Cox regression analysis was first performed to identify potential risk variables. Variables with a significance level of P<0.05 from the univariate analysis, along with those considered clinically relevant, were subsequently incorporated into a multivariate Cox regression model. This model was used to evaluate the independent predictive value of the LAR for both 30-day and 360-day all-cause mortality. Multivariate Cox regression analysis was initially performed in the crude model without adjusting for any confounding factors. Subsequently, potential confounders including sex, race, age and weight were progressively incorporated into the adjusted models. Further adjustments included clinical variables such as norepinephrine use, continuous renal replacement therapy, heart rate, systolic blood pressure, respiratory rate, potassium, anion gap, BUN, INR and urine output. The covariate selection was guided by a pre-defined clinical framework, consistent with established principles of confounder selection in epidemiological research, rather than a purely data-driven approach (23). CCI was included to account for baseline comorbidity burden, while the SOFA score was incorporated to reflect the severity of acute illness at ICU admission. Given that LAR is derived from lactate and albumin, both of which are closely associated with shock severity, inflammatory response, nutritional status and liver function, a multicollinearity assessment was further performed. All included variables exhibited Variance Inflation Factor (VIF) values <5, indicating the absence of significant multicollinearity and supporting the stability and reliability of the model estimates.

The potential nonlinear association between LAR and mortality risk was explored using a Restricted Cubic Spline (RCS) model with four knots. To explore nonlinear associations between the variables and 30-day and 360-day all-cause mortality, RCS with three knots were employed. Furthermore, interaction tests were conducted to assess the heterogeneity of the LAR effect across different pre-specified subgroups. Interaction tests were also performed to assess differences in the effect of the variables across subgroups. Specifically, subgroup analyses were conducted based on age (<65 years and ≥65 years), sex (female and male), chronic lung disease (absent and present), liver disease (absent and present), diabetes (absent and present) and hypertension (absent and present).

To develop machine learning models, the present study first split the dataset into a training set and a test set at a ratio of 7:3. On the training set, the Boruta algorithm (version 8.0.3) was employed in R software (version 4.4.1) for feature selection to identify the most useful variables for predicting the risk of mortality. Subsequently, based on the selected variables, a number of machine learning models were constructed, including Ridge regression, Elastic Net (ENet), support vector machine (SVM), K-nearest neighbors (KNN), random forest (RF) and XGBoost. After model construction, the performance of these models was evaluated using the test set. The evaluation metrics for model performance included the receiver operating characteristic (ROC) curve, precision-recall (PR) curve, calibration curve and decision curve. These metrics enabled a comprehensive assessment of each model's performance in predicting 30-day all-cause mortality among patients with malignancy in the ICU, thereby facilitating the selection of the optimal predictive model. All statistical analyses were performed using R software (version 4.5.1; Posit Software, PBC). A two-tailed P<0.05 was considered to indicate a statistically significant difference for all tests.

Results

Baseline characteristics. A total of 1,634 patients was included in the final analysis. The median age of the cohort was 67.77 years (IQR: 60.20-76.46). The overall median LAR was 0.75 (IQR: 0.46-1.26). The present study population was stratified into tertiles based on LAR values. Comparison of baseline characteristics across these LAR tertiles revealed statistically significant differences in key clinical and physiological parameters, including vital signs (heart rate, systolic and diastolic blood pressure, and respiratory rate), severity-of-illness scores (LODS and VIF), and the prevalence of chronic comorbidities such as congestive heart failure, cerebrovascular disease, chronic pulmonary disease and liver disease (Table I; all P<0.05).

Association between LAR and in-hospital mortality in critically ill patients with cancer. Kaplan-Meier survival curves were plotted for patients stratified by LAR tertiles and compared using the log-rank test. The results demonstrated statistically significant differences in mortality among the LAR tertiles at both 30-day and 360-day follow-ups (Fig. 2; P<0.05). Patients in T1 exhibited the most favorable prognosis, whereas those in T3 demonstrated the worst prognosis. These findings indicated that elevated LAR levels were associated with poorer short-term and long-term outcomes in critically ill patients with malignancy.

Variables for the multivariate Cox regression models were selected based on both univariate Cox regression analysis (P<0.10) and established clinical evidence regarding mortality predictors in critically ill patients with cancer. Covariates with recognized clinical relevance and biological associations with mortality, including organ dysfunction assessed by the Sequential Organ Failure Assessment (SOFA) score and major comorbidities, were prioritized for adjustment (24,25). In addition, the variable selection strategy followed the principle of integrating statistical significance with clinical relevance, which is widely recommended in prognostic modeling studies to improve model interpretability and clinical applicability (26). The multivariate Cox regression models were then used to assess the associations of continuous LAR values and LAR tertiles with 30-day and 360-day all-cause mortality (Table II). For 30-day mortality, the continuous LAR remained a significant predictor of mortality risk in the fully adjusted model (model 3), with a HR of 1.13 (95% CI: 1.04-1.22; P=0.004). Analysis using LAR tertiles revealed that patients in the highest tertile (T3) continued to exhibit a significantly increased risk compared with the reference group (T1), with an HR of 1.29 (95% CI: 1.01-1.64; P=0.040). With regard to 360-day mortality, the continuous LAR was also a significant independent predictor in model 3 (HR=1.15; 95% CI: 1.07-1.23; P<0.001). Similarly, the tertile analysis determined that the T3 group was associated with a significantly elevated mortality risk (HR=1.26; 95% CI: 1.06-1.49; P=0.010).

To evaluate the incremental clinical value of LAR, a comparative analysis with the SOFA score was then performed. The results showed that the SOFA score alone had limited discriminative ability for predicting 30-day mortality [area under the curve (AUC)=0.540], whereas incorporation of LAR significantly improved the model performance, increasing the AUC to 0.622 (DeLong's test, P<0.001; Fig. S1A). LAR remained an independent predictor after adjustment for the SOFA score, indicating its prognostic robustness across different acute clinical settings. ROC curve analysis was also performed, identifying the optimal cut-off value of the LAR for predicting 30-day mortality as 0.760, with a sensitivity of 62.2% and a specificity of 56.2% (Fig. S1B). In clinical practice, this cut-off may serve as an additional tool for identifying patients with cancer who are at increased risk despite relatively stable conventional organ dysfunction scores, such as the SOFA score. Elevated lactate levels are associated with occult tissue hypoperfusion and metabolic stress (27), whereas hypoalbuminemia reflects systemic inflammation and impaired nutritional reserve (25). By integrating these pathophysiological dimensions, the LAR may provide complementary prognostic information beyond conventional organ dysfunction assessment and improve clinical risk stratification (28). Consequently, patients with elevated LAR values may warrant closer monitoring and more comprehensive clinical evaluation in critical care settings.

