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Research Article

Elevated Lactate-to-Albumin Ratio: A Critical Predictor of Adverse Outcomes in Coronary Syndrome

Perihan Varim[1], Ahmet Can Çakmak[2*], Taner Demirci[3], Huriye Erdoğan Dağdaş[4], Ersan Tatlı[1]

[1] Focus Heart and Arrhythmia Center, Department of Cardiology, Sakarya, Türkiye.

[2] Pamukova State Hospital, Department of Cardiology, Sakarya, Türkiye.

[3] Focus Heart and Arrhythmia Center, Department of Endocrinology, Sakarya, Türkiye.

[4] MSAT Analytical Development- Protein Lead MeiraGTx 34-38 Provost Street London N1 7NQ, London, United Kingdom.

*Corresponding author:
drahmetcancakmak@gmail.com

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ABSTRACT

Aim: Acute coronary syndrome (ACS) encompasses a range of life-threatening conditions, including ST-segment elevation myocardial infarction (STEMI) and non-ST-segment elevation myocardial infarction (NSTEMI), in which early mortality continues to pose a significant challenge. Prompt recognition of high-risk patients is crucial to enable timely interventions that may enhance survival outcomes. Current prognostic tools may not be sufficient for early risk assessment. The lactate-albumin ratio (LAR) is a promising, cost-effective marker that could help predict early mortality in ACS patients, enabling better risk stratification and improving clinical outcome

Material and Methods: This retrospective, single-center study included 200 hospitalized patients, comprising 100 with STEMI and 100 with NSTEMI. Laboratory analyses were performed on blood samples and arterial blood gas measurements obtained at the time of admission. In-hospital mortality and arrhythmia rates were compared between the groups based on the lactate-albumin ratio.

Results: LAR levels were compared based on mortality status. The median (IQR) LAR for deceased patients was 1.13 (0.53–1.30), significantly higher than that of surviving patients [median (IQR) LAR: 0.41 (0.32–0.54), $p < 0.001$]. At a cut-off value of 0.89, LAR had 73.3% sensitivity and 97.3% specificity for predicting mortality. Logistic regression analysis confirmed LAR as a strong predictor of mortality (Nagelkerke R^2 = 45.5%, B = 5.78, OR = 323, 95% CI: 35.45–2956, $p < 0.001$).

Conclusion: In acute coronary syndrome, the lactate–albumin ratio may serve as a practical biomarker for early risk stratification and identification of high-risk patients rather than as a diagnostic tool.

Keywords: Lactate, albumin, acute coronary syndrome.

INTRODUCTION

Coronary heart disease (CHD) continues to be a predominant cause of morbidity and mortality across the globe, impacting populations in both developed and developing countries. As a principal determinant of global mortality, CHD accounts for millions of deaths annually. According to the World Health Organization, cardiovascular diseases, including CHD, account for over 17 million deaths annually (1). Severe complications of CHD, including acute myocardial infarction, arrhythmias, heart failure, and thrombosis, can have a profound impact on patient survival and quality of life (2). Therefore, identifying reliable biomarkers to predict prognosis and mortality in CHD patients is crucial for improving clinical outcomes.

Lactate is a metabolic byproduct primarily produced under hypoxic conditions or when tissue perfusion is inadequate, commonly observed in acute clinical conditions such as sepsis, shock, or heart failure (2). Elevated lactate levels often indicate tissue oxygen deficiency and hemodynamic instability. Serum albumin, on the other hand, is a vital protein synthesized by the liver, playing a key role in maintaining plasma oncotic pressure and transporting various substances, including hormones, fatty acids, and drugs (3). A decrease in serum albumin levels (below 3.5 g/dL) is associated with poor clinical outcomes, including prolonged hospitalization, higher complication rates, and increased mortality, particularly in critically ill patients (4,5). Therefore, serum albumin is broadly acknowledged as a significant prognostic indicator in critical care practice (6).

The lactate–albumin ratio (LAR) is an emerging biomarker that integrates lactate and albumin levels, providing a combined reflection of metabolic stress and systemic inflammatory status. In acutely ill or trauma patients, an elevated LAR may reflect heightened physiological stress and inflammatory responses, correlating with poorer outcomes (7). Rather than serving as a diagnostic parameter, LAR may offer additional prognostic information for identifying high-risk patients in acute myocardial infarction and may complement clinical risk assessment.

MATERIAL AND METHODS

Study population and study design

This study was designed as a single-center retrospective observational study. A total of 200 patients diagnosed with acute myocardial infarction (AMI), including 100 with NSTEMI and 100 with STEMI, were enrolled. All patients were diagnosed at the Cardiology Clinics of Sakarya University Faculty of Medicine between January 2021 and September 2021, based on the European Society of

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Cardiology (ESC) 2018 Fourth Universal Definition of Myocardial Infarction.

