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Prognostic Value of the Lactate-to-Albumin Ratio for Predicting Intensive Care Unit Admission in Patients with Diabetic Foot Infection: A Retrospective Cohort Study

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Abstract

Background:

Early identification of diabetic foot infection (DFI) patients at risk for clinical deterioration is critical for timely intervention. Serum lactate reflects tissue hypoperfusion, whereas hypoalbuminemia indicates systemic inflammation and poor nutritional status. Thus, the aim of this study was to evaluate the ability of the lactate-to-albumin ratio (LAR) to predict ICU admission.

Methods:

This retrospective study was conducted in the emergency department of a tertiary care center between [start date] and [end date]. Adult patients (≥ 18 years) with confirmed DFI and available admission lactate and albumin measurements were included. Patients with chronic liver failure, nephrotic syndrome, pregnancy, or incomplete records were excluded. Demographics, comorbidities, vital signs, and laboratory data were retrieved from electronic records. LAR was calculated as lactate (mmol/L) divided by albumin (g/dL). The primary outcome was intensive care unit (ICU) admission. Receiver operating characteristic (ROC) analyses assessed the predictive performance of LAR compared with lactate and albumin. Independent predictors of ICU admission were identified using multivariable logistic regression.

Results:

Among 494 patients (median age, 64 years; 40.3% female), 91 (18.4%) required ICU admission. ICU patients had higher lactate (2.5 vs. 1.8 mmol/L, *P*<.001), lower albumin (3.2 vs. 3.4 g/dL, *P*<.001), and higher LAR (0.8 vs. 0.5, *P*<.001). LAR demonstrated the best discrimination for ICU admission (area under the curve [AUC], 0.717; 95% CI, 0.658–0.777), outperforming albumin (AUC, 0.626; *P* = .009) and similar to lactate (AUC, 0.702; *P* = .134). A cut-off of ≥ 0.73 yielded 57.1% sensitivity and 78.2% specificity. LAR (odds ratio [OR], 1.36; 95% CI, 1.16–1.58; *P*<.001), older age, lower mean arterial pressure, and lower ankle–brachial index were independent predictors of ICU admission.

Conclusions:

The lactate-to-albumin ratio is a simple, cost-effective biomarker that independently predicts ICU admission in DFI patients and may aid early risk stratification.

Introduction

Early identification of critically ill patients at risk of deterioration remains a central challenge in emergencies and intensive care medicine. Among routinely available biomarkers, serum lactate is widely recognized as a marker of tissue hypoperfusion, impaired oxygen utilization, and anaerobic metabolism

(1–3). Elevated lactate levels are independently associated with mortality in a broad spectrum of acute illnesses, including sepsis, septic shock, community-acquired pneumonia, and acute heart failure. However, lactate concentrations may also rise due to non-hypoxic mechanisms such as adrenergic stimulation or impaired clearance, which can limit its specificity as a prognostic marker (4–6).

Serum albumin, on the other hand, is a negative acute-phase reactant whose decline reflects systemic inflammation, increased vascular permeability, and poor nutritional status. Hypoalbuminemia has been associated with worse outcomes in critically ill patients and contributes to capillary leak, reduced oncotic pressure, and impaired drug distribution (7–9). Furthermore, low albumin levels may decrease hepatic lactate clearance, indirectly amplifying lactate accumulation during severe illness.

The lactate-to-albumin ratio (LAR) combines these two complementary pathophysiological signals—acute metabolic stress and the host's inflammatory/nutritional reserve—into a single, easily obtainable metric. Recent studies suggest that LAR predicts mortality more accurately than either biomarker alone in patients with sepsis and septic shock, community-acquired pneumonia, and other critical conditions (10–12). By integrating metabolic and inflammatory pathways, LAR may provide a more robust assessment of disease severity and guide early resuscitative interventions.