LAR exhibits a linear association with all-cause mortality risk, consistent across subgroups. RCS was employed to assess the potential non-linear association between LAR and both 30-day and 360-day all-cause mortality. The results indicated no significant deviation from linearity for the association between LAR and mortality at either time point (nonlinearity P>0.05; Fig. 3). However, a significant overall positive association was observed, demonstrating a linear increase in mortality risk with rising LAR levels. Furthermore, subgroup analyses revealed no significant interaction effects, demonstrating the consistent association between elevated LAR and increased mortality risk across all predefined patient subgroups. While liver disease can influence both lactate metabolism and albumin synthesis, the present interaction analysis indicated that LAR remained a robust predictor of mortality irrespective of hepatic comorbidity, reinforcing its utility as a simple, integrated risk marker in the present heterogeneous population.

Subgroup analysis revealed no significant interaction effects between LAR and any pre-specified subgroups for both 30-day and 360-day all-cause mortality (all interaction P>0.05; Fig. 4). This indicated that the positive association between elevated LAR and increased mortality risk was consistent and independent of the subgroup factors examined. Specifically, stratified and interaction analyses were performed according to liver disease status, which exhibited a non-significant interaction effect (interaction P=0.375; Table III), supporting the consistency of LAR across different hepatic conditions.

Model development and performance comparison. Based on the selected variables, machine learning models were developed on the training set, including Ridge regression, ENet, SVM, KNN, RF and XGBoost. During model development, grid search was employed for hyperparameter tuning. Grid search is a systematic approach that considers all parameter combinations within a specified subset of the hyperparameter space to identify the configuration that maximizes model performance, thereby mitigating the risk of overfitting during the tuning process (29).

On the test set, the area under the ROC curve (ROCAUC) results for each model were as follows (Fig. 5A): Ridge regression was 0.7968 (95% CI: 0.7564-0.8372), ENet was 0.7900 (95% CI: 0.7489-0.8312), KNN was 0.7478 (95% CI: 0.7028-0.7928), RF was 0.7902 (95% CI: 0.7492-0.8313), XGBoost was 0.7832 (95% CI: 0.7423-0.8242) and SVM was 0.7974 (95% CI: 0.7571-0.8377).

On the test set, the area under the precision-recall curve (PRAUC) results for each model were as follows (Fig. 5B): Ridge regression was 0.6376 (95% CI: 0.5548-0.7121), ENet was 0.6161 (95% CI: 0.5333-0.6915), KNN was 0.5561 (95% CI: 0.4652-0.6291), RF was 0.6186 (95% CI: 0.537-0.6978), XGBoost was 0.6019 (95% CI: 0.5176-0.6874) and SVM was 0.5997 (95% CI: 0.5197-0.6812). These results indicated that the Ridge regression model achieved the best PRAUC performance on the test set, with the highest PRAUC value (0.6376), whereas the KNN model exhibited a relatively poorer PRAUC performance. Following comparisons of calibration curves and decision curves on the test set, the SVM was ultimately identified as the optimal model, demonstrating favorable predictive value (Fig. 5C and D).

Discussion

Critically ill patients with malignancy frequently require ICU management due to both disease progression and

Table I. Baseline characteristics of the total study population (n=1634) and LAR tertiles.

Characteristic	Overall (n=1634)	T1 (n=539)	T2 (n=556)	T3 (n=539)	P-value
Median age, years (IQR)	67.77 (60.20-76.46)	69.38 (61.05-78.03)	67.72 (60.07-76.22)	66.80 (59.65-75.55)	0.050
Sex (%)					0.014
Female	640 (39)	238 (44)	202 (36)	200 (37)	
Male	994 (61)	301 (56)	354 (64)	339 (63)	
Ethnicity, n (%)					0.070
Other	489 (30)	155 (29)	153 (28)	181 (34)	
White	1145 (70)	384 (71)	403 (72)	358 (66)	
Weight, kg	78.00 (65.00-93.00)	77.00 (64.00-93.00)	78.05 (65.05-93.35)	78.00 (65.90-91.80)	0.459
Heart rate, bmp	91.38 (79.62-102.64)	86.64 (76.84-97.58)	91.24 (79.85-102.35)	95.60 (85.00-107.31)	<0.001
SBP, mmHg	110.61 (102.39-122.80)	115.42 (105.48-127.58)	110.43 (102.41-123.02)	107.50 (99.73-117.45)	<0.001
DBP, mmHg	61.08 (55.05-68.00)	61.58 (55.21-69.23)	61.67 (55.03-68.57)	60.05 (54.98-66.26)	0.013
RR, bmp	19.56 (16.94-23.07)	19.23 (16.85-21.88)	19.49 (16.67-22.98)	20.21 (17.35-24.12)	<0.001
Temperature, ˚C	36.82 (36.59-37.13)	36.84 (36.62-37.15)	36.87 (36.62-37.13)	36.76 (36.50-37.09)	<0.001
SpO2, %	96.96 (95.36-98.31)	96.96 (95.24-98.16)	96.80 (95.22-98.20)	97.12 (95.56-98.53)	0.049
LODS	6.00 (4.00-8.00)	5.00 (3.00-7.00)	6.00 (4.00-8.00)	7.00 (5.00-10.00)	<0.001
VIF	2.00 (1.00-4.00)	1.00 (0.00-3.00)	2.00 (1.00-4.00)	3.00 (1.00-6.00)	<0.001
CCI	8.00 (6.00-10.00)	8.00 (6.00-10.00)	8.00 (6.00-10.00)	8.00 (6.00-10.00)	0.554
Myocardial infarct (%)	187 (11)	69 (13)	62 (11)	56 (10)	0.445
Congestive heart failure, n (%)	355 (22)	146 (27)	120 (22)	89 (17)	<0.001
Cerebrovascular disease, n (%)	142 (9)	63 (12)	46 (8)	33 (6)	0.005
Chronic pulmonary disease, n (%)	389 (24)	154 (29)	126 (23)	109 (20)	0.004
Liver disease, n (%)	412 (25)	46 (9)	160 (29)	206 (38)	<0.001
Diabetes, n (%)	437 (27)	148 (27)	146 (26)	143 (27)	0.896
Hypertension, n (%)	986 (60)	336 (62)	344 (62)	306 (57)	0.116
RBC, 10^9/l	3.23 (2.77-3.73)	3.21 (2.76-3.79)	3.23 (2.80-3.75)	3.22 (2.74-3.66)	0.469
WBC, 10^9/l	11.46 (7.23-16.82)	10.55 (6.80-15.40)	11.58 (7.93-16.70)	12.61 (7.15-18.97)	<0.001
Platelet, 10^9/l	160.00 (89.22-259.00)	194.50 (126.00-283.00)	152.58 (89.00-255.42)	133.00 (78.00-222.50)	<0.001
Sodium, mmol/l	137.67 (134.50-140.33)	138.00 (134.67-140.33)	137.33 (134.13-139.67)	137.67 (134.60-140.75)	0.059
Potassium, mmol/l	4.20 (3.86-4.65)	4.10 (3.80-4.55)	4.15 (3.81-4.55)	4.37 (3.95-4.84)	<0.001
Calcium, mg/dl	8.15 (7.67-8.67)	8.37 (7.85-8.80)	8.10 (7.65-8.60)	8.00 (7.58-8.56)	<0.001
Glucose, mg/dl	138.71 (112.00-179.50)	130.67 (106.67-156.00)	142.37 (115.00-188.75)	149.67 (115.00-196.00)	<0.001
Lactate, mmol/l	2.06 (1.37-3.40)	1.20 (1.00-1.40)	2.10 (1.80-2.53)	4.18 (3.28-6.18)	<0.001
Albumin, mg/dl	2.88 (2.40-3.30)	3.13 (2.80-3.60)	2.80 (2.48-3.25)	2.55 (2.10-2.93)	<0.001
LAR	0.75 (0.46-1.26)	0.39 (0.32-0.46)	0.75 (0.64-0.89)	1.64 (1.27-2.47)	<0.001
Anion gap	14.20 (12.00-17.00)	13.33 (11.50-15.50)	13.69 (12.00-16.20)	16.20 (13.40-19.67)	<0.001
BUN, mg/dl	23.00 (15.00-38.75)	21.33 (14.00-36.17)	22.63 (15.00-37.00)	26.00 (16.50-42.50)	<0.001
Creatinine, mg/dl	1.10 (0.77-1.73)	1.00 (0.70-1.63)	1.04 (0.75-1.49)	1.33 (0.90-1.87)	<0.001
INR	1.40 (1.20-1.70)	1.30 (1.15-1.50)	1.40 (1.22-1.65)	1.60 (1.35-1.90)	<0.001
PT, sec	15.44 (13.55-18.30)	14.15 (12.65-15.93)	15.46 (13.72-18.06)	17.31 (14.90-20.77)	<0.001
PTT, sec	32.77 (28.30-42.10)	30.65 (27.40-36.75)	32.41 (27.70, 39.50)	36.28 (30.20-47.90)	<0.001
Urine output, ml	1,245.00 (705.00-2025.00)	1,474.00 (861.00-2370.00)	1,268.50 (772.50-2031.50)	1,005.00 (496.00-1642.00)	<0.001
Epinephrine, n (%)	59 (4)	3 (1)	15 (3)	41 (8)	<0.001
Norepinephrine, n (%)	562 (34)	130 (24)	180 (32)	252 (47)	<0.001
MV, n (%)	1,399 (86)	458 (85)	480 (86)	461 (86)	0.812

