



# Predictive value of the albumin-to-creatinine and bicarbonate-to-lactate ratios for 28-day mortality in acute mesenteric ischemia

İbrahim Doğan<sup>1</sup>, Serhat Ocaklı<sup>2</sup>, Firat Canlıkarakaya<sup>3</sup>, Cengiz Ceylan<sup>4</sup>

<sup>1</sup>Department of General Surgery, University of Health Sciences Türkiye, Van Training and Research Hospital, Van, Türkiye

<sup>2</sup>Department of General Surgery, Ankara Medipol University Faculty of Medicine, Ankara, Türkiye

<sup>3</sup>Department of General Surgery, Amasya University Faculty of Medicine, Amasya, Türkiye

<sup>4</sup>Department of Gastrointestinal Surgery, Eskişehir City Hospital, Eskişehir, Türkiye

## ABSTRACT

**Objective:** Acute mesenteric ischemia (AMI) is a life-threatening condition characterized by rapid deterioration, yet it is often identified late owing to vague and non-specific clinical findings. Identifying laboratory markers that can assist in early mortality prediction remains essential for improving outcomes. This study aimed to determine whether the bicarbonate-to-lactate ratio ( $\text{HCO}_3/\text{lactate}$ ) and the albumin-to-creatinine ratio could serve as reliable predictors of early mortality in patients with AMI.

**Material and Methods:** This retrospective case-control study included 87 patients who underwent surgical treatment for acute arterial mesenteric ischemia caused by superior mesenteric artery embolism between 2015 and 2025. Demographic characteristics, comorbidities, laboratory findings, and mortality outcomes were evaluated. The predictive performance of the bicarbonate-to-lactate and albumin-to-creatinine ratios was assessed using receiver operating characteristic (ROC) analysis; independent predictors of mortality were identified through multivariate logistic regression.

**Results:** The 28-day mortality rate was 62.1%. In univariate analysis, lower bicarbonate and albumin levels, reduced  $\text{HCO}_3/\text{lactate}$  and albumin/creatinine ratios, and higher lactate, creatinine, and C-reactive protein values were significantly associated with mortality ( $p < 0.05$ ). ROC analysis identified values of  $< 6$  for the  $\text{HCO}_3/\text{lactate}$  ratio and  $< 2.6$  for the albumin/creatinine ratio as the best cut-off values. In the multivariate model, a  $\text{HCO}_3/\text{lactate}$  ratio  $< 6$  increased the risk of death by more than 13-fold, while an albumin/creatinine ratio  $< 2.6$  increased mortality risk by approximately 4.5-fold.

**Conclusion:** Both the  $\text{HCO}_3/\text{lactate}$  and albumin/creatinine ratios are simple, inexpensive, and easily obtainable biochemical markers that may assist clinicians in predicting early mortality in AMI. Their incorporation into early evaluation algorithms could enhance risk stratification, although validation through prospective studies is warranted.

**Keywords:** Acute mesenteric ischemia, bicarbonate-to-lactate ratio, albumin-to-creatinine ratio, mortality prediction, prognostic biomarkers

## INTRODUCTION

Acute mesenteric ischemia (AMI) represents an uncommon yet catastrophic vascular emergency, arising from a sudden reduction in intestinal perfusion and frequently progressing to transmural bowel necrosis. Despite advances in diagnostic imaging and perioperative care, reported in-hospital mortality rates remain exceedingly high, often surpassing 50% (1). The clinical presentation of AMI is notoriously heterogeneous and frequently disproportionate to physical findings, particularly in elderly patients and those with comorbidities, which contributes to diagnostic delay and adversely affects survival. Consequently, the early recognition of patients at heightened risk of mortality continues to be a critical unmet need in clinical practice.

Various laboratory parameters, including serum lactate, blood urea nitrogen, and creatinine, have been investigated as prognostic indicators in AMI; however, their predictive performance remains suboptimal. Lactate reflects global hypoperfusion and anaerobic metabolism but lacks etiological specificity, whereas elevations in creatinine more commonly indicate systemic hypovolemia, renal hypoperfusion, or sepsis-related organ dysfunction rather than isolated mesenteric ischemia (2). Similarly, although serum albumin and bicarbonate have not been validated as independent prognostic biomarkers in AMI, hypoalbuminemia has consistently been linked to unfavorable outcomes, largely due to its behavior as a negative acute-

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### Corresponding Author

İbrahim Doğan

E-mail: dogan\_203@hotmail.com

ORCID ID: orcid.org/0000-0001-7413-1837

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phase reactant in the setting of inflammation, surgical stress, and critical illness (3).

