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RESEARCH ARTICLE

Prognostic value of the lactate-based modified cally score in postoperative gastric cancer patients admitted to the ICU

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Abstract

Background Gastric cancer is a major cause of cancer-related mortality, and reliable postoperative risk prediction is essential in critically ill patients. The C-reactive protein–albumin–lymphocyte (CALLY) index reflects inflammatory and nutritional status, while lactate indicates metabolic stress and tissue hypoperfusion. This study aimed to develop a lactate-based CALLY (CALLY-I) score and evaluate its prognostic value in postoperative gastric cancer patients admitted to the intensive care unit (ICU).

Methods This retrospective study included 186 patients who underwent gastric cancer surgery and required postoperative ICU care between January 2022 and January 2025. Demographic characteristics, laboratory parameters, APACHE II and SAPS II scores, and derived indices (CALLY and CALLY-I) were analyzed. Predictors of 30- and 90-day mortality were assessed using Receiver Operating Characteristic (ROC) analyses, and significant variables were included in multivariate logistic regression.

Results The 30-day and 90-day mortality rates were 18.2% and 26.7%, respectively. Lactate demonstrated the strongest predictive ability for both 30-day (AUC = 0.865) and 90-day (AUC = 0.806) mortality. The CALLY-I score showed superior prognostic performance compared with the classical CALLY index and was an independent predictor of 30-day mortality (OR = 0.47, p = 0.032). APACHE II, albumin, and BUN were also independently associated with mortality, while the classical CALLY index did not show independent significance.

Conclusion The lactate-based CALLY-I score enhances prognostic accuracy by combining metabolic, inflammatory, and nutritional markers. CALLY-I may serve as a practical tool for postoperative risk stratification in gastric cancer patients requiring ICU monitoring. Prospective multicenter studies are needed for further validation.

Keywords Gastric cancer · Postoperative mortality · Lactate-based CALLY score · Prognostic biomarkers · Intensive care unit (ICU)

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Introduction

Gastric cancer is one of the leading causes of cancer-related death worldwide, representing a malignancy notable for its aggressive course and high mortality rate. Diagnosis at an advanced stage significantly reduces the likelihood of curative treatment and worsens the prognosis [1]. While surgical resection remains the primary method for curative treatment, predicting preoperative mortality and morbidity risks in these patients is crucial for optimizing treatment strategies. Preoperative risk stratification allows surgeons to assess patient risk profiles, select appropriate treatment modalities, and more precisely evaluate the risk–benefit balance [2].

Predicting perioperative and early mortality risk is particularly important for clinical decision-making in patient

populations undergoing surgery, chemotherapy, or radiotherapy for malignant diseases. Studies have shown that the Acute Physiology and Chronic Health Evaluation II (APACHE II) and Simplified Acute Physiology Score II (SAPS II) also have significant prognostic value in oncologic patients. For example, Kisa et al. [3] used the APACHE II score to predict mortality after pancreatic cancer surgery and reported that high scores were associated with early deaths. Similarly, a study conducted at the France reported that the SAPS II score correlated with the mortality in gastrointestinal cancers [4].

In recent years, certain laboratory biomarkers have gained increasing importance in predicting post-surgical survival and the risk of complications. The C-reactive protein–albumin–lymphocyte (CALLY) index, developed in this context, is a composite parameter that includes C-reactive protein (CRP), albumin, and lymphocyte counts, reflecting systemic inflammation, nutritional status, and immune function. While serum albumin levels and lymphocyte counts decrease in cancer patients due to malnutrition and immune suppression, CRP levels increase due to chronic inflammation. Therefore, the CALLY index has been found to be associated with prognosis, particularly in digestive system cancers [5].

