International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 24s,2025
https://theaspd.com/index.php

A Clinical Study on the Association Between Serum Lactate–Albumin Ratio and Sepsis Severity in ICU Patients at a Tertiary Care Hospital

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Abstract: Introduction: *Sepsis remains a leading cause of morbidity and mortality in intensive care units (ICUs), with outcomes influenced by timely recognition and severity assessment. The lactate/albumin ratio (LAR) has emerged as a simple, accessible biomarker with prognostic potential.*

Aim: *To evaluate the association between serum LAR and sepsis severity in ICU patients at a tertiary care hospital in Chennai.*

Methods: *This hospital-based observational study included 100 adult ICU patients diagnosed with sepsis. Demographic, clinical, and laboratory data, including serum lactate and albumin levels, were collected to calculate LAR. Associations between LAR, SOFA scores, organ dysfunction, and outcomes were analyzed using SPSS, with $p < 0.05$ considered statistically significant.*

Results: *The mean age was 56.8 ± 14.2 years, with 62% males. The mean LAR was 1.5 ± 0.5 and was significantly higher in patients with multiorgan dysfunction and mortality ($p < 0.001$). LAR positively correlated with SOFA scores, creatinine, and INR, and inversely with platelet count. Patients with LAR > 1.25 exhibited significantly increased rates of organ dysfunction and death. Systemic hypertension and anemia were notable predictors of severity.*

Conclusion: *LAR is a reliable, independent marker of sepsis severity, correlating strongly with SOFA scores and adverse outcomes. Its simplicity and accessibility make it a valuable adjunct in early sepsis assessment and ICU triage.*

Keywords: *Sepsis, Lactate/Albumin Ratio, ICU, SOFA Score, Multiorgan Dysfunction, Mortality, Biomarker.*

1. INTRODUCTION

Sepsis is a complex, life-threatening syndrome defined as organ dysfunction caused by a dysregulated host response to infection. It remains a major global health challenge, with the World Health Organization (WHO) identifying it as a global health priority, affecting over 49 million people annually and contributing to approximately 11 million deaths—nearly 20% of global mortality (1). Despite advances in intensive care and antimicrobial therapy, sepsis continues to be a leading cause of morbidity and mortality among critically ill patients, particularly in intensive care units (ICUs). The burden is disproportionately high in low- and middle-income countries, including India, where late presentation, limited ICU resources, and high rates of multidrug-resistant organisms worsen outcomes.

The pathophysiology of sepsis involves a complex interplay of infection, immune dysregulation, tissue hypoperfusion, and metabolic derangements. Early identification and accurate severity stratification are essential for improving patient outcomes. Commonly used scoring systems, such as the Sequential Organ Failure Assessment (SOFA) and the Acute Physiology and Chronic Health Evaluation II (APACHE II), provide valuable prognostic information but require multiple physiological and biochemical parameters, making them resource-intensive (2,3). Consequently, there is growing interest in simple, cost-effective biomarkers that can reliably predict sepsis severity and outcomes.

Serum lactate is a well-established biomarker reflecting tissue hypoperfusion and anaerobic metabolism. Elevated lactate levels often precede overt hypotension and are associated with higher mortality in sepsis, even in hemodynamically stable patients (2,3). However, lactate levels can be influenced by factors such as liver dysfunction, beta-agonist use, and chronic comorbidities, which may limit its specificity. Similarly, serum albumin, a marker of nutritional status and systemic inflammation, is frequently reduced in sepsis due to increased vascular permeability, decreased hepatic synthesis, and catabolic state. Hypoalbuminemia correlates

with poor outcomes, but its interpretation is complicated by confounding factors like hydration status, hepatic function, and protein losses (4,5).

To address the limitations of these individual biomarkers, the lactate/albumin ratio (LAR) has been proposed as a composite index integrating metabolic stress and protein reserve status. By combining these two parameters, LAR offers a potentially more sensitive indicator of systemic severity. Recent studies support its prognostic value. Cakir and Turan (2021) demonstrated that LAR had a higher diagnostic accuracy for predicting ICU mortality in septic patients (AUC = 0.869) compared to lactate (AUC = 0.816) or albumin (AUC = 0.812) alone (6). Lichtenauer et al. (2017) similarly reported that elevated LAR was significantly associated with both short- and long-term mortality, independent of APACHE II and SAPS II scores (7). Furthermore, Chen et al. (2023) found that LAR was a strong linear predictor of mortality in septic patients with myocardial injury (8,9), and other studies have linked LAR to adverse outcomes in respiratory failure-related sepsis (10).

In India, sepsis accounts for nearly 30% of ICU admissions, with a case fatality rate approaching 35% (8). Factors contributing to this high burden include delays in initiating appropriate antimicrobial therapy, higher prevalence of multidrug-resistant infections, and limited access to advanced diagnostic modalities. In such settings, the LAR's simplicity, cost-effectiveness, and reliance on routinely available laboratory tests make it particularly appealing. Moreover, dynamic indices like LAR may better capture evolving illness severity than static measurements, as suggested by Kendall et al. (2019), who found that trends in albumin were more predictive of ICU mortality than baseline values (11).