Despite these promising findings, data on the prognostic performance of LAR in patients with diabetic foot infection remain limited. The present study was therefore designed to evaluate the ability of LAR to predict ICU admission.

Methods

Study Design and Setting

This retrospective observational study was conducted at the Emergency Department (ED) of a Training and Research Hospital, a tertiary care center with an annual census of approximately 260000 patient visits. The study period extended from January 1, 2023 to October 31, 2025. The study protocol was approved by the Training and Research Hospital Clinical Research Ethics Committee and the requirement for informed consent was waived due to the noninterventional design and anonymized data analysis.

Study Population

Adult patients (≥ 18 years) who presented the ED during the study period and had both serum lactate and serum albumin levels measured within the first 1 hour of admission were eligible. Patients were included if they were diagnosed with diabetic foot infection based on clinical findings, laboratory markers of infection, and imaging studies when available. Exclusion criteria were: (1) missing or delayed laboratory measurements, (2) transfer from another facility with incomplete records, (3) known chronic liver failure, nephrotic syndrome, or other conditions causing baseline hypoalbuminemia, and (4) pregnancy.

Data Collection

Demographic data (age, sex), comorbidities (hypertension, diabetes, chronic kidney disease, malignancy, etc.), vital signs at ED presentation, and laboratory parameters (lactate, albumin, complete blood count, creatinine, C-reactive protein, etc.) were extracted from the electronic medical record system. LAR was calculated by dividing serum lactate (mmol/L) by serum albumin (g/dL) obtained at ED arrival. The primary clinical outcome was intensive care unit (ICU) admission. The decision for intensive care unit (ICU) admission was based on predefined clinical criteria, including hemodynamic instability requiring vasopressor support, persistent hypotension despite adequate fluid resuscitation, respiratory failure requiring advanced oxygen therapy or mechanical ventilation, altered mental status, or the need for close invasive monitoring. ICU admission decisions were made collaboratively by emergency physicians and intensivists according to institutional protocols.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR) depending on distribution, and categorical variables as counts and percentages. Group comparisons were performed using the independent samples t-test or Brunner-Munzel test for continuous variables and the chi-square or Fisher's exact test for categorical variables when distributional assumptions for parametric testing were not met (14). Receiver operating characteristic (ROC) curve analysis was used to assess the discriminatory ability of LAR and to identify optimal cut-off values using the Youden index. Pairwise comparisons of area under the ROC curve (AUC) between LAR and individual biomarkers (lactate, albumin) were performed using DeLong's test. Variables with $p < 0.10$ in univariate analysis were entered into a multivariate logistic regression model to identify independent predictors of ICU admission and results were expressed as odds ratios (ORs) with 95% confidence intervals (CIs). A two-tailed p value < 0.05 was considered statistically significant. Statistical analyses were performed using Jamovi software, version 2.6.26.0.

Results

Baseline Characteristics

A total of 494 patients were included in the analysis, of whom 91 (18.4%) required intensive care unit (ICU) admission. Patients admitted to the ICU were older than those who were not (median age, 66.0 vs. 64.0 years; P = .008). Median lactate and lactate-to-albumin ratio were significantly higher in ICU patients compared with non-ICU patients (lactate: 2.5 vs. 1.8 mmol/L, P < .001; lactate-to-albumin ratio: 0.8 vs. 0.5, P < .001). Median albumin levels were lower in ICU patients (3.2 vs. 3.4 g/dL; P < .001). Systolic and diastolic blood pressures, peripheral oxygen saturation, ankle–brachial index, heart rate, and respiratory rate also differed significantly between groups (all P < .01). Other comorbidities and laboratory parameters, including duration of diabetes, hypertension, coronary artery disease, chronic kidney

disease, neutrophil and lymphocyte counts, platelet count, C-reactive protein, and systemic immune-inflammation index, did not differ significantly between groups (Table 1).

