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Lactate/Albumin Ratio as a Simple Prognostic Biomarker in Acute COPD Exacerbations Presenting to the Emergency Department

Acil Servise Başvuran Akut KOAH Alevlenmelerinde Basit Bir Prognostik Biyobelirteç Olarak Laktat/Albümin Oranı

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Abstract: Acute exacerbations of chronic obstructive pulmonary disease (COPD) are a major cause of hospitalization and mortality worldwide, and early identification of high-risk patients in the emergency department is critical for optimizing clinical management. The lactate-to-albumin ratio (LAR) has recently gained attention as a simple biochemical marker reflecting both metabolic stress and systemic inflammation. This retrospective study aimed to evaluate the prognostic value of LAR in patients admitted with acute COPD exacerbation and to compare its performance with established clinical scoring systems. A total of 721 patients aged 18 years or older who were hospitalized after presenting to the emergency department with a confirmed diagnosis of COPD exacerbation between September 2024 and September 2025 were included. Demographic, clinical, and laboratory variables were recorded, and LAR, Pneumonia Severity Index (PSI), and CURB-65 scores were calculated at admission. The primary outcome was intensive care unit (ICU) admission, and secondary outcomes included endotracheal intubation and in-hospital mortality. LAR levels were significantly higher in patients who required ICU care, intubation, or subsequently died, and increasing LAR values were associated with adverse outcomes. Although PSI and CURB-65 demonstrated superior discriminative power compared with LAR, the ratio provided a moderately sensitive indicator of clinical deterioration. These findings suggest that LAR, a readily accessible and inexpensive laboratory parameter, may serve as a complementary adjunct for early risk stratification in acute COPD exacerbations. Further prospective studies are needed to define its optimal use in clinical decision-making.

Keywords: Chronic obstructive pulmonary disease; Lactate-to-albumin ratio; Emergency department

Özet: Kronik obstrüktif akciğer hastalığının (KOAH) akut alevlenmeleri dünya genelinde hastaneye yatış ve mortalite oranlarının başlıca nedenleri arasındadır ve acil serviste yüksek riskli hastaların erken dönemde tanımlanması uygun klinik yönetim açısından büyük önem taşımaktadır. Laktat/albumin oranı (LAR), metabolik stres ile sistemik inflamasyonu birlikte yansıtan basit bir biyokimyasal belirteç olarak son yıllarda dikkat çekmektedir. Bu retrospektif çalışmanın amacı, akut KOAH alevlenmesi nedeniyle hastaneye yatırılan hastalarda LAR'ın prognostik değerini değerlendirmek ve bu oranın performansını mevcut klinik skorlama sistemleriyle karşılaştırmaktır. Çalışmaya Eylül 2024–Eylül 2025 tarihleri arasında acil servise başvuru sonrası KOAH alevlenmesi tanısı doğrulanan ve 18 yaş üzerindeki toplam 721 hasta dahil edilmiştir. Hastaların demografik, klinik ve laboratuvar verileri kaydedilmiş; başvuru anında LAR, Pnömoni Şiddet İndeksi (PSI) ve CURB-65 skorları hesaplanmıştır. Birincil sonlanım yoğun bakım ünitesine (YBÜ) yatış olup, ikincil sonlanımlar entübasyon gereksinimi ve hastane içi mortalitedir. LAR düzeylerinin YBÜ'ye yatışı, entübasyonu ve mortaliteyi öngörmede anlamlı derecede yüksek olduğu, artan LAR değerleriyle kötü klinik sonuçların daha sık görüldüğü belirlenmiştir. PSI ve CURB-65'in ayırt edici gücü LAR'dan üstün olmakla birlikte, LAR'ın klinik kötüleşmeyi belirlemede orta düzeyde duyarlılık gösterdiği görülmüştür. Bulgularımız, kolay erişilebilir ve düşük maliyetli bir parametre olan LAR'ın akut KOAH alevlenmelerinde erken risk sınıflandırmasında tamamlayıcı bir belirteç olarak kullanılabileceğini düşündürmektedir. Klinik uygulamadaki yerinin netleştirilmesi için prospektif çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Kronik obstrüktif akciğer hastalığı; Laktat-albümin oranı; Acil servis

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Onam: Yazarlar retrospektif bir çalışma olduğu için olgulardan imzalı onam almadıklarını beyan etmişlerdir**.**

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Çıkar Çatışması Bildirimi: Yazarlar çıkar çatışması olmadığını beyan etmişlerdir**.**

Destek Beyanı: Yazarlar bu çalışma için

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1. Introduction

Chronic obstructive pulmonary disease (COPD) is a progressive respiratory disorder characterized by irreversible airflow limitation and systemic consequences. Chronic inflammation, oxidative stress, and protease–antiprotease imbalance play key roles in its pathogenesis (1). According to the World Health Organization, COPD ranks among the leading causes of morbidity and mortality worldwide (2). Frequent exacerbations, hypoxemia, hypercapnia, pulmonary hypertension, and muscle wasting contribute to increased mortality during the course of the disease (3).