Despite promising global evidence, Indian-specific data on LAR—particularly from regional tertiary care centers—remain scarce. Differences in nutritional status, infectious disease epidemiology, and healthcare infrastructure may influence the prognostic performance of LAR in this population. Additionally, variability in sepsis diagnosis and management across Indian hospitals underscores the need for context-specific validation.

Given these gaps, the present study was conducted in a tertiary care hospital in Chennai to evaluate the association between serum LAR and sepsis severity in ICU patients. By providing region-specific evidence, this work aims to assess whether LAR can serve as a practical and reliable adjunct to established scoring systems for early risk stratification in Indian ICU settings.

2. MATERIALS AND METHODS

This cross-sectional observational study was conducted in the ICU of Sree Balaji Medical College and Hospital, Chennai, from April 2023 to September 2024, to evaluate the association between serum lactate/albumin ratio (LAR) and sepsis severity in adults diagnosed with sepsis or septic shock as per Sepsis-3 criteria. Using purposive sampling, 100 eligible patients aged ≥18 years were enrolled, excluding those with nosocomial sepsis, normal albumin levels, pregnancy, or terminal non-infectious illnesses. Demographic details, comorbidities, clinical parameters, and laboratory investigations—including lactate, albumin, and other routine tests—were recorded using a structured proforma, with LAR calculated as lactate (mmol/L) divided by albumin (g/dL). Sepsis severity was assessed using SOFA scores, and outcomes such as organ dysfunction, ventilatory or vasopressor support, ICU stay, and mortality were analyzed. Statistical tests included Chi-square, t-test, and ANOVA, with $p \leq 0.05$ considered significant, using SPSS v24. Ethical clearance and informed consent were obtained, and the study aimed to validate LAR as a simple, cost-effective prognostic marker superior to lactate alone for early risk stratification in ICU sepsis patients.

3. RESULT

The mean patient age was 56.8 years, with a male predominance (62%), reflecting global trends where older adults and males face higher sepsis risk due to comorbidities and immune decline (**Figure 1**).

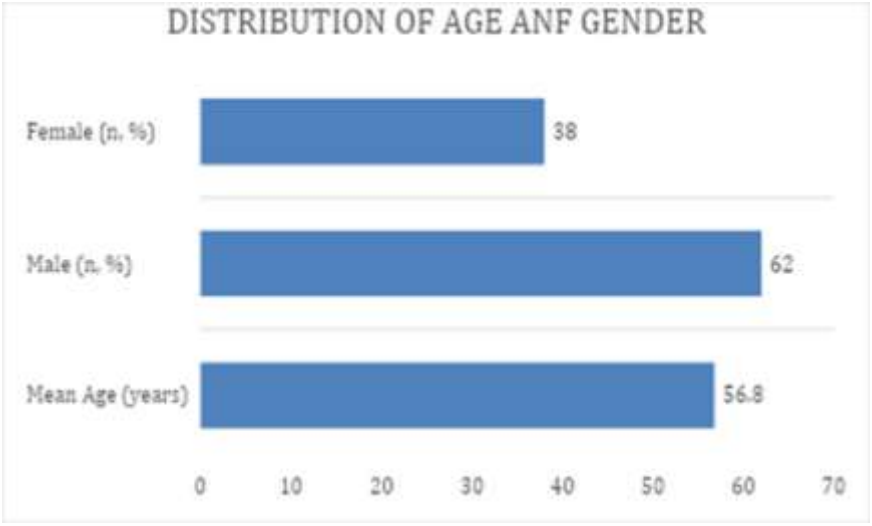

Figure 1: Age and Gender Distribution

Most patients had tachypnea (mean RR 24/min) and tachycardia (mean HR 98/min), with low MAP (78 mmHg) and SpO_2 (91%), indicating early septic shock physiology (**Figure 2**).