Table 1
Baseline characteristics of the study population according to intensive care unit (ICU) admission status

Variable	ICU = 0 (n = 403, 81.6%)	ICU = 1 (n = 91, 18.4%)	Total (N = 494)	*P* value
Age, y, median (IQR)	64.0 (57.0–70.0)	66.0 (60.0–74.0)	64.0 (57.0–70.0)	.008
Duration of diabetes, y, median (IQR)	10.3 (6.9–15.3)	11.2 (8.1–15.2)	10.5 (7.0–15.3)	.409
Hypertension, No. (%)	228 (56.6)	55 (60.4)	283 (57.3)	.578
Coronary artery disease, No. (%)	123 (30.5)	15 (16.5)	138 (27.9)	.010
Chronic kidney disease, No. (%)	98 (24.3)	18 (19.8)	116 (23.5)	.432
Current smoking, No. (%)	151 (37.5)	29 (31.9)	180 (36.4)	.378
Neutrophil count, ×10⁹/L, median (IQR)	6.1 (4.5–7.4)	5.8 (4.1–7.3)	6.1 (4.5–7.4)	.427
Lymphocyte count, ×10⁹/L, median (IQR)	1.6 (1.2–2.0)	1.6 (1.1–2.0)	1.6 (1.2–2.0)	.827
Platelet count, ×10⁹/L, median (IQR)	269 (230–304)	252 (217.5–300.5)	266.5 (227.2–303.8)	.399
C-reactive protein, mg/L, median (IQR)	30.0 (17.5–51.0)	32.4 (20.4–53.8)	30.4 (17.8–51.3)	.420
Lactate, mmol/L, median (IQR)	1.8 (1.2–2.4)	2.5 (1.8–3.0)	1.9 (1.3–2.5)	< .001
Blood urea nitrogen, mg/dL, median (IQR)	27.4 (18.1–37.5)	29.2 (22.2–38.0)	27.6 (18.7–37.6)	.115
Creatinine, mg/dL, median (IQR)	1.2 (0.9–1.8)	1.2 (0.8–1.7)	1.2 (0.9–1.7)	.108
Albumin, g/dL, median (IQR)	3.4 (3.0–3.8)	3.2 (2.9–3.4)	3.3 (3.0–3.7)	< .001
Wagner grade, No. (%)				.828
0	26 (6.5)	7 (7.7)	33 (6.7)	
1	51 (12.7)	14 (15.4)	65 (13.2)	
2	117 (29.0)	30 (33.0)	147 (29.8)	
3	119 (29.5)	21 (23.1)	140 (28.3)	
4	72 (17.9)	15 (16.5)	87 (17.6)	
5	18 (4.5)	4 (4.4)	22 (4.5)	
Systemic immune-inflammation index, median (IQR)	1006.8 (645.6–1507.3)	1001.6 (718.7–1372.7)	1006.1 (650.9–1497.2)	.656

Variable	ICU = 0 (n = 403, 81.6%)	ICU = 1 (n = 91, 18.4%)	Total (N = 494)	*P* value
Surgical intervention required, No. (%)	106 (26.3)	28 (30.8)	134 (27.1)	.462
Length of stay, d, median (IQR)	9.0 (7.0–12.0)	15.0 (13.0–18.0)	10.0 (7.0–14.0)	< .001
Systolic blood pressure, mm Hg, median (IQR)	126.0 (116.0–135.5)	113.0 (103.0–123.0)	124.0 (113.0–134.0)	< .001
Diastolic blood pressure, mm Hg, median (IQR)	75.0 (68.0–81.0)	72.0 (64.5–78.0)	74.0 (67.0–81.0)	.003
Heart rate, beats/min, median (IQR)	86.0 (75.0–95.0)	101.0 (93.0–111.5)	88.0 (77.0–98.0)	< .001
Respiratory rate, /min, median (IQR)	18.0 (16.0–20.0)	22.0 (21.0–24.0)	19.0 (16.0–21.0)	< .001
Body temperature, °C, median (IQR)	36.9 (36.5–37.2)	36.9 (36.5–37.2)	36.9 (36.5–37.2)	.858
Peripheral oxygen saturation, %, median (IQR)	96.0 (95.0–97.0)	93.0 (92.0–95.0)	96.0 (94.0–97.0)	< .001
Ankle–brachial index, median (IQR)	0.8 (0.7–0.9)	0.7 (0.6–0.8)	0.8 (0.6–0.9)	< .001
Lactate-to-albumin ratio, median (IQR)	0.5 (0.3–0.7)	0.8 (0.6–1.0)	0.6 (0.4–0.8)	< .001