Table I. Continued.

Characteristic	Overall (n=1634)	T1 (n=539)	T2 (n=556)	T3 (n=539)	P-value
CRRT, n (%)	131 (8)	23 (4)	31 (6)	77 (14)	<0.001
Los hospital, days	11.76 (7.03-20.26)	11.08 (6.85-18.69)	11.34 (7.10-19.74)	13.05 (7.04-23.50)	0.106
Los ICU, days	2.92 (1.84-5.33)	2.80 (1.77-5.12)	2.86 (1.93-5.01)	3.24 (1.82-6.64)	0.045
30-day hospital mortality, %	527 (32)	124 (23)	170 (31)	233 (43)	<0.001
360-day hospital mortality, %	950 (58)	273 (51)	314 (56)	363 (67)	<0.001

T1, tertile 1; T2, tertile 2; T3, tertile 3; SBP, systolic blood pressure; DBP, diastolic blood pressure; SpO2, oxygen saturation; LODS, Logistic Organ Dysfunction Score; CCI, Charlson Comorbidity Index; RBC, red blood cell count; WBC, white blood cell count; LAR, lactate-to-albumin ratio; INR, international normalized ratio; CCRT, continuous renal replacement therapy; BUN, blood urea nitrogen; PT, prothrombin time; PTT, partial thromboplastin; RR, respiratory rate; VIF, variance inflation factor; MV, mechanical ventilation; Los, length of stay.

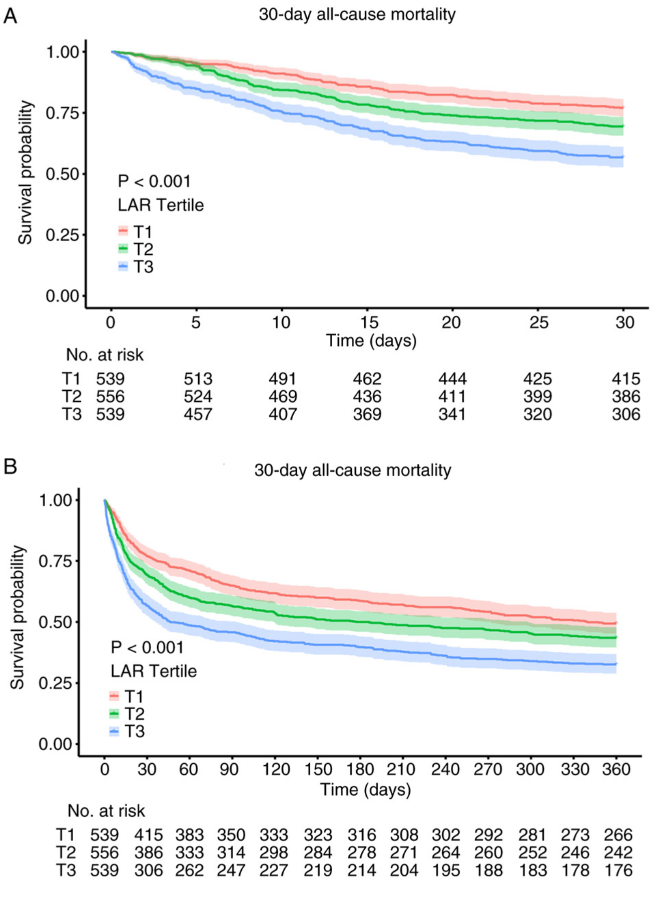


Figure 2. Kaplan-Meier plots of 30-day and 360-day mortality in critically ill patients with cancer grouped by tertiles of the LAR index. Kaplan-Meier survival curves were plotted for critically ill patients with malignancy and significant differences in mortality were observed among the LAR tertiles at both (A) 30-day and (B) 360-day follow-ups. LAR, lactate-to-albumin ratio; T1, tertile 1; T2, tertile 2; T3, tertile 3.

treatment-associated complications. The high mortality rate in this population poses a challenge in the field of critical care medicine. Therefore, the accurate identification of prognostic risk factors and the optimization of risk assessment strategies is important in improving patient outcomes. Based on the MIMIC-IV database, to the best of our knowledge, the present study is the first to systemically investigate the prognostic value of the LAR in critically ill patients with cancer. The present results determined that an elevated LAR was significantly associated with increased 30-day and 360-day all-cause mortality and serves as an independent risk factor. These findings thus present a novel potential biomarker for prognostic assessment in this vulnerable patient population.