Hospital records of patients aged eighteen years or older were retrospectively reviewed to collect demographic and clinical data. Laboratory parameters, including neutrophil, lymphocyte, platelet, white blood cell (WBC), C-reactive protein (CRP), lactate, and albumin levels, were analyzed, and the lactate-to-albumin ratio (LAR) was calculated for each patient.

Patients were excluded from the study if they were younger than 18 years or had chronic liver disease, chronic renal disease, diabetic ketoacidosis, pulmonary edema, hemorrhagic shock, pregnancy, nephrotic syndrome, seizure, or trauma. Those taking medications such as lamivudine or metformin were also excluded.

Lactate levels were measured from blood gas samples collected upon admission to the coronary intensive care unit (CICU) from the emergency department or at the time of transfer to the catheterization laboratory for STEMI procedures. Hematological parameters were analyzed using a hematology analyzer (Abbott CELL-DYN 3700 System, Ramsey, MN, USA) within 30 minutes of blood collection. Serum albumin levels were measured using the kinetic alkaline picrate method with the Architect C 16000 analyzer (Abbott, IL, USA) in the hospital's biochemistry laboratory. Venous blood samples were collected using heparinized syringes, and lactate levels were measured using the GEM Premier 3500 analyzer (International Co. for Medical Equipment, USA). LAR values were then calculated.

Patients were categorized into two groups based on AMI type: Group 1 (NSTEMI, n=100) and Group 2 (STEMI, n=100). Hematological parameters and LAR values were compared between the two groups.

Statistical analysis

Statistical analyses were conducted using SPSS Statistics software (IBM Corp., Somers, NY; version 22). The distribution of continuous variables was evaluated with the Kolmogorov–Smirnov test. Depending on distribution characteristics, continuous variables were reported as mean ± standard deviation or as median with interquartile range, while categorical variables were summarized as counts and percentages. The prognostic utility of LAR in predicting mortality was examined through Receiver Operating Characteristic (ROC) curve analysis. Logistic regression models were applied to identify laboratory parameters, clinical features, and demographic factors associated with mortality. A two-sided p-value of <0.05 was considered indicative of statistical significance.

RESULTS

Baseline patient characteristics

A total of 200 patients diagnosed with coronary artery disease, aged between 36 and 96 years (mean age: 61.4 ± 10.6), were included in the study. Among them, 155 (77.5%) were male, and 128 (64%) were smokers. Other demographic characteristics and the prevalence of chronic diseases are summarized in Table 1. The mean albumin level in the overall patient population was 3.7 (3.5–4.0) g/dL, while the mean lactate level was 1.82 ± 0.89 mmol/L. The median lactate-to-albumin ratio (LAR) was 0.42 (0.33–0.54). Laboratory test results for the entire patient group are detailed in Table 2.

Table 1. Baseline clinical and demographic characteristics of the patients

	Patients (n=200)
Age (years)	61.4±10.6
Gender (M/F)	155/45
Smoking, yes, n (%)	128 (64)
DM, yes, n (%)	54 (27)
HT, yes, n (%)	106 (53)
ASKH, yes, n (%)	23 (11.5)
NST, yes, n (%)	96 (48.0)
ST, yes, n (%)	99 (49.5)
Number of clogged vessels	
1	140 (70.0)
2	38 (19.0)
3	21 (10.5)
4	1 (0.5)

Abbreviations: DM, Diabetes mellitus; HT, Hypertension; ASKH, Atherosclerotic cardiovascular disease; NST, non-ST elevation myocardial infarction; ST, ST elevation myocardial infarction

Table 2. Laboratory charasteristics of patients

	Results (n=200)
White blood cell count, $10^3/mm^3$	10.4±3.25
Creatinine, mg/dL	0.88±0.26
Alanine transaminase, IU/L	23 (16.2-37.0)
Low-density lipoprotein, mg/dL	146.2±41.7
High-density lipoprotein, mg/dL	43.6±9.6
Triglyceride, mg/dL	111 (69.2-176.2)
C-reactive protein, mg/L	4 (3.0-10.75)
Fasting blood sugar, mg/dL	151.7±74.5
Lactate, mmol/L	1.82±0.89
Albumin, g/dL	3.7 (3.5-4.0)
Lactate albumin ratio	0.42 (0.33-0.58)
Troponin, ng/L	2684 (675-21325)
Creatine kinase-MB, IU/L	48 (22.2-106.5)

*Descriptive results for continuous variables were expressed as mean and standard deviation or as median and interquartile range, depending on the normality of their distribution.