Diagnostic Performance of Lactate-to-Albumin Ratio, Albumin, and Lactate

Receiver operating characteristic (ROC) curve analysis demonstrated that lactate-to-albumin ratio had an area under the curve (AUC) of 0.717 (95% CI, 0.658–0.777; P < .001), indicating good discriminative ability for ICU admission. The AUCs for albumin and lactate were 0.626 (95% CI, 0.563–0.688; P < .001) and 0.702 (95% CI, 0.641–0.762; P < .001), respectively. Optimal cut-off values determined by Youden's index were ≥ 0.73 for lactate-to-albumin ratio, ≤ 3.41 g/dL for albumin, and ≥ 2.54 mmol/L for lactate. At these thresholds, lactate-to-albumin ratio showed a sensitivity of 57.1% (95% CI, 46.3%–67.5%), specificity of 78.2% (95% CI, 73.8%–82.1%), positive predictive value of 37.1% (95% CI, 31.4%–43.3%), negative predictive value of 89.0% (95% CI, 86.4%–91.2%), and overall accuracy of 74.3% (95% CI, 70.2%–78.1%). Albumin demonstrated a sensitivity of 73.6%, specificity of 48.4%, positive predictive value of 24.4%, negative predictive value of 89.0%, and accuracy of 53.0%, whereas lactate had a sensitivity of 49.5%, specificity of 82.6%, positive predictive value of 39.1%, negative predictive value of 87.9%, and accuracy of 76.5% (Table 2). However, the identified cut-off value should not be interpreted as

a standalone criterion for ICU admission but rather as a supportive parameter within a comprehensive clinical and physiological assessment.

Table 2
Diagnostic Performance of Lactate-to-Albumin Ratio, Albumin, and Lactate for Predicting ICU Admission

Metric	Lactate-to-Albumin Ratio	Albumin	Lactate
Area under the curve (95% confidence interval)	0.717 (0.658–0.777)	0.626 (0.563–0.688)	0.702 (0.641–0.762)
Cut-off	≥ 0.73	≤ 3.41	≥ 2.54
Sensitivity % (95% CI)	57.1 (46.3–67.5)	73.6 (63.4–82.3)	49.5 (38.8–60.1)
Specificity % (95% CI)	78.2 (73.8–82.1)	48.4 (43.4–53.4)	82.6 (78.6–86.2)
Positive Predictive Value % (95% CI)	37.1 (31.4–43.3)	24.4 (21.6–27.3)	39.1 (32.3–46.4)
Negative Predictive Value % (95% CI)	89.0 (86.4–91.2)	89.0 (85.0–92.1)	87.9 (85.5–89.9)
Accuracy % (95% CI)	74.3 (70.2–78.1)	53.0 (48.5–57.5)	76.5 (72.5–80.2)
Positive likelihood ratio	2.62	1.43	2.85
Negative likelihood ratio	0.55	0.55	0.61