On the other hand, lactate levels are used as a robust biomarker of hemodynamic deterioration and tissue hypoxia in critically ill patients. Lactate, a product of glucose metabolism, accumulates during oxygen deprivation due to the anaerobic conversion of pyruvate. Therefore, lactate levels are considered a reliable parameter for predicting morbidity and mortality, particularly in critically ill patients, and are helpful in the hemodynamic resuscitation process [6]. Given that the CALLY index reflects nutritional status and immune-inflammatory responses, while lactate reflects metabolic and circulatory status, combining these two parameters may provide a more comprehensive prognostic marker. However, the current literature lacks a holistic prognostic tool that integrates the CALLY index with serum lactate levels. Previous studies have primarily evaluated the CALLY index as an independent immunonutritional marker across various clinical settings, while serum lactate has been extensively investigated as a standalone indicator of metabolic stress and tissue hypoperfusion. To date, there is a notable gap in the literature regarding a comprehensively evaluated integrated score that simultaneously captures inflammatory, nutritional, immune, and metabolic components, particularly for predicting intensive care mortality in postoperative gastric cancer patients. Therefore, the primary aim of this study was to develop a lactate-based CALLY (CALLY-I) score and to evaluate its prognostic value in this specific patient population.

In this study, we aimed to propose and evaluate a lactate-based modification of the CALLY index (CALLY-I) by incorporating serum lactate levels into the original score, and to assess its prognostic value for predicting mortality in patients undergoing gastric cancer surgery and requiring postoperative intensive care. Rather than establishing a new gold standard, our objective was to investigate whether the integration of metabolic information provided by lactate could enhance the prognostic performance of the conventional CALLY index and complement existing prognostic biomarkers.

Methods

This study was designed as a retrospective, observational, single-center study. After obtaining ethics committee approval from the Kastamonu University Non-Interventional Clinical Research Ethics Committee (Approval No: 2025-44, Date: 22.09.2025), the study included patients who underwent surgery for gastric cancer and were followed in the intensive care unit (ICU) postoperatively between January 2022 and January 2025, using data from the Hospital Information Management System (HIS) and Operation Information System (OBS). Inclusion criteria were as follows: patients aged 18 years or older, those who underwent surgery for gastric cancer, had postoperative ICU follow-up, and had complete laboratory and clinical data available at the time of data extraction. Patients with incomplete preoperative or postoperative data, inaccurate or missing ICU records, or hematological malignancies or receiving immunosuppressive therapy were excluded prior to analysis.

Demographic and clinical data were collected from HIS and OBS records, including age, gender, comorbidities (such as hypertension, diabetes, or COPD), and body mass index (BMI). Postoperative laboratory parameters obtained upon ICU admission included hematocrit, leukocytes, neutrophils, lymphocytes, monocytes, platelets, C-reactive protein (CRP), albumin, blood urea nitrogen (BUN), creatinine, pH, CO_2, HCO_3, and lactate levels.Physiological scores recorded upon ICU admission included APACHE II and SAPS II scores.From these data, several inflammatory and nutritional biomarkers were calculated: Neutrophil/Lymphocyte Ratio (NLR), Platelet/Lymphocyte Ratio (PLR), Monocyte/Lymphocyte Ratio (MLR), and CRP/Albumin Ratio (CAR).

Additionally, two indices were calculated: the CALLY index, defined as

$$\text{CALLY} = [\text{Serum Albumin (g/dL)} \times \text{Lymphocytes } (10^3/\mu\text{L})]/\text{CRP (mg/L)},$$

and the lactate-based CALLY score, a novel parameter defined as $\text{Lactate-based CALLY} = \{[\text{Serum Albumin (g/dL)} \times \text{Lymphocytes } (10^3/\mu\text{L})]/\text{CRP (mg/L)}\} \div \text{Lactate (mmol/L)}$ [7].

The primary endpoints of this study were 30-day and 90-day mortality, obtained from the hospital record system (HIS).

Sample size considerations

This was a retrospective, observational, single-center study; therefore, no formal a priori sample size calculation was performed. All consecutive patients who met the inclusion criteria during the study period were included to minimize selection bias. The sample size was determined by the availability of eligible cases rather than predefined statistical assumptions.