The prognostic value of the LAR stems from its role as an integrated marker reflecting multiple underlying pathophysiological states (17,30). The unique glycolytic metabolism of tumor cells continuously generates large amounts of lactate. In advanced-stage tumors or under notable tumor burden, metabolic dysregulation is exacerbated, leading to lactate accumulation (31,32). Furthermore, complications frequently encountered in critically ill patients with cancer, including infections and sepsis, can induce inadequate tissue perfusion and hypoxia, thereby further promoting lactate generation while simultaneously inhibiting its clearance (33). On the other hand, tumor burden, systemic inflammation and inadequate nutritional intake lead to reduced albumin synthesis. As a key protein in maintaining vascular osmotic pressure, binding toxins and modulating inflammatory responses, decreased albumin levels exacerbate the pathological damage to the patient (34). The LAR provides a comprehensive assessment of patient disease severity and prognosis by integrating the dynamics of both lactate and albumin, thereby reflecting the extent of tumor metabolic aberration, tissue hypoxia, as well as the inflammatory status and nutritional reserves of the body (30,35,36). In the present study, the T3 group, which exhibited a higher LAR, also exhibited significantly higher LODS and SOFA scores, along with a greater rate of norepinephrine use, demonstrating the association between LAR and disease severity.

LAR holds prognostic value in critically ill patients beyond the oncology setting (37-40). Studies have shown that in patients with sepsis, the LAR outperforms either lactate or albumin alone in predicting mortality (41,42) and among septic patients with co-existing heart failure, an LAR >0.98 has been associated with an elevated mortality risk (43). The present findings demonstrated a linear association between

Table II. Cox proportional hazards regression analysis of LAR and mortality in critically ill patients with cancer.

	Model 1		Model 2		Model 3	
Variable	HR (95% CI)	P-value	HR (95% CI)	P-value	HR (95% CI)	P-value
30-day all-cause mortality						
LAR	1.39 (1.31~1.48)	<0.001	1.38 (1.31~1.47)	<0.001	1.13 (1.04~1.22)	0.004
LAR tertile						
T1	1.00 (reference)		1.00 (reference)		1.00 (reference)	
T2	1.41 (1.12~1.78)	0.004	1.44 (1.14~1.81)	0.002	1.17 (0.92~1.48)	0.204
T3	2.23 (1.80~2.78)	<0.001	2.31 (1.85~2.87)	<0.001	1.29 (1.01~1.64)	0.040
360-day all-cause mortality						
LAR	1.32 (1.25~1.39)	<0.001	1.32 (1.26~1.39)	<0.001	1.15 (1.07~1.23)	<0.001
LAR tertile						
T1	1.00 (reference)		1.00 (reference)		1.00 (reference)	
T2	1.23 (1.05~1.45)	0.013	1.27 (1.08~1.50)	0.004	1.12 (0.95~1.32)	0.188
T3	1.73 (1.48~2.03)	<0.001	1.83 (1.56~2.14)	<0.001	1.26 (1.06~1.49)	0.010

T1, tertile 1; T2, tertile 2; T3, tertile 3; LAR, lactate-to-albumin ratio.

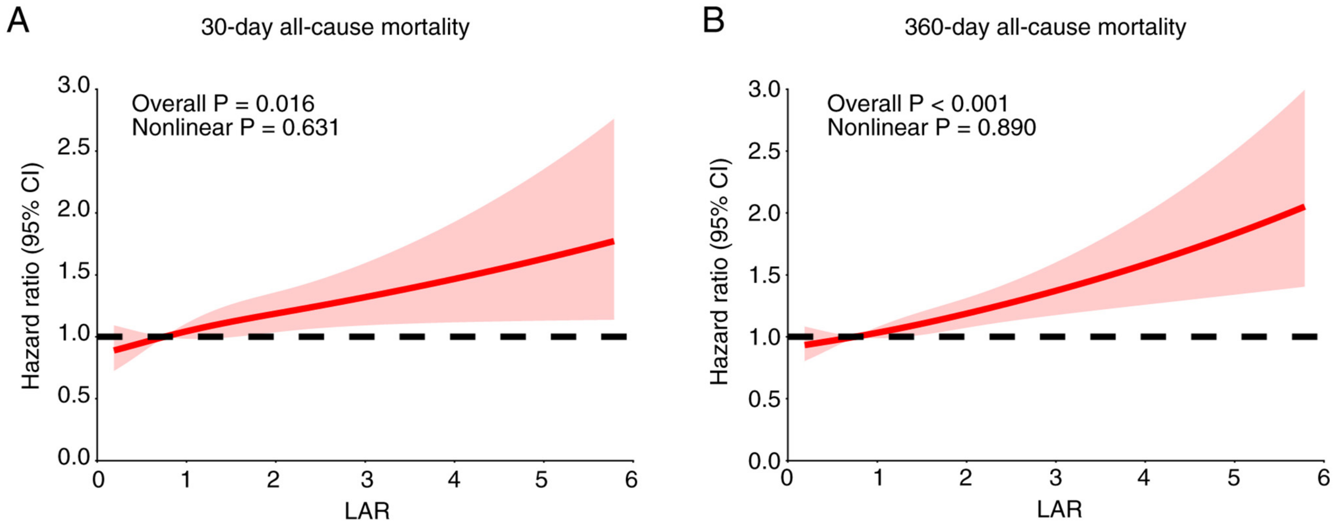
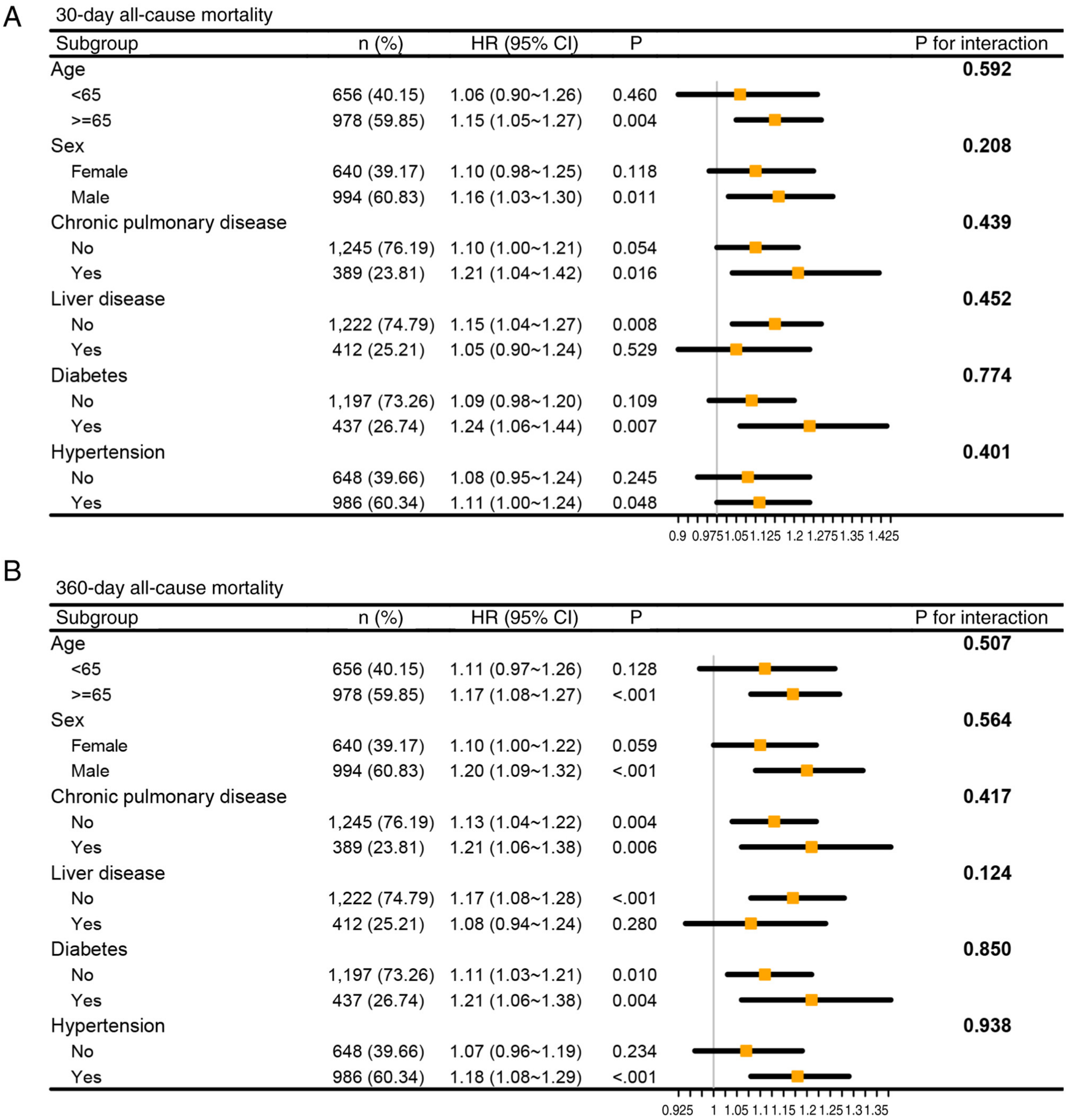