During acute exacerbations, hypoxia and tissue hypoperfusion can lead to metabolic disturbances and biochemical alterations. Lactate, the end product of anaerobic metabolism, increases in states of tissue hypoperfusion, hypoxia, or metabolic stress (4,5). In COPD exacerbations, elevated lactate levels may result from increased respiratory effort, hypoventilation, hypoxemia, and the use of β_2-agonists. Several studies have reported that high lactate concentrations during COPD exacerbations are associated with adverse outcomes and prolonged hospitalization (6,7).

Albumin, synthesized in the liver, is an essential protein responsible for maintaining plasma oncotic pressure and exerting antioxidant effects (8). Hypoalbuminemia reflects systemic inflammation, malnutrition, and poor overall health status. In COPD, low serum albumin levels have been associated with prolonged hospital stay and increased mortality (9,10).

The lactate-to-albumin ratio (LAR) has recently emerged as a novel prognostic biomarker integrating two distinct physiological pathways—tissue hypoperfusion and systemic inflammation. A high LAR reflects elevated lactate and decreased albumin levels, suggesting both metabolic stress and nutritional/inflammatory burden (11,12). Previous studies have shown that increased LAR predicts mortality in various critical illnesses, including sepsis and respiratory failure (13–15). Moreover, LAR has been reported to outperform lactate or albumin alone in predicting short-term outcomes in critical care and emergency medicine settings (12,14).

In this retrospective study, we aimed to evaluate whether LAR, a routinely available biochemical parameter, could serve as a prognostic indicator in patients with acute respiratory failure due to COPD exacerbation admitted through the emergency department. We also compared its prognostic performance with established clinical scoring systems such as the Pneumonia Severity Index (PSI) and CURB-65. Although originally developed for pneumonia, these scores have been evaluated and applied in acute COPD exacerbations to estimate disease severity and short-term outcomes in emergency and inpatient settings (16).

2. Materials and Methods

The study protocol was approved by the institutional ethics committee (approval number: (ESH/BAEK 2025/267/06/11/2025). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Study design and population

This retrospective study included patients evaluated between September 2024 and September 2025, and data were obtained from the hospital's electronic medical record system. Patients aged 18 years or older who presented to the emergency department with a clinically and radiologically confirmed diagnosis of COPD and were subsequently hospitalized were included in the study. The diagnosis of COPD was based on a documented prior clinical diagnosis consistent with GOLD criteria, supported by patient history, previous spirometric findings when available, and radiological evidence of chronic airway disease. Patients younger than 18 years, those who were referred to another hospital, who refused treatment or left the hospital against medical advice, as well as individuals whose follow-up data were incomplete, were excluded. In addition, patients with terminal malignancy or missing laboratory data were not included in the analysis. Only patients hospitalized due to acute exacerbation of COPD, defined by worsening respiratory symptoms requiring acute medical treatment, were included; patients admitted for other causes with stable COPD were not considered. Hospitalized patients were selected to ensure complete clinical, laboratory, and outcome data, acknowledging that this may limit the generalizability of the findings to all emergency department presentations with COPD.

Data collection

Demographic characteristics, comorbidities, vital signs (heart rate, respiratory rate, blood pressure, and oxygen saturation), and laboratory parameters at

admission were recorded. Routine laboratory data included complete blood count (white blood cell, hemoglobin, and platelet counts), serum biochemical tests (sodium, potassium, glucose, BUN, uric acid, ALT, AST, albumin), arterial blood gas parameters (pO_2, pH, lactate), and C-reactive protein (CRP). Lactate and albumin values were obtained from the first blood samples collected at admission; thus, no additional laboratory testing was performed for the purposes of this study.

The primary outcome was ICU admission. Secondary outcomes included the need for endotracheal intubation and in-hospital mortality. Poor prognostic outcomes were defined as the occurrence of any of these events during hospitalization.