Pairwise comparisons of AUCs using DeLong's test indicated that lactate-to-albumin ratio had significantly better discriminative ability than albumin (AUC difference = 0.091; 95% CI, 0.023–0.160; P = .009), whereas differences between lactate-to-albumin ratio and lactate (AUC difference = 0.015; 95% CI, − 0.005–0.036; P = .134) and between albumin and lactate (AUC difference = − 0.076; 95% CI, − 0.159–0.007; P = .073) were not statistically significant. In multivariable logistic regression analysis, increasing age (odds ratio [OR], 1.05 per year; 95% CI, 1.02–1.07; P < .001) and lactate-to-albumin ratio (OR, 1.36; 95% CI, 1.16–1.58; P < .001) were independently associated with higher odds of ICU admission. Ankle–brachial index was also an independent predictor (OR, 1.25; 95% CI, 1.08–1.44; P = .002). Mean arterial pressure was inversely associated with ICU admission (OR, 0.98; 95% CI, 0.96–0.99; P = .005). C-reactive protein, heart rate, and other variables did not reach statistical significance in the multivariable model (Table 3). The lack of independent association for C-reactive protein may be attributed to its delayed kinetic response, which limits its ability to reflect early physiological deterioration at emergency department presentation. The model demonstrated good statistical fit (deviance = 153, Akaike information criterion = 171, McFadden R^2 = 0.68).

Table 3
Logistic Regression Analysis for Intensive Care Unit Admission

Predictor	Estimate (β)	SE	Z	p	Odds Ratio (95% CI)
Age (per year)	**0.045**	0.012	3.75	< 0.001	**1.05** (1.02–1.07)
Lactate-to-albumin ratio	**0.310**	0.080	3.88	< 0.001	**1.36** (1.16–1.58)
C-reactive protein (mg/L)	0.012	0.007	1.71	0.088	1.01 (0.99–1.03)
Mean arterial pressure (mmHg)	**−0.025**	0.009	−2.78	0.005	**0.98** (0.96–0.99)
Heart Rate (bpm)	0.018	0.010	1.80	0.072	1.02 (0.99–1.04)
Ankle–brachial index	**0.220**	0.070	3.14	0.002	**1.25** (1.08–1.44)
Intercept	−3.120	0.850	−3.67	< 0.001	—

Discussion

In this retrospective cohort of patients admitted with diabetic foot infection, we demonstrated that the lactate-to-albumin ratio is a valuable predictor of intensive care unit admission. Although both serum lactate and albumin individually showed significant associations with disease severity, their combined ratio provided superior discriminative ability compared with albumin alone and comparable performance to lactate. Importantly, lactate-to-albumin ratio remained independently associated with ICU admission even after adjustment for age, mean arterial pressure, and ankle–brachial index. Although serum lactate alone demonstrated comparable discriminative ability, the lactate-to-albumin ratio provides additional clinical insight by integrating acute metabolic stress with the patient's inflammatory and nutritional reserve. In particular, LAR may offer improved risk stratification in patients with intermediate lactate levels, where lactate alone may be insufficient to fully reflect overall disease severity. Therefore, LAR should be regarded as a complementary biomarker rather than a replacement for serum lactate. (13)

Previous research has consistently shown that elevated serum lactate levels serve as a sensitive marker of tissue hypoperfusion, anaerobic metabolism, and compromised mitochondrial function. Under conditions like sepsis, severe infection, or ischemia, when oxygen delivery to tissues falls below demand, lactate accumulates due to accelerated glycolysis and impaired clearance (for example by the liver). On the other hand, albumin is not merely a nutritional marker, but also a negative acute-phase reactant; hypoalbuminemia reflects a complex interplay of systemic inflammation, increased vascular permeability ("capillary leak"), dilutional effects with fluid resuscitation, and decreased protein synthesis in the liver. Thus, albumin levels capture the chronic or subacute burden of illness, immune dysregulation, and nutritional reserve (3, 15, 16).

When these two parameters are combined into the LAR, the resulting metric can theoretically incorporate both rapid-onset metabolic derangement (lactate rise) and the patient's baseline ability to respond (albumin reserve and inflammatory status). This dual information may allow LAR not only to identify

patients in immediate distress but also to discriminate against those less likely to tolerate the stress of infection or ischemia over time.