Figure 3. Restricted cubic spline plot of the nonlinear association between LAR and 30-day and 360-day all-cause mortality. Restricted cubic spline curves were employed to examine the association between LAR and all-cause mortality at (A) 30-day and (B) 360-day follow-ups. LAR, lactate-to-albumin ratio.

LAR and mortality in critically ill patients with cancer that is unaffected by age, sex or underlying diseases. This linear association diverges from the nonlinear dynamics observed in studies of cirrhotic patients with sepsis (16,44), a difference that may stem from the distinct metabolic and pathophysiological state of patients with tumors. Critically, LAR was found to be an independent prognostic factor, retaining significance after correcting for confounders including SOFA score and organ-support interventions. Addressing the potential issue of over-adjustment, it should be acknowledged that adjustment for variables located along the mediational pathway between LAR and clinical outcomes, such as organ support-associated variables, may partially attenuate the effect estimates. Despite this, such adjustments were considered necessary to demonstrate that the prognostic value of LAR is not just a reflection of acute physiological derangement in the present study. This implies that LAR could deliver supplemental prognostic insight beyond conventional scoring systems, thereby potentially augmenting risk stratification in severely ill cohorts where cancer-associated metabolic dysregulation is prominent.

The prognostic evaluation of critically ill patients with cancer necessitates dual consideration of the specific traits of the neoplasm and the attendant pathophysiological changes of critical illness. Whereas conventional scoring systems [such as SOFA and Acute Physiology and Chronic Health Evaluation (APACHE)] are capable of indicating organ function impairment (41), they fall short in specifically addressing cancer-associated metabolic aberrations. The LAR is readily obtainable through routine laboratory tests within 24 h of ICU admission, offering a cost-effective and convenient tool



A 30-day all-cause mortality

Subgroup	n (%)	HR (95% CI)	P	P for interaction
Age				**0.592**
<65	656 (40.15)	1.06 (0.90~1.26)	0.460	
>=65	978 (59.85)	1.15 (1.05~1.27)	0.004	
Sex				**0.208**
Female	640 (39.17)	1.10 (0.98~1.25)	0.118	
Male	994 (60.83)	1.16 (1.03~1.30)	0.011	
Chronic pulmonary disease				**0.439**
No	1,245 (76.19)	1.10 (1.00~1.21)	0.054	
Yes	389 (23.81)	1.21 (1.04~1.42)	0.016	
Liver disease				**0.452**
No	1,222 (74.79)	1.15 (1.04~1.27)	0.008	
Yes	412 (25.21)	1.05 (0.90~1.24)	0.529	
Diabetes				**0.774**
No	1,197 (73.26)	1.09 (0.98~1.20)	0.109	
Yes	437 (26.74)	1.24 (1.06~1.44)	0.007	
Hypertension				**0.401**
No	648 (39.66)	1.08 (0.95~1.24)	0.245	
Yes	986 (60.34)	1.11 (1.00~1.24)	0.048	

B 360-day all-cause mortality

Subgroup	n (%)	HR (95% CI)	P	P for interaction
Age				**0.507**
<65	656 (40.15)	1.11 (0.97~1.26)	0.128	
>=65	978 (59.85)	1.17 (1.08~1.27)	<.001	
Sex				**0.564**
Female	640 (39.17)	1.10 (1.00~1.22)	0.059	
Male	994 (60.83)	1.20 (1.09~1.32)	<.001	
Chronic pulmonary disease				**0.417**
No	1,245 (76.19)	1.13 (1.04~1.22)	0.004	
Yes	389 (23.81)	1.21 (1.06~1.38)	0.006	
Liver disease				**0.124**
No	1,222 (74.79)	1.17 (1.08~1.28)	<.001	
Yes	412 (25.21)	1.08 (0.94~1.24)	0.280	
Diabetes				**0.850**
No	1,197 (73.26)	1.11 (1.03~1.21)	0.010	
Yes	437 (26.74)	1.21 (1.06~1.38)	0.004	
Hypertension				**0.938**
No	648 (39.66)	1.07 (0.96~1.19)	0.234	
Yes	986 (60.34)	1.18 (1.08~1.29)	<.001	

Figure 4. Analysis of the interaction between LAR and subgroups. Subgroup analyses were performed to evaluate the interaction between LAR and prespecified subgroup variables on (A) 30- and (B) 360-day all-cause mortality. LAR, lactate-to-albumin ratio; HR, hazard ratio.

for rapid risk stratification. This facilitates the development of individualized treatment strategies: Patients with a high LAR warrant intensified lactate monitoring, optimized tissue perfusion and aggressive management of nutrition and inflammation, with early organ support if indicated, whereas a more conservative approach can be adopted for those with a low LAR to avoid overtreatment and optimize resource allocation. Furthermore, the linear association of LAR with risk provides an intuitive metric for clinicians to track clinical deterioration and enhances objective doctor-patient communication (45).

The present study exhibits a number of limitations. Firstly, its retrospective design and reliance on a single database may have introduced selection bias and detailed information regarding specific tumor pathology and treatment regimens was lacking. Although the SOFA score was used to reflect the overall acute physiological derangement and the degree of organ dysfunction at ICU admission, residual confounding associated with the reason for ICU admission cannot be completely excluded. Owing to MIMIC-IV limitations, TNM stage and detailed treatment data were unavailable. The present study adjusted for CCI, tumor type and metastatic

Table III. Stratified and interaction analyses by liver disease status.