Association between LAR and mortality

LAR levels were compared according to mortality status. The median (IQR) LAR of deceased patients was 1.13 (0.53–1.30), which was significantly higher than that of surviving patients [median (IQR) LAR: 0.41 (0.32–0.54), p < 0.001] (Figure 1).

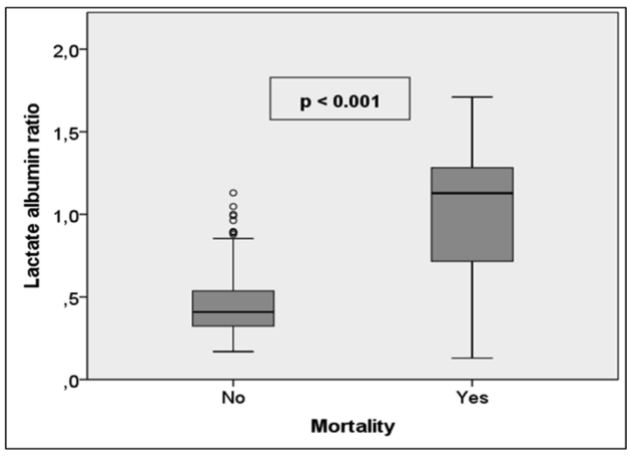
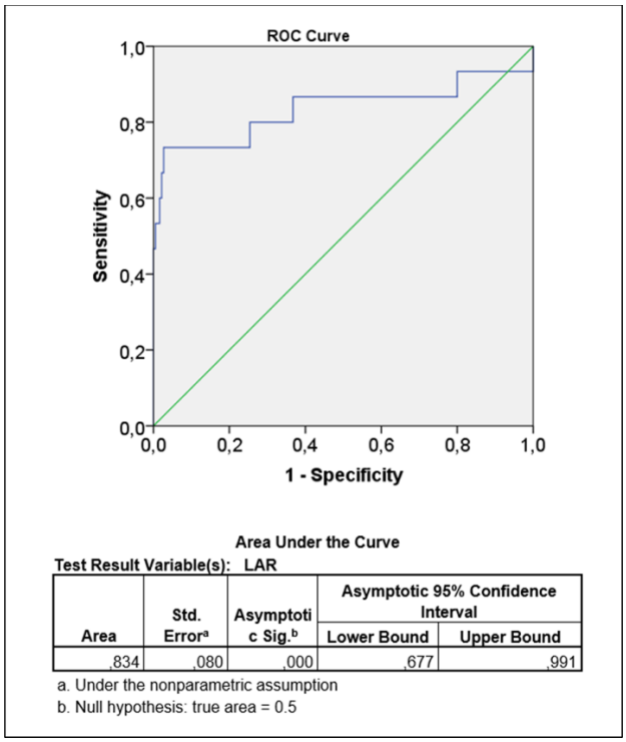


Figure 1. Comparison of LAR levels according to mortality.

Additionally, LAR levels were compared between patients with and without arrhythmia. Nonetheless, no statistically significant difference was observed between the two groups [median (IQR) LAR: 0.50 (0.33–0.99) in patients with arrhythmia versus 0.41 (0.32–0.57) in those without, p = 0.132].

The predictive value of LAR for mortality was assessed using ROC analysis. LAR demonstrated a significant predictive effect on mortality (AUC = 0.834, 95% CI: 0.667–0.991, p < 0.001). When a cut-off value of 0.89 was used, LAR showed a sensitivity of 73.3% and a specificity of 97.3% for predicting mortality (Figure 2).



Area Under the Curve

Test Result Variable(s): LAR

Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
,834	,080	,000	,677	,991

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Figure 2. ROC curve analyzing the effect of LAR on mortality.

Furthermore, logistic regression analysis was conducted to assess the effect of LAR on mortality (Nagelkerke R^2 = 45.5%). The analysis identified LAR as a significant predictor of mortality (B = 5.78, OR = 323, 95% CI: 35.45–2956, p < 0.001).

DISCUSSION

This retrospective study demonstrated a significant correlation between elevated LAR levels and increased mortality among patients with CHD. Patients exhibiting higher LAR values were at a substantially greater risk of death compared to those with lower levels. The predictive power of LAR for mortality was assessed using ROC analysis, which demonstrated a significant predictive effect (LAR: 0.834). When a cut-off value of 0.89 was used, the sensitivity for predicting mortality was 73.3%, while the specificity was 97.3%.