In recent years, attention has shifted toward composite indices derived from routinely available biochemical measurements to enhance prognostic discrimination. The bicarbonate-to-lactate ratio ( $\text{HCO}_3^-/\text{lactate}$ ) provides an integrated reflection of metabolic acidosis and tissue hypoxia, whereas the albumin-to-creatinine ratio may serve as a surrogate marker of both physiological reserve and renal function. Notably, a retrospective analysis in patients with occlusive arterial AMI demonstrated that a bicarbonate-to-lactate ratio below 10 was strongly associated with 30-day mortality, particularly in cases with abrupt symptom onset, where its predictive accuracy was reported to be exceptionally high (4). In contrast, while the serum albumin-to-creatinine ratio has been shown to predict in-hospital mortality in severe acute pancreatitis and exhibits a strong inverse relationship with short-term mortality in ST-elevation myocardial infarction, its role in the context of AMI has not yet been systematically examined (5,6).

It is essential to emphasize that these ratios do not represent disease-specific biomarkers; rather, they function as global indicators of critical illness, systemic inflammation, and metabolic derangement. Accordingly, their relevance in AMI lies in assessing whether such general critical illness markers preserve their prognostic utility within this uniquely lethal clinical entity. Against this background, the present study sought to investigate the prognostic value of the  $\text{HCO}_3^-/\text{lactate}$  and albumin/creatinine ratios in predicting early mortality in patients with AMI, with the hypothesis that these readily accessible indices may facilitate early risk stratification and support urgent clinical decision-making.

## MATERIAL and METHODS

### Study Design and Patient Population

This retrospective case-control study was conducted by reviewing the institutional electronic medical records of patients who underwent operative management for acute arterial mesenteric ischemia between January 2015 and December 2025. A total of 87 adult patients meeting the eligibility criteria were identified and included in the analysis.

Baseline demographic data [including age (years) and sex] and relevant clinical characteristics (such as documented comorbid conditions) were extracted. Laboratory parameters obtained at the time of initial hospital presentation and prior to surgical intervention were recorded. These included serum bicarbonate (mmol/L), lactate (mmol/L), creatinine (mg/dL), albumin (g/dL), and C-reactive protein [(CRP) mg/L]. In addition, composite indices—the bicarbonate-to-lactate ratio and the albumin-to-creatinine ratio—were calculated for each patient.

The primary endpoint of the study was 28-day mortality, defined as death from any cause occurring within 28-days following the index surgical procedure.

### Eligibility Criteria

Patients were eligible for inclusion if they were 18 years of age or older and had a confirmed diagnosis of AMI secondary to embolic occlusion of the superior mesenteric artery requiring surgical intervention.

Patients were excluded if they had chronic mesenteric ischemia, received non-operative management, had incomplete clinical, laboratory, or radiological records, or had baseline renal dysfunction attributable to end-stage renal disease, which could confound serum creatinine measurements.

After enrollment, patients were stratified as survivors or non-survivors based on 28-day mortality, and all variables were analyzed accordingly.

### Ethical Considerations

The study protocol was reviewed and approved by the Institutional Review Board of Amasya University (approval number: 2025/101; date: 12 June 2025). The study was conducted in accordance with the principles of the Declaration of Helsinki.

### Statistical Analysis

Sample size estimation was performed using G\*Power version 3.1, assuming a statistical power of 80% and a two-sided alpha level of 0.05. Based on these assumptions, a minimum of 31 patients per group was required, yielding a minimum total sample size of 62 participants.

The distribution of continuous variables was evaluated using the Shapiro-Wilk normality test. As most variables deviated from normality, non-parametric statistical methods were employed. Continuous data are presented as medians with interquartile ranges and are compared between groups using the Mann-Whitney U test.

Categorical variables are expressed as absolute numbers and percentages and compared using the chi-square test. Variables demonstrating statistical significance in univariate analyses were subsequently entered into a forward stepwise multivariable logistic regression model to identify independent predictors of 28-day mortality. Model calibration was assessed using the Hosmer-Lemeshow goodness-of-fit test. A p-value of less than 0.05 was considered statistically significant.