Liver disease	Patients	Events (n)	HR (95% CI)	P value	P for interaction
Yes	412	85	1.28 (1.11-1.48)	0.001	0.375
No	1,222	206	1.25 (1.18-1.32)	<0.001	

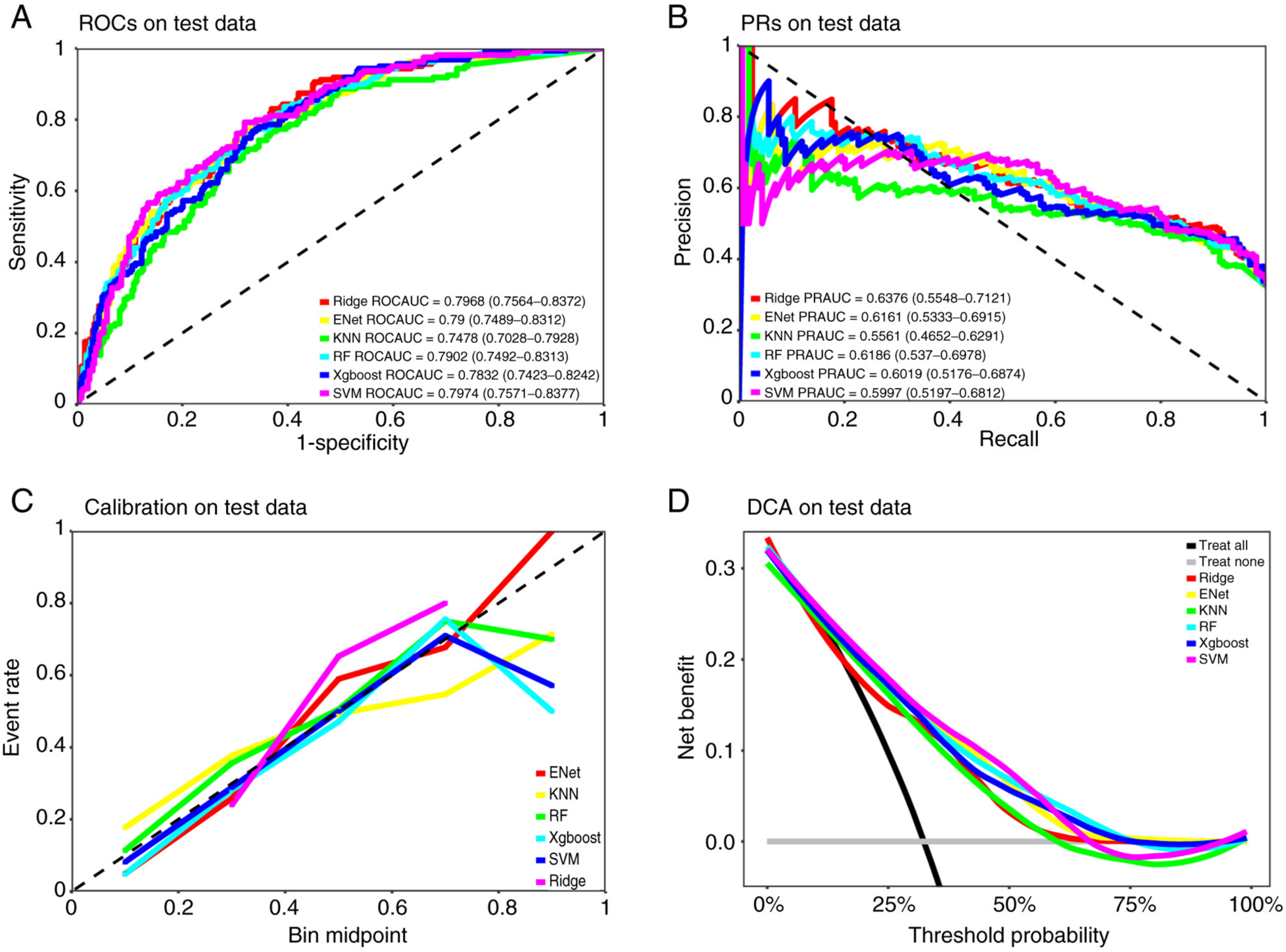


Figure 5. Performance comparison of machine learning models for predicting prognosis in critically ill patients with cancer. (A) ROCAUC with 95% CIs for six models on the test set. (B) PRAUC with 95% CIs for the same six models on the test set. (C) Calibration curves comparing predicted probabilities with observed event rates for each model on the test set. (D) Decision curves illustrating the net benefit of each model across a range of threshold probabilities. ROCAUC, receiver operating characteristic area under the curve; PRAUC, precision-recall area under the curve; KNN, K-nearest neighbors; RF, random forest; SVM, support vector machine; Enet, Elastic Net.

status (all VIF<5). Residual confounding may persist, yet LAR remained independently prognostic, indicating added metabolic risk beyond conventional oncological variables. Secondly, the analysis utilized only the LAR from the first ICU day, failing to capture its dynamic trends and their potential impact on prognosis. Finally, the absence of a direct comparison with established scoring systems such as APACHE II or SOFA precludes a definitive assessment of the incremental predictive value of LAR. Due to the retrospective nature of the MIMIC database, the present study was unable to obtain accurate records of albumin infusion and nutritional support for all patients and could not analyze the impact of these dynamic interventions on prognosis. Future prospective studies should therefore consider collecting such information to more comprehensively evaluate the predictive value of the LAR. Furthermore, tumor heterogeneity is a key factor influencing prognosis, encompassing intrinsic heterogeneity at the molecular level (genetic, epigenetic and transcriptomic differences) and observable heterogeneity at the clinical level (tumor type, stage, metastatic burden and differences in treatment response). Due to the original data sources and data structure of the MIMIC-IV database, there are inherent limitations in the systematic availability of staging information. The CCI score is one of the most widely used comorbidity assessment tools in cancer prognosis research (46-48). Validation studies in specific cancer types such as lung cancer, breast cancer and gastric cancer have shown that the CCI score has varying degrees of prognostic predictive value across different cancer types (46,48,49). In a cohort of patients with non-small cell lung cancer, the CCI score was systematically compared with other comorbidity scores to optimize the prediction of 4-month survival (50). The present study adopted the CCI score primarily because it includes the highly weighted category of 'metastatic disease', which allows for some incorporation of the impact of metastasis on prognosis. However, it must be acknowledged that the aggregated total CCI score cannot disentangle the independent prognostic contributions of different sources, tumor-related factors (metastatic burden), treatment-related factors and comorbidities unrelated to treatment, implying that the predictive performance of the present model may be diluted by heterogeneity. Future multi-center prospective studies are therefore needed to validate the applicability of LAR across different tumor types, investigate the importance of its dynamic monitoring and develop integrated prediction models that incorporate LAR to enhance prognostic accuracy in critically ill patients with cancer.