Given the exploratory and prognostic nature of the study, multivariate models were constructed with careful consideration of the number of outcome events to minimize the risk of overfitting, and multicollinearity among variables was assessed using variance inflation factors.

Statistical analysis

All data obtained in this study were analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages (%). The normality of data distribution was evaluated using the Kolmogorov–Smirnov test. For group comparisons, the independent samples t-test was applied to normally distributed variables, whereas the Mann–Whitney U test was used for non-normally distributed variables. Differences between categorical variables were assessed using the Chi-square test or Fisher's exact test, as appropriate. Receiver Operating Characteristic (ROC) curve analysis was performed to evaluate the predictive performance of laboratory and clinical parameters for 30-day and 90-day mortality. The area under the curve (AUC), optimal cut-off value (determined using the Youden index), sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each parameter. Multivariate logistic regression analysis was conducted to identify independent predictors of mortality. Variables that were statistically significant in the ROC analysis were included in the regression model. Multicollinearity among variables was assessed using the Variance Inflation Factor (VIF). Multivariate logistic regression analysis was conducted to identify independent predictors of mortality. Variables that were statistically significant in the ROC analysis were included in the regression model. Multicollinearity among variables was assessed using the Variance Inflation Factor (VIF). Model performance was evaluated using the Hosmer–Lemeshow goodness-of-fit test, the area under the receiver operating characteristic curve (AUC), and the Brier score. A p-value < 0.05 was considered statistically significant.A p-value < 0.05 was considered statistically significant.

Results

A total of 186 patients who underwent surgery for gastric cancer between January 2022 and January 2025 and were monitored postoperatively in the intensive care unit (ICU) were included in the study. The mean age of the patients was 71.6 ± 14.6 years, and the male-to-female ratio was 99:87. The mean body mass index (BMI) was 22.7 ± 3.5 kg/m^2. A total of 75.4% of the patients had at least one comorbidity. The most common comorbidities were hypertension (27.3%), cardiac disease (26.7%), diabetes mellitus (12.8%), respiratory disease (11.2%), cerebrovascular accident (10.2%), and chronic renal failure (6.4%).

The 30-day mortality rate was 18.2% (n = 34), and the 90-day mortality rate was 26.7% (n = 50). The mean APACHE II and SAPS II scores were 20.7 ± 5.6 and 41.7 ± 16.1, respectively. Among the immunonutritional parameters, the mean CALLY index was 0.96 ± 0.22, and the mean lactate-based CALLY index was 0.46 ± 0.20. In patients with 30-day mortality, albumin ($p < 0.001$), hematocrit ($p = 0.004$), and pH ($p < 0.001$) levels were significantly lower, whereas blood urea nitrogen (BUN) ($p = 0.02$) and lactate ($p < 0.001$) levels were significantly higher. The APACHE II ($p < 0.001$) and SAPS II ($p < 0.001$) scores were also significantly higher, while both the CALLY index ($p = 0.032$) and lactate-based CALLY index ($p < 0.001$) were significantly lower.

Similarly, in patients with 90-day mortality, albumin ($p < 0.001$), hematocrit ($p < 0.001$), and pH ($p = 0.004$) levels were significantly lower, whereas BUN ($p < 0.001$) and lactate ($p < 0.001$) levels were significantly higher. The APACHE II ($p < 0.001$) and SAPS II ($p < 0.001$) scores were significantly higher, while the CALLY index ($p = 0.008$) and lactate-based CALLY index ($p < 0.001$) were significantly lower (Table 1).

According to the ROC analysis for 30-day mortality, the highest AUC values were observed for lactate (AUC = 0.865), APACHE II (AUC = 0.788), and CALLY-I (AUC = 0.782). The cut-off value for lactate was 2.0 mmol/L, with a sensitivity of 93.9% and a specificity of 71.7%. APACHE II had a cut-off value of 26, with a specificity of 91.4% and a sensitivity of 58.8%. For albumin level, AUC = 0.757 and a cut-off value of 2.6 g/dL were determined; mortality was significantly increased below this threshold ($p < 0.001$) (Table 2, Fig. 1).