PSI and CURB-65 scores were calculated for all patients based on clinical and laboratory data obtained at the time of presentation. LAR was calculated by dividing serum lactate (mmol/L) by serum albumin (g/dL).

Statistical analysis

Statistical analyses were performed using SPSS version 22.0 (IBM Corp. Armonk, NY). Normality of distribution was assessed with the Shapiro–Wilk test, and homogeneity of variances with Levene's test. Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range [IQR]) as appropriate. Categorical variables were presented as numbers and percentages.

Comparisons between groups (ICU vs non-ICU) were made using Student's t-test or Mann–Whitney U test for continuous variables and the chi-square test for categorical variables. Correlation between variables was assessed using Pearson or Spearman correlation coefficients. Receiver operating characteristic (ROC) analysis was used to evaluate the discriminative ability of LAR, PSI, and CURB-65 for predicting ICU admission, intubation, and mortality; area under the curve (AUC) values were compared using DeLong's test. Statistical significance was defined as $p < 0.05$.

3. Results

Patients were excluded due to age <18 years, referral to another hospital, refusal of treatment or discharge against medical advice, terminal malignancy, or incomplete follow-up or laboratory data; after these exclusions, 721 patients constituted the final study population. Of these, 215 patients (29.8%) required ICU admission, while 506 patients (70.2%) were managed in the general ward.

Baseline characteristics

The mean age of the study population was 74 ± 9.5 years, and 63% were male. ICU-admitted patients were significantly older than non-ICU patients (76 ± 9.6 vs. 73 ± 9.3 years, $p = 0.010$). The median oxygen saturation was lower in the ICU group (91% [IQR 88–94] vs. 93% [IQR 90–96], $p = 0.010$).

Comorbid malignancy (15.3% vs. 6.7%, $p < 0.001$) and cerebrovascular disease (28.3% vs. 12.0%, $p < 0.001$) were significantly more prevalent among ICU patients, whereas diabetes mellitus was more common in the non-ICU group (33.3% vs. 21.3%, $p = 0.001$). The in-hospital mortality rate was markedly higher in the ICU group (49.3% vs. 0.6%, $p < 0.001$).

Laboratory findings

Patients admitted to the ICU had significantly lower pH values and arterial pO_2 levels, and higher serum lactate concentrations. The median serum lactate was 2.4 (1.6–3.5) mmol/L in the ICU group and 1.7 (1.1–2.4) mmol/L in the non-ICU group ($p < 0.001$). Serum albumin levels were similar between groups (4.4 ± 0.6 vs. 4.6 ± 0.5 g/dL, $p = 0.357$).

Consequently, LAR was significantly higher in ICU patients (0.6 ± 0.5 vs. 0.5 ± 0.3, $p < 0.001$).

Predictive performance of LAR, PSI, and CURB-65

Receiver operating characteristic (ROC) analysis revealed that the ability of LAR to predict ICU admission was moderate, with an area under the curve (AUC) of 0.647 (95% CI 0.601–0.693). In contrast, the PSI and CURB-65 scores demonstrated higher discriminatory power (AUC 0.821 [0.787–0.854] and 0.776 [0.738–0.815], respectively; all $p < 0.001$).

For predicting endotracheal intubation, the AUC values were 0.641 for LAR, 0.844 for PSI, and 0.806 for CURB-65. Similarly, in-hospital mortality was best predicted by PSI (AUC 0.848) and CURB-65 (AUC 0.795), while LAR achieved an AUC of 0.661 (95% CI 0.612–0.710).

The optimal cutoff value of LAR for ICU admission was 0.442, yielding a sensitivity of 64.7% and a specificity of 61.1%. Higher LAR values were observed in patients requiring ICU admission, endotracheal intubation, and in those who died during hospitalization.

Table 1. Baseline demographic and clinical characteristics of the study population

Variable	Total (n=721)	ICU (n=215)	Non-ICU (n=506)	p value
Age, years (mean ± SD)	74 ± 9.5	76 ± 9.6	73 ± 9.3	0.010
Male sex, n (%)	454 (63.0)	136 (63.3)	318 (62.8)	0.901
Oxygen saturation, % (median [IQR])	92 [89–95]	91 [88–94]	93 [90–96]	0.010
Malignancy, n (%)	70 (9.7)	33 (15.3)	34 (6.7)	<0.001
Cerebrovascular disease, n (%)	117 (16.2)	61 (28.3)	61 (12.0)	<0.001
Diabetes mellitus, n (%)	222 (30.8)	46 (21.3)	168 (33.3)	0.001
In-hospital mortality, n (%)	108 (15.0)	106 (49.3)	3 (0.6)	<0.001