Several large studies support this concept. For instance, evaluated 1,381 adult septic patients and found that the L/A ratio had an AUC of ~ 0.67 in predicting in-hospital mortality, which was significantly better than lactate alone (5). Similarly, Yoon et al. in a systematic review & meta-analysis of 4,723 patients with sepsis or septic shock reported that pooled diagnostic performance of LAR had sensitivity ~ 0.71 and specificity ~ 0.68 for mortality, with an overall AUC of ~ 0.74 (17). In another study of sepsis patients admitted to ICU (n ≈ 1,136), the L/A ratio (cut-off > 0.71) showed stronger discriminative power for mortality (AUC ~0.869) compared to albumin or lactate alone (18).

In the setting of community-acquired pneumonia, Hancı et al. (2025) demonstrated that LAR was comparable to established severity scores like PSI, CURB-65, and qSOFA in predicting both ICU admission and mortality (9). This supports the idea that LAR may be broadly applicable in infectious and inflammatory conditions beyond classical sepsis. Moreover, in patients with sepsis-associated acute kidney injury (AKI), elevated LAR (in highest quartile) was associated with significantly increased risks of 30-day and 90-day mortality (19).

Our results also highlight the role of ankle–brachial index as an independent predictor of ICU admission. Peripheral arterial disease is a key contributor to the pathogenesis and severity of diabetic foot infection, and lower ankle–brachial index values reflect impaired limb perfusion and higher risk of tissue necrosis, potentially necessitating more intensive monitoring and management (20, 21). Conversely, higher mean arterial pressure was protective, consistent with previous data linking hypotension to worse outcomes in diabetic foot infection and sepsis. The lack of a significant association between Wagner grade and ICU admission in our cohort may be explained by the fact that Wagner classification primarily reflects local wound severity rather than systemic physiological derangement. While Wagner grade is valuable for surgical decision-making and assessment of local infection extent, it may not adequately capture the systemic inflammatory and hemodynamic burden that necessitates intensive care.

This study has several limitations. First, its retrospective design may introduce selection bias and limit causal inference. Second, lactate and albumin measurements were obtained at a single time point upon admission; dynamic changes during hospitalization were not evaluated. Third, our findings are derived from a single center, which may limit generalizability to other populations and healthcare settings. Despite these limitations, the large sample size, standardized data collection, and robust statistical analysis strengthen the validity of our results. The high discriminative performance observed in the multivariable logistic regression model should be interpreted with caution. Given the retrospective single-center design and the inclusion of physiologically related variables, the possibility of model overfitting cannot be fully excluded. External validation in independent cohorts is required to confirm the robustness and generalizability of the predictive model.

Reporting guidelines

This study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. (13)

Conclusion

The LAR is an easily obtainable and inexpensive biomarker that demonstrates good diagnostic performance for predicting ICU admission in patients with diabetic foot infection. Incorporating this ratio into routine assessment may facilitate early risk stratification and guide timely interventions, potentially improving outcomes in this high-risk population. Prospective multicenter studies are warranted to validate these findings and explore whether lactate-to-albumin–guided management strategies can enhance clinical decision-making.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Training and Research Hospital Clinical Research Ethics Committee (approval number: XXX). Due to the retrospective and non-interventional design of the study, the requirement for informed consent was waived.

Competing interests

The authors declare that they have no competing interests.

Clinical trial number

Not applicable.

Consent to publish

Not applicable.

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Author Contribution

Data collection and analysis were performed by Kaan Yusufoglu and Omer Yonga.The first draft of the manuscript was written by Kaan Yusufoglu.All authors commented on previous versions of the manuscript and approved the final manuscript..