For 90-day mortality, lactate (AUC = 0.806; cut-off = 1.8 mmol/L), albumin (AUC = 0.784; cut-off = 2.8 g/dL), APACHE II (AUC = 0.772; cut-off = 23), and SAPS II (AUC = 0.766; cut-off = 45) demonstrated relevant

Table 1 Demographic and Clinical Characteristics of the Patient Group

Variable	All Patients (n = 186)	30-day Non-survivors (n = 34)	p	90-day Non-survivors (n = 50)	P
Age (years)	71.6 ± 14.6	72.1 ± 9.4	0.09	68.9 ± 15.6	0.12
Male (%)	99 (53.2)	19 (55.9)	0.85	26 (52.0)	0.87
BMI (kg/m^2)	22.7 ± 3.5	23.9 ± 3.9	0.63	22.9 ± 3.7	0.99
Presence of comorbidity (%)	141 (75.4)	22 (64.7)	0.10	36 (72.0)	0.56
Diabetes mellitus (%)	24 (12.8)	2 (5.9)	0.18	4 (8.0)	0.33
Hypertension (%)	51 (27.3)	6 (17.6)	0.16	10 (20.0)	0.19
Cerebrovascular accident (%)	19 (10.2)	5 (14.7)	0.34	8 (16.0)	0.17
Chronic renal failure (%)	12 (6.4)	2 (5.9)	0.88	5 (10.0)	0.31
Cardiac disease (%)	50 (26.7)	7 (20.6)	0.36	14 (28.0)	0.85
Respiratory disease (%)	21 (11.2)	2 (5.9)	0.38	4 (8.0)	0.60
Albumin (g/dL)	3.02 ± 0.61	2.54 ± 0.71	**< 0.001**	2.57 ± 0.62	**< 0.001**
CRP (mg/L)	126.63 ± 60.3	125.06 ± 58.13	0.86	124.34 ± 61.8	0.75
BUN (mg/dL)	52.01 ± 32.9	68.15 ± 45.25	**0.02**	69.56 ± 42.7	**< 0.001**
Creatinine (mg/dL)	1.14 ± 0.9	1.18 ± 0.72	0.77	1.28 ± 1.0	0.22
CAR (CRP/Albumin ratio)	44.35 ± 25.4	52.41 ± 26.20	**0.04**	50.96 ± 27.47	0.31
Hematocrit (%)	33.51 ± 6.1	31.12 ± 6.34	**0.004**	31.40 ± 6.22	**< 0.001**
Leukocytes (× 10^3/µL)	11.83 ± 6.1	12.16 ± 6.76	0.73	12.25 ± 6.44	0.56
Platelets (× 10^3/µL)	227.77 ± 99.2	212.85 ± 95.3	0.31	208.68 ± 94.8	0.91
Neutrophils (× 10^3/µL)	9.39 ± 4.7	8.98 ± 4.35	0.69	9.45 ± 4.87	0.84
Lymphocytes (× 10^3/µL)	1.30 ± 0.95	1.16 ± 0.81	0.40	1.12 ± 0.68	0.10
Monocytes (× 10^3/µL)	0.76 ± 0.74	0.72 ± 0.46	0.63	0.73 ± 0.46	0.76
NLR (Neutrophil/Lymphocyte ratio)	10.9 ± 9.3	11.87 ± 11.44	0.49	11.76 ± 10.56	0.43
PLR (Platelet/Lymphocyte ratio)	241.51 ± 169.2	272.15 ± 219.01	0.24	249.60 ± 189.81	0.69
MLR (Monocyte/Lymphocyte ratio)	0.78 ± 0.74	0.90 ± 0.56	0.34	0.87 ± 0.78	0.32
pH	7.35 ± 0.10	7.29 ± 0.18	**< 0.001**	7.31 ± 0.16	**0.004**
pCO_2 (mmHg)	39.71 ± 10.09	41.7 ± 15.35	0.21	41.29 ± 13.60	0.19
HCO_3 (mmol/L)	21.65 ± 4.03	20.42 ± 6.80	0.48	21.06 ± 6.02	0.23
Lactate (mmol/L)	2.09 ± 1.33	3.41 ± 1.50	**< 0.001**	3.02 ± 1.48	**< 0.001**
APACHE II score	20.7 ± 5.6	26.2 ± 7.1	**< 0.001**	24.9 ± 6.6	**< 0.001**
SAPS II score	41.7 ± 16.1	54.3 ± 20.0	**< 0.001**	52.6 ± 17.5	**< 0.001**
CALLY index	0.96 ± 0.22	0.029 ± 0.024	**0.032**	0.029 ± 0.022	**0.008**
Lactate-based CALLY (CALLY-L)	0.46 ± 0.20	0.011 ± 0.010	**< 0.001**	0.013 ± 0.011	**< 0.001**