## RESULTS

A total of 87 patients who underwent surgical treatment for AMI were included in the analysis. Of these, 63 patients (72.4%) were female. The median age of the study population was 76 years, with an interquartile range of 67 to 81 years. The most prevalent

comorbidities were coronary artery disease (57.5%), diabetes mellitus (57.5%), atrial fibrillation (55.2%), hypertension (44.8%), and chronic obstructive pulmonary disease (20.7%). The overall perioperative mortality rate observed in the cohort was 62.1% (Table 1).

Comparative univariate analyses demonstrated that several biochemical parameters differed significantly between survivors and non-survivors. These included lower serum bicarbonate levels ( $p<0.001$ ), higher lactate concentrations ( $p<0.001$ ),

reduced bicarbonate-to-lactate ratios ( $p<0.001$ ), elevated creatinine levels ( $p=0.019$ ), decreased albumin levels ( $p=0.001$ ), lower albumin-to-creatinine ratios ( $p=0.004$ ), and increased CRP values ( $p<0.001$ ) (Table 2).

Receiver operating characteristic (ROC) curve analysis was subsequently performed to assess the discriminative performance of the composite ratios. The analysis identified an optimal cut-off value of  $<6$  for the bicarbonate-to-lactate ratio and  $<2.6$  for the albumin-to-creatinine ratio in predicting mortality (Table 3). The corresponding ROC curves are illustrated in Figure 1. The cut-off values were determined as  $\text{HCO}_3^-/\text{lactate} <6$  and  $\text{albumin}/\text{creatinine} <2.6$ . Multivariate analysis showed that an  $\text{HCO}_3^-/\text{lactate}$  ratio of  $<6$  and an  $\text{albumin}/\text{creatinine}$  ratio of  $<2.6$  were associated with 13-fold and approximately 4.5-fold increases in mortality, respectively (Table 4).

## DISCUSSION

AMI is a severe vascular emergency that typically manifests as an acute abdomen and is associated with high mortality rates. Beyond clinical assessment, biochemical parameters play an important role in identifying patients at increased risk of adverse outcomes. Previous studies have reported the prognostic relevance of several biomarkers, including CRP, D-dimer, lactate, globulin, creatinine, and intestinal fatty acid-binding protein (I-FABP) (7-9). In the present study, univariate analysis revealed significant associations between mortality and lower

**Table 1. Descriptive analysis results of demographic data**

Variables		Count (%)	Median (IQR)
Gender	Male	24 (27.6%)	
	Female	63 (72.4%)	
Age, years			76 (67-81)
DM		50 (57.5%)	
AF		48 (55.2%)	
CAD		50 (57.5%)	
HT		39 (44.8%)	
COPD		18 (20.7%)	
Mortality	Alive	33 (37.9%)	
	Death	54 (62.1%)	

IQR: Interquartile range, DM: Diabetes mellitus, AF: Atrial fibrillation, CAD: Coronary artery disease, HT: Hypertension, COPD: Chronic obstructive pulmonary disease.

**Table 2. Univariate analysis results of the variables**

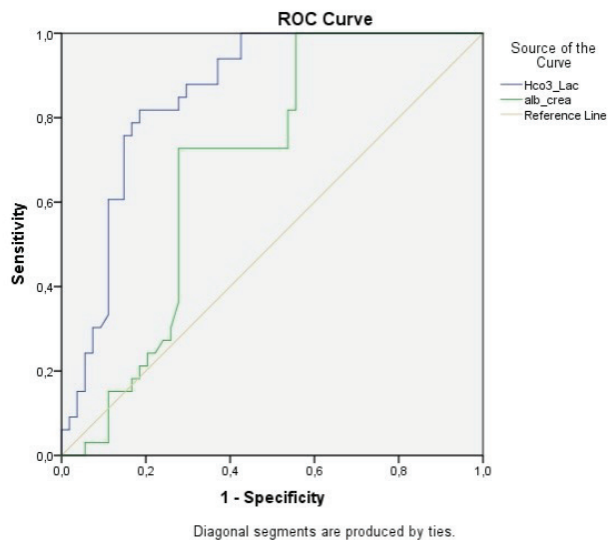
		Alive		Death		
Variables		Count (%)	Median (IQR)	Count (%)	Median (IQR)	p-value
Gender	Male	12 (36.4%)		12 (22.2%)		0.152
	Female	21 (63.6%)		42 (77.8%)		
Age			76 (66-79)		77 (69-82)	0.449
$\text{HCO}_3^-$			22 (20.3-24.6)		16.2 (12-17.4)	<b>&lt;0.001</b>
Lactate			2.36 (1.78-3.2)		5.15 (3-8)	<b>&lt;0.001</b>
$\text{HCO}_3^-/\text{lactate}$			9.32 (6.97-14.94)		2.93 (1.73-5.64)	<b>&lt;0.001</b>
Creatinine			0.93 (0.68-1.23)		1.02 (0.9-2.1)	<b>0.019</b>
Albumin			2.94 (2.63-3.2)		2.47 (2.15-3.04)	<b>0.001</b>
Albumin/creatinine			3.37 (2.09-4.26)		2.17 (1.34-4.24)	<b>0.004</b>
CRP			74.85 (34.6-135)		203.1 (99-265.9)	<b>&lt;0.001</b>