Lactate is a byproduct of anaerobic metabolism, and its elevated levels are a direct consequence of impaired oxygen delivery, leading to increased glycolysis (7). Elevated lactate levels indicate tissue hypoxia, metabolic disturbances, and systemic inflammation, all of which are strongly linked to cardiovascular diseases. Vermeulen et al. demonstrated an association between high lactate levels and mortality in STEMI patients, with elevated lactate also correlating with hypotension, increased heart rate, and the need for thrombolysis (8). Similarly, Lazzeri et al. identified a relationship between elevated lactate levels and the occurrence of cardiogenic shock, cardiac arrest, and refractory cardiac arrest in acute cardiac patients (9).

Albumin, a protein synthesized by the liver, plays a crucial role in maintaining osmotic pressure and transporting substances such as fatty acids, hormones, and drugs. Serum albumin levels provide valuable insight into a patient's nutritional status, liver function, and inflammatory response. Numerous studies have examined the relationship between low albumin levels and cardiovascular diseases (CVD). Decreased serum albumin has been recognized as an independent risk factor for ischemic heart disease, ischemic stroke, and myocardial infarction. In the ARIC study, a robust association was observed between low albumin levels and the occurrence of atrial fibrillation (10,11). Additionally, the JASPER study demonstrated that reduced serum albumin serves as an independent predictor of mortality in patients with heart failure (11).

The LAR, combining lactate and albumin measurements, offers a more holistic evaluation of a patient's prognosis by capturing both metabolic stress and nutritional status. Several studies have demonstrated that LAR is superior to lactate or albumin alone in predicting mortality and complications in critically ill patients (7). Higher LAR values are consistently associated with worse prognoses, making it a more sensitive and specific indicator of clinical outcomes. Moreover, LAR improves risk stratification, enabling clinicians to recognize high-risk patients who could benefit from timely interventions and more intensive therapeutic approaches (12).

Coronary heart disease (CHD) is frequently linked to stenosis or occlusion of the coronary arteries, leading to a diminished oxygen supply to myocardial cells. Under hypoxic conditions, myocardial cells switch from aerobic metabolism (oxidative phosphorylation) to anaerobic glycolysis to generate energy. This metabolic shift leads to lactate accumulation due to inadequate oxygen supply and impaired lactate clearance. CHD patients frequently experience endothelial dysfunction, which further reduces coronary blood flow, exacerbating myocardial ischemia and increasing lactate levels. Furthermore, sympathetic nervous system activation in patients with CHD increases myocardial metabolic demand, thereby further promoting lactate accumulation (13,14).

In patients experiencing myocardial infarction, Yang et al. reported significantly higher LAR values among non-survivors, supporting its prognostic utility for mortality (14). Moreover, elevated serum lactate and decreased albumin levels in acute coronary syndrome (ACS) patients have been linked to poorer clinical outcomes, as well as increased in-hospital and long-term mortality (15).

The combination of lactate and albumin in a single ratio is more advantageous than assessing each marker individually. While both are independently associated with mortality risk in various diseases, their inverse relationship, where lactate rises due to metabolic stress while albumin decreases due to systemic inflammation, enhances the predictive value of LAR. High LAR values

have been linked to poor outcomes in acute myocardial infarction, septic shock, acute respiratory failure, and critical illness-related mortality (10-12). The high lactate-to-albumin ratio is statistically more significant than lactate or albumin alone, making it a valuable and cost-effective prognostic tool in clinical practice.

Study Limitations

Despite the valuable insights provided by this study, several limitations should be considered. First, the sample size may not fully represent the broader population of acute myocardial infarction patients, potentially limiting the generalizability of our findings. Second, the retrospective design of this study may introduce potential biases, including incomplete or missing data, which could affect the accuracy of the results. Additionally, the influence of confounding factors such as comorbidities and variations in treatment protocols, was not fully accounted for, which could have affected the observed relationships between lactate, albumin, and mortality. Finally, since this study was performed at a single center, it may not fully reflect broader population trends or regional variations in AMI outcomes. Future multicenter, prospective studies with larger cohorts are warranted to validate these findings and to further investigate the clinical utility of LAR in predicting AMI prognosis. In addition, established clinical risk scores such as TIMI or GRACE could not be calculated due to the retrospective nature of the dataset and incomplete availability of certain clinical variables. Therefore, LAR should be interpreted as a complementary biomarker rather than a replacement for validated risk models.

CONCLUSION

The lactate–albumin ratio appears to be a simple and easily obtainable biomarker for identifying high-risk patients with acute myocardial infarction. Rather than serving as a diagnostic test, LAR may complement clinical evaluation by reflecting both metabolic stress and inflammatory status, thereby contributing to early risk stratification and supporting clinical decision-making.

DECLARATIONS

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Use of AI Tools: The authors declare that no Artificial Intelligence (AI) tools were used in the preparation of this article.

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