BMI Body Mass Index, *CRP* C-reactive Protein, *BUN* Blood Urea Nitrogen, *CAR* C-reactive Protein-to-Albumin Ratio, *NLR* Neutrophil-to-Lymphocyte Ratio, *PLR* Platelet-to-Lymphocyte Ratio, *MLR* Monocyte-to-Lymphocyte Ratio, *pCO_2* Partial Pressure of Carbon Dioxide, *HCO_3* Bicarbonate, *APACHE II* Acute Physiology and Chronic Health Evaluation II, *SAPS II* Simplified Acute Physiology Score II, *CALLY* C-reactive Protein–Albumin–Lymphocyte Index, *CALLY-L (or L-CALLY)* Lactate-Based CALLY Index, *ICU* Intensive Care Unit

Bold values indicate statistical significance (p<0.05)

discriminatory performance in ROC curve analysis (Table 3, Fig. 1).

Multivariate logistic regression analysis was conducted to identify independent predictors of 30- and 90-day mortality. Variables that were significant in univariate analyses ($p < 0.10$) — or considered clinically relevant — including APACHE II, SAPS II, CALLY, CALLY-I, BUN, hematocrit, pH, albumin, and lactate, were included in the multivariate model.. A p value < 0.05 was considered statistically significant. APACHE II, BUN, lactate, albumin, pH, hematocrit, and CALLY-I scores showed independent and significant associations with 30-day mortality (Table 4). The model demonstrated excellent performance with an AUC of 0.90 and a Brier score of 0.09, indicating strong discriminatory power and good calibration.

In the multivariate logistic regression analysis for 90-day mortality, APACHE II score, lactate level, BUN, and albumin were included in the final model, while the CALLY-I score showed a p value close to the predefined significance threshold (Table 5).

Table 2 ROC Analysis for 30-Day Mortality

Variable	AUC	Cut-off (unit)	Sensitivity	Specificity	PPV	NPV
SAPS II	0.740	55 (score)	0.50	0.89	0.52	0.89
APACHE II	0.788	26 (score)	0.59	0.91	0.61	0.91
BUN	0.630	72 mg/dL	0.38	0.84	0.35	0.86
Lactate	0.865	2.0 mmol/L	0.94	0.72	0.42	0.98
pH	0.620	7.26	0.44	0.93	0.58	0.88
CALLY	0.619	0.021	0.53	0.70	0.29	0.87
CALLY-I (Lactate-based)	0.782	0.011	0.74	0.78	0.42	0.93
Hematocrit	0.634	31%	0.50	0.71	0.28	0.86
Albumin	0.757	2.6 g/dL	0.65	0.82	0.45	0.91

BUN Blood Urea Nitrogen, *APACHE II* Acute Physiology and Chronic Health Evaluation II, *SAPS II* Simplified Acute Physiology Score II, *CALLY* C-reactive Protein–Albumin–Lymphocyte Index, *CALLY-L (or L-CALLY)* Lactate-Based CALLY Index