In conclusion, based on the present analytical findings, the LAR demonstrates guiding value for predicting ICU outcomes in patients with cancer, exhibiting a linear association with mortality risk. As an inexpensive and readily accessible clinical biomarker, the LAR effectively integrates information on both metabolic and nutritional status in this patient population, thereby providing a reliable reference for prognosis. This indicator holds promise as an effective tool for risk stratification in clinical practice, offering valuable insights for optimizing clinical decision-making and healthcare resource allocation. However, its application in clinical prognostic assessment still requires further validation through large-scale, multicenter studies.

Acknowledgements

Not applicable.

Funding

The present study was funded by the Science & Technology Development Fund of Tianjin Education Commission for Higher Education (grant no. 2022KJ230), the Tianjin Health Research Project (grant no. TJWJ2023QN014) and the Tianjin Science and Technology Plan Project (grant nos. 21JCYBJC01450 and 24JCYBJC00750).

Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

JB conceived and designed the study, analyzed data and drafted the manuscript. YX analyzed data and manuscript revision. JB and YX confirm the authenticity of all the raw data. KW interpreted data and revised the manuscript. XF designed and supervised the study, and performed a final review of the manuscript. All authors have read and approved the final version of the manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

1. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I and Jemal A: Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 74: 229-263, 2024.
2. Dong Q, Xia R, Xing XZ, Wang CS, Ma G, Wang HZ, Zhu B, Zhao JH, Zhou DM, Zhang L, *et al*: Intensive care unit outcomes and prognostic factors of colorectal cancer. World J Gastrointest Oncol 17: 108539, 2025.
3. Theodoulidis V, Kissoudi K, Chatzistamatiou K, Tzitzis P, Zouzoulas D, Theodoulidis I, Anthoulakis C, Sifaki F, Moysiadis T, Koraki E, *et al*: Predictors of extended intensive care unit utilization after ovarian cancer surgery. Cancers (Basel) 17: 3203, 2025.
4. Al Khamis M, Aljishi M, Busbaih A, Al Dandan R, Salam A and Al Yousef H: Evaluating prognosis and prognostic factors in critically Ill patients with and without cancer: An observational comparative study. Cureus 17: e96493, 2025.
5. Wang HX, Huang XH, Ma LQ, Yang ZJ, Wang HL, Xu B and Luo MQ: Association between Lactate-to-Albumin ratio and Short-Time mortality in patients with acute respiratory distress syndrome. J Clin Anesth 99: 111632, 2024.
6. Yang X, Ying S, Yuan X, Ying J, Yang J and Lv L: Lactate-to-albumin ratio as an independent predictor of mortality in critically ill patients with gastrointestinal bleeding: A retrospective cohort study. BMC Gastroenterol 25: 653, 2025.
7. Aydin H: The Cancer-Induced lactate load and oncologic remodeling hypothesis: Lactate as a driver of biosynthesis and epigenetics in cancer. Front Oncol 15: 1638108, 2025.
8. Huang K, Han Y, Chen Y, Shen H, Zeng S and Cai C: Tumor metabolic regulators: Key drivers of metabolic reprogramming and the promising targets in cancer therapy. Mol Cancer 24: 7, 2025.
9. Altea-Manzano P, Decker-Farrell A, Janowitz T and Erez A: Metabolic interplays between the tumour and the host shape the tumour macroenvironment. Nat Rev Cancer 25: 274-292, 2025.
10. Bozgul SMK, Kurtulmus IA, Gunes A, Koymen G, Bozkurt D, Karaman ZT, Islamoglu K, Ozkilic B, Barutcuoglu B, Cilli FF and Soyer NA: Lactate level is an independent predictor of mortality in patients with hematologic malignancy receiving urgent chemotherapy in intensive care unit. Curr Res Transl Med 72: 103451, 2024.
11. Erdur A, Guven R, Can D, Gurkan TT, Ak E and Avci A: Prognostic importance of lactate and blood gas parameters in predicting mortality in patients with critical malignancies. Ethiop J Health Sci 33: 255-262, 2023.
12. Liu Q, Zheng HL, Wu MM, Wang QZ, Yan SJ, Wang M, Yu JJ and Li DP: Association between lactate-to-albumin ratio and 28-days all-cause mortality in patients with acute pancreatitis: A retrospective analysis of the MIMIC-IV database. Front Immunol 13: 1076121, 2022.
13. Shin J, Hwang SY, Jo IJ, Kim WY, Ryoo SM, Kang GH, Kim K, Jo YH, Chung SP, Joo YS, *et al*: Prognostic value of the Lactate/Albumin ratio for predicting 28-Day mortality in critically ILL sepsis patients. Shock 50: 545-550, 2018.
14. Kong T, Chung SP, Lee HS, Kim S, Lee J, Hwang SO, Shin SD, Song KJ, Cha KC and You JS; Korean Cardiac Arrest Research Consortium (KoCARC) Investigators: The Prognostic usefulness of the lactate/Albumin ratio for predicting clinical outcomes in Out-of-hospital cardiac arrest: A prospective, multicenter observational study (koCARC) study. Shock 53: 442-451, 2020.