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Not applicable.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Figures

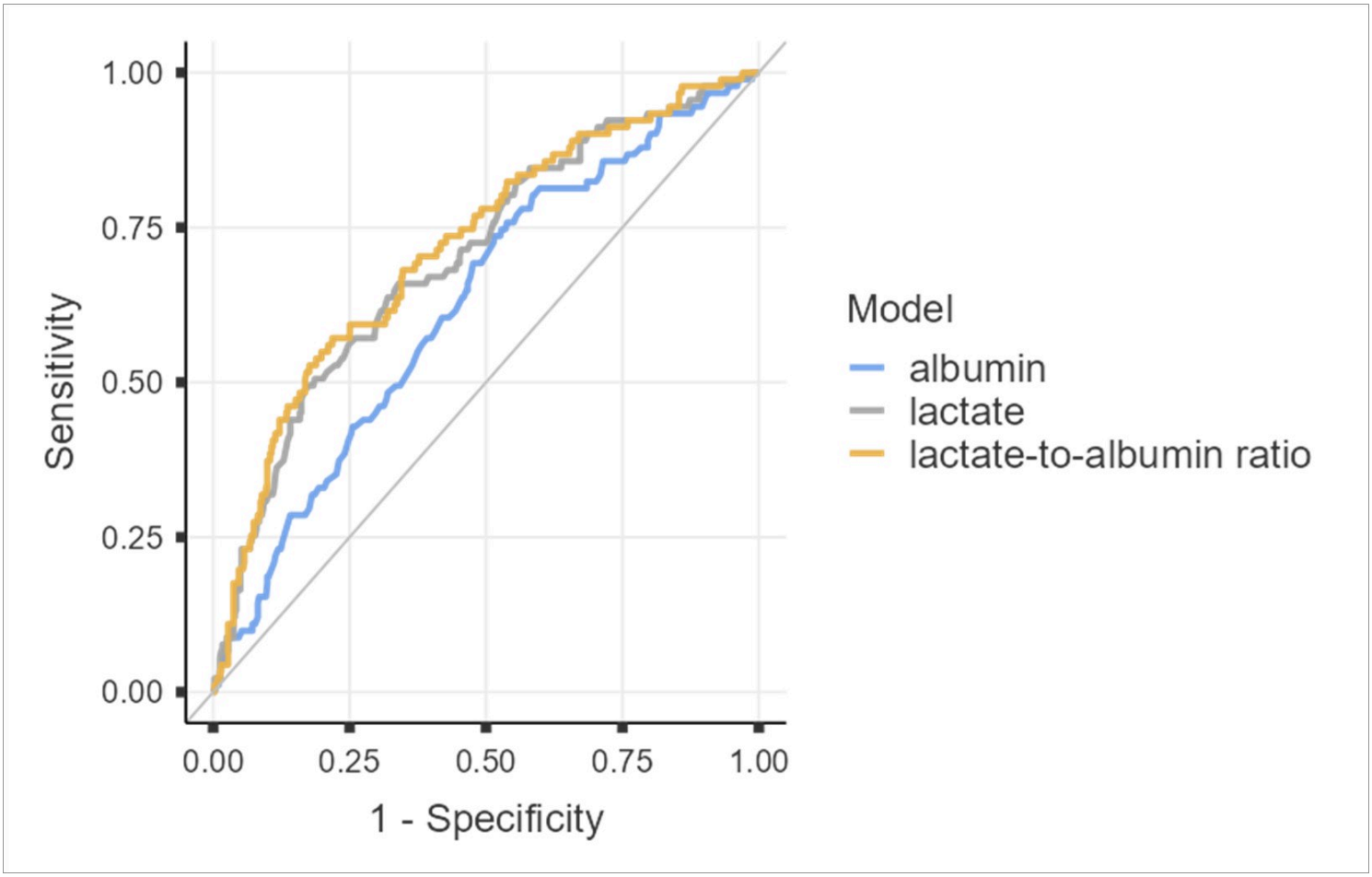


Figure 1

Receiver Operating Characteristic Curves for Lactate-to-Albumin Ratio, Albumin, and Lactate in Predicting Intensive Care Unit Admission