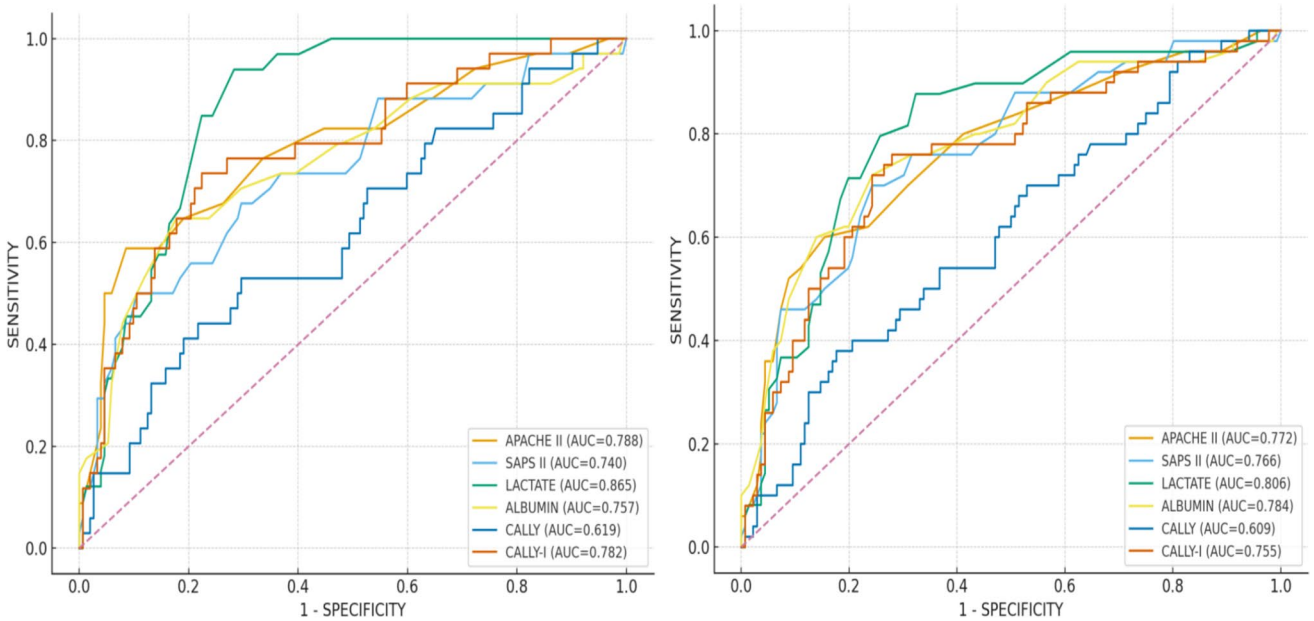

Fig. 1 ROC Curve for 30-and 90- Day Mortality

Table 3 ROC Analysis for 90-Day Mortality

Variable	AUC	Cut-off (unit)	Sensitivity	Specificity	PPV	NPV
SAPS II	0.766	45 (score)	0.70	0.76	0.52	0.87
APACHE II	0.772	23 (score)	0.60	0.85	0.59	0.85
BUN	0.681	60 mg/dL	0.52	0.79	0.48	0.82
Lactate	0.806	1.8 mmol/L	0.88	0.68	0.49	0.94
pH	0.580	7.26	0.38	0.95	0.73	0.81
CALLY	0.609	0.016	0.38	0.82	0.44	0.78
CALLY-I (Lactate-based)	0.755	0.014	0.76	0.72	0.50	0.89
Hematocrit	0.642	31%	0.50	0.74	0.41	0.80
Albumin	0.784	2.8 g/dL	0.72	0.76	0.52	0.88

BUN Blood Urea Nitrogen, *APACHE II* Acute Physiology and Chronic Health Evaluation II, *SAPS II* Simplified Acute Physiology Score II, *CALLY* C-reactive Protein–Albumin–Lymphocyte Index, *CALLY-L (or L-CALLY)* Lactate-Based CALLY Index