15. Ren J, Kang Q, Wang F and Yu W: Association of lactate/albumin ratio with in-hospital mortality in ICU patients with acute respiratory failure: A retrospective analysis based on MIMIC-IV database. Medicine (Baltimore) 102: e35410, 2023.
16. Wang J, Chen X, Qin C, Shi R, Huang Y, Gong J, Zeng X and Wang D: Lactate-to-Albumin ratio as a potential prognostic predictor in patients with cirrhosis and sepsis: A retrospective cohort study. BMC Infect Dis 25: 223, 2025.
17. Gou J, Liu C, Lang M and Yao F: Prognostic value of the lactate-to-albumin ratio in critically ill chronic heart failure patients with sepsis: Insights from a retrospective cohort study. Front Med (Lausanne) 12: 1593524, 2025.
18. Hanci P, Temel E, Bilir F and Kaya BS: Lactate to albumin ratio as a determinant of intensive care unit admission and mortality in hospitalized patients with Community-Acquired pneumonia. BMC Pulm Med 25: 224, 2025.
19. Johnson AEW, Bulgarelli L, Shen L, Gayles A, Shammout A, Horng S, Pollard TJ, Hao S, Moody B, Gow B, *et al*: Author Correction: MIMIC-IV, a freely accessible electronic health record dataset. Sci Data 10: 219, 2023.
20. Charlson ME, Pompei P, Ales KL and MacKenzie CR: A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. J Chronic Dis 40: 373-383, 1987.
21. Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, Saunders LD, Beck CA, Feasby TE and Ghali WA: Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care 43: 1130-1119, 2005.
22. Heymans MW and Twisk JWR: Handling missing data in clinical research. J Clin Epidemiol 151: 185-188, 2022.
23. VanderWeele TJ: Principles of confounder selection. Eur J Epidemiol 34: 211-219, 2019.
24. Vincent JL, Moreno R, Takala J, Willatts S, De Mendonca A, Bruining H, Reinhart CK, Suter PM and Thijs LG: The SOFA (Sepsis-related Organ Failure Assessment) score to describe organ dysfunction/failure. On behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine. Intensive Care Med 22: 707-710, 1996.
25. den Boer S, de Keizer NF and de Jonge E: Performance of prognostic models in critically ill cancer patients-a review. Crit Care 9: R458-R463, 2005.
26. Steyerberg EW, Vickers AJ, Cook NR, Gerds T, Gonen M, Obuchowski N, Pencina MJ and Kattan MW: Assessing the performance of prediction models: A framework for traditional and novel measures. Epidemiology 21: 128-138, 2010.
27. Bakker J and Jansen TC: Don't take vitals, take a lactate. Intensive Care Med 33: 1863-1865, 2007.
28. Lichtenauer M, Wernly B, Ohnewein B, Franz M, Kabisch B, Muessig J, Masyuk M, Lauten A, Schulze PC, Hoppe UC, *et al*: The Lactate/Albumin ratio: A valuable tool for risk stratification in septic patients admitted to ICU. Int J Mol Sci 18: 1893, 2017.
29. Hastie T, Tibshirani R, Friedman J and Franklin J: The elements of statistical learning: Data mining, inference, and prediction. Math Intell 27: 83-85, 2004.
30. Gharipour A, Razavi R, Gharipour M and Mukasa D: Lactate/Albumin Ratio: An early prognostic marker in critically Ill patients. Am J Emerg Med 38: 2088-2095, 2020.
31. Vayakkattil AB, Pazhanchery AS, Andrews S and Vayakkattil U: The warburg effect redefined: A kinetic and regulatory perspective. Cureus 17: e93331, 2025.
32. Hou X, Hong Z, Zen H, Zhang C, Zhang P, Ma D and Han Z: Lactylation in cancer biology: Unlocking new avenues for research and therapy. Cancer Commun (Lond) 45: 1367-1406, 2025.
33. Nuyttens L, Heyerick M, Heremans G, Moens E, Roes M, Van Dender C, De Bus L, Decruyenaere J, Dewaele J, Vandewalle J and Libert C: Unraveling mitochondrial pyruvate dysfunction to mitigate hyperlactatemia and lethality in sepsis. Cell Rep 44: 116032, 2025.
34. Kring SK, Beck AM, Wessel I, Ustrup KS, Dieperink KB, Zwisler AD and Kristensen MB: Nutrition screening and assessment tools for adult patients with cancer and survivors of cancer: A systematic review. Nutr Cancer 78: 7-29, 2026.
35. Zhao K, Zhou L, Ni Y, Tao J, Yu Z, Li X and Wang L: Association between lactate-to-Albumin ratio and 28-day all-cause mortality in critical care patients with COPD: Can both arterial and peripheral venous lactate serve as predictors? Int J Chron Obstruct Pulmon Dis 20: 1419-1434, 2025.
36. Dong Y, Shi X, Wang C, Hu Y, Li J, Luo H, Zhu M, Hu F and Chu Q: The impact of the lactate-to-albumin ratio on long-term mortality risk in patients with severe heart failure and type 2 diabetes. BMC Cardiovasc Disord 25: 234, 2025.
37. Zhang R, Yao J, Li H, Liu D and Lin D: Lactate to albumin ratio as a novel predictor of short-term prognosis for liver cirrhosis in ICU. Sci Rep 15: 35754, 2025.
38. Acharya CP, Yadav A, Pokhrel S, Bastola S and Jha S: Prognostic significance of lactate/albumin ratio in respiratory failure and sepsis. Ann Med 57: 2482024, 2025.
39. Song Z, Miao H, Xin X, Guo D, Deng Y, Wang H and Wang F: Elevated lactate-to-albumin ratio predicts short- and long-term mortality in trauma and surgical intensive care patients: A retrospective MIMIC-IV cohort study. Sci Rep 15: 45121, 2025.
40. Wu Y, Wang L and Wen Q: Association of lactate to albumin ratio with short-term and long-term mortality in critically ill patients with heart failure complicated by sepsis: A retrospective study using the MIMIC-IV database. Front Cardiovasc Med 12: 1636375, 2025.
41. Ranzani OT, Singer M, Salluh JIF, Shankar-Hari M, Pilcher D, Berger-Estilita J, Coopersmith CM, Juffermans NP, Laffey J, Reinikainen M, *et al*: Development and validation of the sequential organ failure assessment (SOFA)-2 Score. JAMA 334: 2090-2103, 2025.
42. Bugarin-Arellano AL, Ramirez-Gonzalez LR, Suarez-Carreon LO, Lopez-Bernal NE, Leon-Flores PG, Gonzalez-Ojeda A and Fuentes-Orozco C: Lactate/albumin index as mortality predictor in abdominal sepsis. Cir Cir 93: 361-366, 2025.
43. Liu Y: Association between lactate/albumin ratio and 28-day mortality in ICU critical patients with coronary heart disease: A retrospective analysis of the MIMIC-IV database. Front Cardiovasc Med 11: 1486697, 2024.
44. Ma Y, Du L, Bai L and Tang H: Association between lactate-to-albumin ratio and all-cause mortality in critically ill cirrhotic patients with sepsis: A retrospective analysis of the MIMIC-IV database. BMC Gastroenterol 25: 112, 2025.
45. Han D, Sun S, Liu A, Hao C and Sun J: Lactate dehydrogenase-to-albumin ratio predicts 30-day and 90-day mortality in glucocorticoid-treated ICU patients with pneumonia: A secondary analysis of a multicenter cohort. Front Med (Lausanne) 13: 1832943, 2026.
46. Salas M, Henderson M, Sundararajan M, Tu N, Islam Z, Ebeid M and Horne L: Use of comorbidity indices in patients with any cancer, breast cancer, and human epidermal growth factor Receptor-2-positive breast cancer: A systematic review. PLoS One 16: e0252925, 2021.
47. Kubo Y, Tanaka K, Yamasaki M, Yamashita K, Makino T, Saito T, Yamamoto K, Takahashi T, Kurokawa Y, Motoori M, *et al*: Influences of the charlson comorbidity index and nutrition status on prognosis after esophageal cancer surgery. Ann Surg Oncol 28: 7173-7182, 2021.
48. Cao W, Liu S, Wang S, Wang S, Song Y and He Y: Effect of charlson comorbidity index and treatment strategy on survival of elderly patients after endoscopic submucosal dissection for gastric adenocarcinoma: A multicenter retrospective study. Front Public Health 9: 803113, 2022.
49. Lin JX, Huang YQ, Xie JW, Wang JB, Lu J, Chen QY, Cao LL, Lin M, Tu RH, Huang ZN, *et al*: Age-adjusted charlson comorbidity index (ACCI) is a significant factor for predicting survival after radical gastrectomy in patients with gastric cancer. BMC Surg 19: 53, 2019.
50. Pluchart H, Bailly S, Chanoine S, Moro-Sibilot D, Bedouch P and Toffart AC: Comparison of seven comorbidity scores on Four-month survival of lung cancer patients. BMC Med Res Methodol 23: 256, 2023.