Table 2. Laboratory findings of ICU and non-ICU groups

Parameter	ICU (n=215)	Non-ICU (n=506)	p value
pH	7.32 ± 0.07	7.38 ± 0.05	<0.001
pO_2 (mmHg)	59 ± 13	67 ± 15	<0.001
Lactate (mmol/L), median [IQR]	2.4 [1.6–3.5]	1.7 [1.1–2.4]	<0.001
Albumin (g/dL)	4.4 ± 0.6	4.6 ± 0.5	0.357
Lactate/Albumin ratio (LAR)	0.6 ± 0.5	0.5 ± 0.3	<0.001
CRP (mg/L)	65 ± 35	48 ± 29	<0.001
BUN (mg/dL)	38 ± 17	31 ± 15	<0.001

Table 3. Predictive performance of LAR, PSI, and CURB-65 for clinical outcomes

Outcome	Index	AUC (95% CI)	Cutoff	Sensitivity (%)	Specificity (%)
ICU admission	LAR	0.647 (0.601–0.693)	0.442	64.7	61.1
	PSI	0.821 (0.787–0.854)	—	—	—
	CURB-65	0.776 (0.738–0.815)	—	—	—
Intubation	LAR	0.641 (0.595–0.687)	0.482	63.5	60.3
	PSI	0.844 (0.802–0.886)	—	—	—
	CURB-65	0.806 (0.763–0.849)	—	—	—
In-hospital mortality	LAR	0.661 (0.612–0.710)	0.467	65.2	59.4
	PSI	0.848 (0.810–0.887)	—	—	—
	CURB-65	0.795 (0.748–0.842)	—	—	—

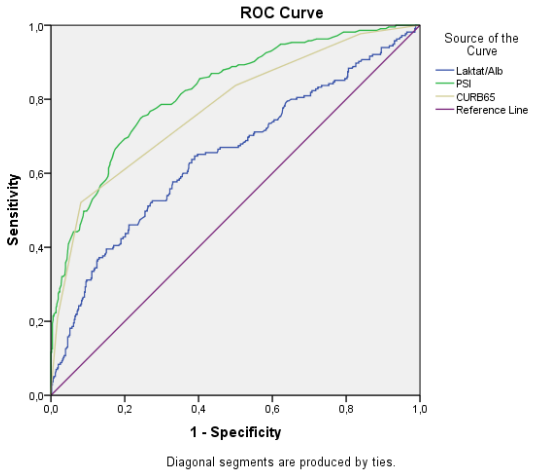

Figure 1. The ROCs of LAR, PSI, and Curb65 for ICU admission

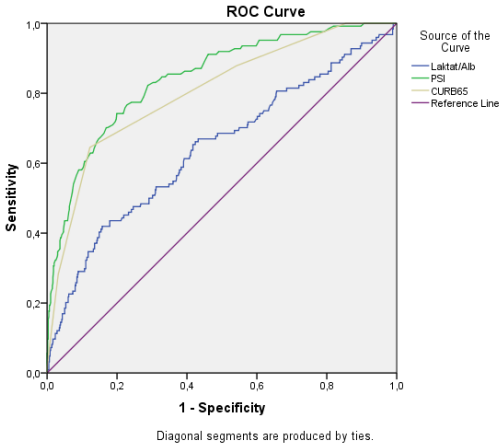

Figure 2. The ROCs of LAR, PSI, and Curb65 for intubation

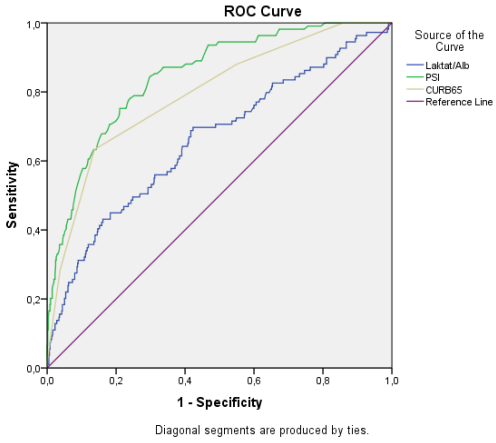

Figure 3. The ROCs of LAR, PSI, and Curb65 for mortality

4. Discussion

Our retrospective cohort of 721 patients with acute exacerbation of COPD admitted through the emergency department offers further insights into the prognostic utility of the LAR. We found that LAR was significantly elevated in patients who required ICU admission, endotracheal intubation or suffered in-hospital mortality. Although its discriminative performance (AUC ~0.64–0.66) was inferior to that of established clinical severity indices such as PSI and CURB-65 in our cohort, the significance of LAR as a readily available biochemical marker merits detailed discussion.