Table 4 Multivariate Logistic Regression Analysis for 30-Day Mortality

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p value
Constant	0.01	(0.00–0.03)	< 0.001
APACHE II	1.12	(1.02–1.25)	**0.010**
SAPS II	1.01	(0.97–1.05)	0.465
BUN (mg/dL)	1.02	(1.00–1.03)	**0.041**
Hematocrit (%)	0.90	(0.83–0.98)	**0.025**
pH	0.61	(0.40–0.92)	**0.021**
Albumin (g/dL)	0.71	(0.55–0.91)	**0.009**
Lactate (mmol/L)	1.29	(1.09–1.54)	**0.004**
CALLY	0.88	(0.59–1.31)	0.559
CALLY-I (Lactate-based)	0.47	(0.24–0.91)	**0.032**

BUN Blood Urea Nitrogen, *APACHE II* Acute Physiology and Chronic Health Evaluation II, *SAPS II* Simplified Acute Physiology Score II, *CALLY* C-reactive Protein–Albumin–Lymphocyte Index, *CALLY-L (or L-CALLY)* Lactate-Based CALLY Index

Bold values indicate statistical significance (p<0.05)

Table 5 Multivariate Logistic Regression Analysis for 90-Day Mortality

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p value
Constant	0.02	(0.00–0.06)	< 0.001
APACHE II	1.11	(1.01–1.24)	**0.014**
SAPS II	1.02	(0.98–1.07)	0.223
BUN (mg/dL)	1.02	(1.00–1.03)	**0.044**
Hematocrit (%)	0.93	(0.87–1.01)	0.083
pH	0.73	(0.47–1.11)	0.115
Albumin (g/dL)	0.75	(0.59–0.96)	0.031
Lactate (mmol/L)	1.26	(1.08–1.51)	**0.007**
CALLY	0.92	(0.64–1.33)	**0.595**
CALLY-I (Lactate-based)	0.63	(0.41–0.99)	**0.048**

*BUN*Blood Urea Nitrogen, *APACHE II*Acute Physiology and Chronic Health Evaluation II, *SAPS II* Simplified Acute Physiology Score II, *CALLY* C-reactive Protein–Albumin–Lymphocyte Index, *CALLY-L (or L-CALLY)* Lactate-Based CALLY Index

Bold values indicate statistical significance (p<0.05)

Discussion

This study investigated clinical and biochemical markers that could predict short- and medium-term mortality in patients monitored in the intensive care unit after gastric cancer surgery. Our findings suggest that lactate levels, in particular, as well as APACHE II and SAPS II scores, are associated with mortality and may have prognostic relevance.

APACHE II and SAPS II are well-established scoring systems that have long been used to estimate mortality risk in critically ill patients. Numerous studies have confirmed their association with postoperative mortality [3, 4]. In our study, APACHE II showed a strong relationship with both 30- and 90-day mortality and remained an independent prognostic factor in multivariate analyses. Although SAPS II exhibited significant predictive power in ROC analysis, it did not retain independent significance in multivariate analysis. This finding suggests that, while SAPS II is associated with mortality, its prognostic contribution may be less pronounced when considered alongside APACHE II and biochemical parameters such as lactate, albumin, and the CALLY-I score.

Serum albumin is an important biochemical parameter that reflects nutritional status, colloidal osmotic pressure, and systemic inflammation. Low albumin levels (hypoalbuminemia) have been linked to increased complication rates and mortality in various malignancies. Gupta et al. [8] reported that preoperative serum albumin levels below 3.5 g/dL were significantly associated with higher postoperative mortality in cancer patients. Similarly, Hua et al. [9] found that hypoalbuminemia adversely affected 90-day survival in advanced malignancies. Consistent with these findings, our study demonstrated that low albumin levels were significantly associated with both 30- and 90-day mortality, and multivariate analysis identified albumin as an independent protective factor (OR = 0.71, p = 0.009 for 30-day; OR = 0.75, p = 0.031 for 90-day mortality). These results support the influence of systemic inflammation and malnutrition on postoperative outcomes.