IQR: Interquartile range, CRP: C-reactive protein, Categorical data were analyzed using the Pearson chi-square test, continuous numerical variables were analyzed with the Mann-Whitney U test, and a p-value of  $<0.05$  was considered statistically significant.

**Table 3. ROC analysis results**

Variable	AUC	95% CI	p-value
$\text{HCO}_3^-/\text{lactate}$	0.855	0.777-0.934	<b>&lt;0.001</b>
Albumin/creatinine	0.686	0.575-0.797	<b>0.004</b>

AUC: Area under the curve, ROC: Receiver operating characteristic, CI: Confidence interval, a p-value of  $<0.05$  was considered statistically significant.



**Figure 1.** ROC analysis of predictive markers for mesenteric ischemia. ROC: Receiver operating characteristic.

Table 4. Multivariate analysis results of the variables			
Variable	OR	95% CI	p-value
HCO <sub>3</sub> /lactate <6	13.35	4.21-42.31	<0.001
Albumin/creatinine <2.6	4.46	1.43-13.94	0.01

OR: Odds ratio, CI: Confidence interval, a p-value of <0.05 was considered statistically significant.

bicarbonate and albumin levels, lower bicarbonate-to-lactate and albumin-to-creatinine ratios, and elevated CRP, creatinine, and lactate levels. However, multivariate analysis demonstrated that a bicarbonate-to-lactate ratio below 6 was linked to an approximately 13-fold increase in mortality risk, while an albumin-to-creatinine ratio below 2.6 was associated with nearly a 4.5-fold higher risk of mortality.

In the literature, the HCO<sub>3</sub>/lactate ratio has been evaluated as a prognostic marker in AMI, and in some studies, a threshold value of <10 for this ratio has been identified with significant accuracy in predicting mortality (4). However, in the present study, this threshold was determined to be <6. Given that both studies had a retrospective design, this discrepancy is more likely attributable to differences in the clinical characteristics of the patient populations, the stage of mesenteric ischemia, and the timing of laboratory measurements rather than to methodological variations. In our study cohort, delayed presentation and more pronounced metabolic derangements may have contributed to the establishment of a lower HCO<sub>3</sub>/lactate ratio as the prognostic threshold.

Previous studies have reported that preoperative bicarbonate and lactate levels are independent predictors of mortality in mesenteric ischemia. In a retrospective analysis by Uchino et

al. (10), which examined factors affecting 90-day postoperative mortality in patients with non-occlusive mesenteric ischemia, low serum bicarbonate levels as well as elevated lactate levels were found to be significantly associated with mortality. In the present study, consistent with these findings, patients with fatal outcomes had significantly lower bicarbonate levels and higher lactate levels. This similarity supports considering biochemical parameters that reflect acid–base balance and tissue perfusion in the early stages of high-mortality conditions, such as mesenteric ischemia, during clinical decision-making.

Although the prognostic value of the serum albumin/creatinine ratio has not been directly investigated in patient populations specific to mesenteric ischemia, this ratio has been addressed in various other critical illness settings. For instance, in a study of patients with pancreatitis managed in intensive care units, the albumin/creatinine ratio was found to be significantly associated with both short- and long-term mortality (11). Similarly, in a retrospective analysis conducted by Hu et al. (12) in patients with chronic sepsis, lower albumin/creatinine ratios were associated with 30- and 60-day mortality, and the ratio was reported to be an independent prognostic marker. Differing pathophysiological processes and levels of systemic inflammatory burden in the patient groups assessed in these studies may have amplified the prognostic power of the albumin/creatinine ratio.