The pathophysiological rationale underpinning LAR is biologically plausible in COPD exacerbations. Elevated lactate levels reflect increased anaerobic metabolism, tissue hypoperfusion or oxygen-delivery/consumption mismatch, which may occur secondary to severe airflow limitation, hypoxemia, hypercapnia and increased work of breathing in exacerbations (4–6). Concurrently, hypoalbuminemia represents systemic inflammation, nutritional depletion, capillary leak and adverse general health status (8–10). The ratio LAR thus combines two distinct but complementary prognostic pathways—metabolic stress and nutritional/inflammatory burden. This concept has been demonstrated in various critical illnesses: for example, elevated LAR was independently associated with 28-day mortality in COPD patients admitted to ICU (17). Additionally, meta-analytic and cohort data in sepsis and critical care populations have shown the superiority of LAR over lactate or albumin alone in prognostication (12–15).

Our findings align with previous COPD-specific research. Recent studies have reported that higher LAR levels are significantly associated with increased short- and mid-term all-cause mortality among AECOPD patients (16-18). The association of higher LAR with ICU admission, intubation and in-hospital mortality in our study parallels this evidence, supporting LAR's external validity as a prognostic biomarker in COPD exacerbations (16–18).

The AUC values we observed (~0.647 for ICU admission; ~0.661 for mortality) indicate moderate discriminative ability. This is inferior to the PSI (AUC ~0.82) and CURB-65 (AUC ~0.78–0.80), which integrate multiple clinical and laboratory parameters and therefore capture global illness severity more comprehensively (16,19). By contrast, LAR is a single biochemical ratio and therefore may carry less predictive power. Nevertheless, the ease of obtaining lactate and albumin levels in the emergency department underscores its clinical practicality (11,14).

An important question is whether LAR adds incremental prognostic value beyond existing scoring systems. Previous investigations have shown that integrating LAR into multivariate models can improve discrimination and calibration in critically ill populations (12,20). Future prospective analyses should evaluate whether adding LAR to PSI or CURB-65 enhances predictive performance using DeLong testing, NRI, or decision curve analysis.

Specific subgroup considerations warrant attention. Our ICU group included older patients and a higher prevalence of malignancy and cerebrovascular disease—well-established predictors of poor outcome (3,19). These factors can influence both lactate and albumin levels, potentially confounding the LAR–outcome relationship. Nonetheless, other studies have demonstrated that LAR maintains its predictive power across age, sex, and comorbidity strata (17,18).

The clinical utility of LAR must be interpreted considering its limitations. As a retrospective, single-center study, selection bias and data heterogeneity may exist. Timing of lactate and albumin measurement at ED presentation is essential, as early interventions (oxygen therapy, bronchodilators, non-invasive ventilation) may alter results (6,7). Moreover, albumin levels may reflect chronic nutritional status, hepatic function, or fluid shifts, limiting interpretability (8–10). Despite these caveats, our cutoff of ~0.442 for ICU admission showed fair accuracy (sensitivity 65%, specificity 61%), suggesting potential use as a supplemental marker rather than a stand-alone tool.

Finally, from a clinical perspective, LAR represents a rapid, inexpensive, and widely available marker that may complement established scoring systems. Its integration into early triage protocols could help identify high-risk COPD patients for prompt ICU referral, aggressive therapy, or nutritional optimization (11,14,20). Prospective multicenter studies are warranted to confirm our findings and determine whether LAR-guided management strategies can improve clinical outcomes.

5. Conclusion

In patients presenting with acute exacerbation of COPD and requiring hospitalization, the lactate-to-albumin ratio (LAR) measured at admission was significantly associated with ICU admission,

endotracheal intubation and in-hospital mortality. Although LAR's predictive performance was modest compared with established scoring systems such as PSI and CURB-65, its simplicity and availability make it a useful adjunct in early risk stratification. Further prospective, multicenter studies are warranted to evaluate the incremental value of LAR when added to conventional severity scores and to determine optimal thresholds for clinical application.

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