Hematocrit is a physiological indicator that directly influences oxygen delivery to tissues. A low hematocrit level (anemia) contributes to tissue hypoxia and increased oxidative stress during postoperative recovery. Zou et al. [10] reported that a decrease in hematocrit significantly increases the risk of death in intensive care patients. In our study, mortality rates rise with decreasing hematocrit levels (AUC = 0.63 in ROC analysis; OR = 0.90, p = 0.025 in multivariate analysis), suggesting that low preoperative hematocrit may serve as an independent risk factor for early postoperative mortality.

In contrast to the classical CALLY score, which did not show an independent association with mortality in multivariate logistic regression, the lactate-based CALLY-I score emerged as a significant independent predictor in both 30-day and 90-day mortality models. This finding indicates that inclusion of lactate, a marker of tissue perfusion and metabolic stress, enhances the prognostic performance of the model.

These results align with prior studies. Zhang et al. [11] demonstrated that lower CALLY index values were independently associated with increased 30-day mortality in sepsis patients. Similarly, Lida et al. [12] found that a higher

CALLY index predicted better survival after hepatocellular carcinoma surgery. Furthermore, Wu et al. [5] emphasized that the CALLY index represents a composite prognostic indicator integrating inflammation, nutrition, and immune response into a single score.

The association between elevated lactate levels and mortality has been well documented. A meta-analysis by Liu et al. [13] identified lactate as an independent predictor of mortality in sepsis, with higher discriminatory power than the qSOFA score. Hayashi et al. [14] showed that peak arterial lactate levels measured within the first 24 h of intensive care were strong predictors of 90-day survival. Likewise, Shapiro et al. [15] demonstrated that lactate levels measured upon emergency department admission were significantly associated with in-hospital mortality.

The CALLY-I score, which proved to be an independent predictor in our study, appears to capture the integrated effects of inflammation, nutritional status, and tissue perfusion (through lactate). The lack of significance for the classical CALLY score may stem from the absence of lactate, an essential marker of acute metabolic stress. An odds ratio below 1 for CALLY-I supports the concept that decreasing scores correspond to higher mortality risk. Since the CALLY index has previously been used to predict mortality in various patient populations (e.g., sepsis, hepatocellular carcinoma), our findings extend its applicability to patients undergoing gastric cancer surgery.

The present study has several limitations that should be acknowledged. First, its retrospective and single-center design inherently limits causal inference and may introduce selection bias, as only patients with complete and available records could be included. Second, the relatively small sample size, particularly with respect to the number of outcome events, may limit the statistical power of the analyses and increase the risk of model overfitting, despite efforts to mitigate this through careful variable selection and multicollinearity assessment. Third, important oncological variables, such as tumor stage, histopathological characteristics, surgical complexity, and the use of neoadjuvant or adjuvant therapies, were not available for analysis and may have influenced patient outcomes. Additionally, lactate and other laboratory parameters were assessed at a single postoperative time point, and dynamic changes over time were not evaluated. Finally, as the proposed CALLY-I score has not yet been externally validated, the generalizability of these findings to other institutions or patient populations remains uncertain. Prospective, multicenter studies with larger cohorts are warranted to confirm and extend the present results.

In conclusion, the lactate-based CALLY-I score showed improved prognostic performance compared with the classical CALLY index in this study population. The incorporation of lactate enhances the model's predictive accuracy by integrating markers of inflammation, metabolic stress, and nutritional deficiency. Therefore, the clinical application of the CALLY-I score may aid in early postoperative risk stratification; however, further multicenter prospective studies are warranted for validation.

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Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest The authors declare that they have no conflicts of interest related to this study.

Research involving human participants and/or animals and Informed consent Ethical approval for this retrospective study was obtained from the Kastamonu University Non-Interventional Clinical Research Ethics Committee (Approval No: 2025-44, Date: 22.09.2025). Due to the retrospective nature of the study, the requirement for informed consent was waived.

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