In the present study, the albumin/creatinine ratio was also identified as a statistically significant prognostic marker. Notably, a ratio of <2.6 was associated with an approximately 4.5-fold increase in mortality risk and an AUC of 0.686. Although the predictive power of this ratio was lower than the HCO<sub>3</sub>/lactate ratio, it is considered potentially valuable as a secondary risk stratification tool in clinical practice.

Previous investigations have examined the prognostic significance of serum albumin and creatinine levels in patients with mesenteric ischemia. Toda et al. (13) demonstrated that, among patients with non-occlusive mesenteric ischemia treated conservatively, serum albumin concentrations were significantly higher in survivors compared with those who died. Likewise, Don and Kaysen (14) reported markedly lower albumin levels in patients who experienced fatal outcomes.

However, certain limiting factors should be considered when interpreting the clinical significance of albumin. Albumin is a negative acute-phase reactant and therefore decreases in the presence of a systemic inflammatory response. In addition, numerous conditions—such as malnutrition, chronic diseases, hemodilution, and liver dysfunction—can also affect albumin levels (14). Consequently, a decrease in albumin levels may reflect the patient's systemic physiological reserve and inflammatory burden rather than being a specific consequence of mesenteric ischemia.

Similarly, in the literature, low albumin levels have also been reported to be associated with poor clinical outcomes in ischemic stroke, myocardial infarction, and other organ ischemias (15,16). This suggests that albumin may serve not only as a prognostic marker in mesenteric ischemia but also as a general biomarker of ischemia-related pathophysiological stress.

In the systematic review and meta-analysis conducted by Wu et al. (17), it was reported that patients with elevated preoperative creatinine levels had a significantly increased risk of short-term postoperative mortality. The study also noted that advanced age, heart failure, and renal disorders further increased mortality risk.

In the present study, elevated preoperative creatinine levels were also found to be significantly associated with mortality. This finding may be explained by the detrimental effects of hypoperfusion and the systemic inflammatory response in AMI on renal function, leading to increased creatinine levels. Furthermore, creatinine is known to reflect not only renal function but also the patient's metabolic reserve and muscle mass (18). Therefore, the combination of impaired renal perfusion and accelerated catabolic processes in the acute phase may reinforce the prognostic significance of elevated creatinine levels in predicting mortality.

Our findings, consistent with previous literature, indicate that AMI is observed more frequently and is associated with higher mortality in elderly patients and those with comorbidities. Our mortality rate of 62.1% is parallel to the range of 60-80% reported in the literature (19). Furthermore, significant differences in classical biomarkers (CRP, creatinine, and albumin) observed in the univariate analysis support the crucial role of systemic inflammation and organ dysfunction in AMI.

### Study Limitations

Several limitations of this study should be acknowledged. First, the retrospective design and relatively limited sample size may have contributed to instability in the multivariate regression model. This is reflected in the wide confidence intervals observed for certain predictors, particularly the HCO<sub>3</sub>/lactate ratio, suggesting a potential overestimation of the effect size. In addition, collinearity among metabolic and inflammatory biomarkers cannot be fully excluded. Although the identified ratios demonstrated significant associations with mortality, these findings should be interpreted with caution and considered hypothesis-generating rather than definitive. Larger prospective studies are required to validate the prognostic thresholds identified in this analysis.

### CONCLUSION

The findings of this study suggest that the HCO<sub>3</sub>/lactate and albumin/creatinine ratios are easily accessible, cost-effective

parameters that may be utilized to predict early mortality in patients with AMI. The integration of these ratios into clinical practice could make valuable contributions to individualized patient management and risk stratification. However, these results should be confirmed in larger-scale prospective studies.

### Ethics

**Ethics Committee Approval:** The study protocol was reviewed and approved by the Institutional Review Board of Amasya University (approval number: 2025/101; date: 12 June 2025). The study was conducted in accordance with the principles of the Declaration of Helsinki.

**Informed Consent:** Informed consent was not required due to the retrospective nature of the study.

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### Footnotes

#### Author Contributions

Concept - İ.D., C.C.; Design - İ.D., C.C.; Data Collection or Processing - İ.D., F.C.; Analysis or Interpretation - S.O., C.C.; Literature Search - İ.D., S.O., F.C., C.C.; Writing - İ.D., C.C.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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