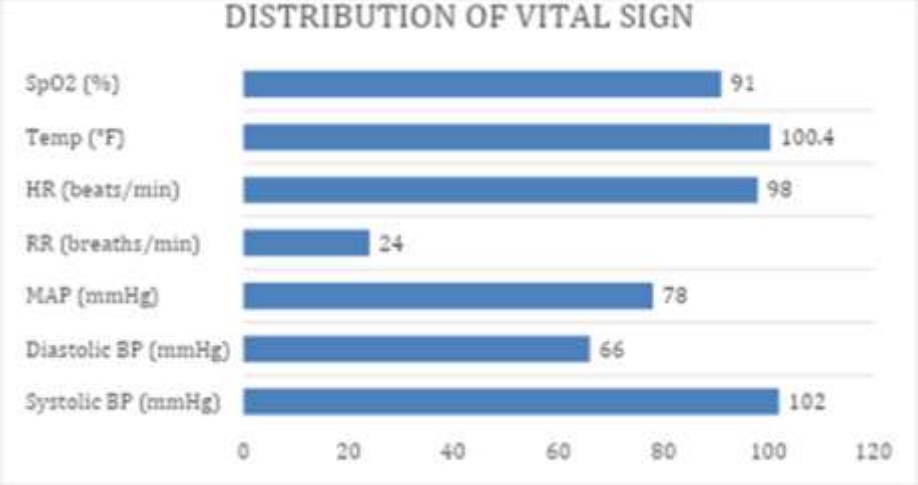

Figure 2: Vital Signs Summary

Table 1: Laboratory Investigations Summary

Investigation	Mean ± SD	p-value
Serum Lactate (mmol/L)	4.2 ± 1.5	<0.001**
Serum Albumin (g/dL)	2.8 ± 0.6	<0.001**
Lactate/Albumin Ratio	1.5 ± 0.5	<0.001**
Blood Glucose (mg/dL)	148 ± 38	<0.001**
Urea (mg/dL)	56 ± 24	<0.001**
Creatinine (mg/dL)	2.1 ± 1.3	<0.001**
Na+ (mEq/L)	134 ± 5	<0.001**
K+ (mEq/L)	4.3 ± 0.8	<0.001**
WBC (cells/mm^3)	14,000 ± 5000	<0.001**
Hemoglobin (g/dL)	11.2 ± 2.3	<0.001**
Platelets (cells/mm^3)	108,000 ± 40,000	<0.001**
Total Bilirubin (mg/dL)	6.5 ± 3.4	<0.001**
INR	2.6 ± 1.1	<0.001**

Significant lab abnormalities ($p<0.001$) included high lactate (4.2 mmol/L), low albumin (2.8 g/dL), and mean LAR 1.5, indicating metabolic stress and poor prognosis (**Table 1**). Renal, liver, and coagulation derangements confirmed multi-organ dysfunction, supporting LAR as a key biomarker.

Table 2: Presenting Complaints

Variable	Yes [n(%)]	No [n(%)]	P-value
Presenting Complaint: Fever	40 (40%)	60 (60%)	0.056
Presenting Complaint: Breathlessness	32 (32%)	68 (68%)	0.16
Presenting Complaint: Confusion	27 (27%)	73 (73%)	0.066
Presenting Complaint: Oliguria	32 (32%)	68 (68%)	0.061
Presenting Complaint: Hypotension	28 (28%)	72 (72%)	0.047

Fever and breathlessness were common, but hypotension (28%) showed a significant association ($p=0.047$), highlighting early hemodynamic compromise, while other symptoms trended toward significance (**Table 2**).

Table 3: Past History

Variable	Yes [n(%)]	No [n(%)]	P-value
Past History: SHTN	33 (33%)	67 (67%)	0.004
Past History: DM	35 (35%)	65 (65%)	0.146
Past History: CAD	28 (28%)	72 (72%)	0.065
Past History: CVA	25 (25%)	75 (75%)	0.133
Past History: Renal Disease	39 (39%)	61 (61%)	0.112
Past History: Other	31 (31%)	69 (69%)	0.069

Systemic hypertension (33%) was the most common comorbidity with a significant association ($p=0.004$), suggesting vascular vulnerability, while other chronic illnesses showed no significant impact on sepsis severity (**Table 3**).

Table 4: Family History

Variable	Yes [n(%)]	No [n(%)]	P-value
Family History: SHTN	29 (29%)	71 (71%)	0.023
Family History: DM	27 (27%)	73 (73%)	0.008
Family History: CAD	36 (36%)	64 (64%)	0.199
Family History: CVA	29 (29%)	71 (71%)	0.047
Family History: Renal Disease	25 (25%)	75 (75%)	0.012
Family History: Other	27 (27%)	73 (73%)	0.039

Family history of hypertension ($p=0.023$), diabetes ($p=0.008$), stroke ($p=0.047$), and renal disease ($p=0.012$) showed significant associations, suggesting genetic or familial predisposition to sepsis and poorer outcomes (**Table 4**).

Table 5: Personal History

Variable	Yes [n(%)]	No [n(%)]	P-value
Personal History: Smoking	36 (36%)	64 (64%)	0.149
Personal History: Alcoholic	29 (29%)	71 (71%)	0.161

Smoking (36%) and alcohol use (29%) showed no significant association with sepsis outcomes, suggesting no independent effect, possibly due to sample size or self-reporting limitations (**Table 5**).

Table 6: General Examination

Variable	Yes [n(%)]	No [n(%)]	P-value
General Exam: Anaemia	25 (25%)	75 (75%)	0.028
General Exam: Jaundice	30 (30%)	70 (70%)	0.053
General Exam: Cyanosis	27 (27%)	73 (73%)	0.078
General Exam: Clubbing	34 (34%)	66 (66%)	0.189

General Exam: Pedal Edema	25 (25%)	75 (75%)	0.122
General Exam: JVP	33 (33%)	67 (67%)	0.167

Anaemia (25%) was significantly associated with sepsis severity (p=0.028), while jaundice and cyanosis showed borderline significance, supporting the value of systemic exam findings in bedside assessments **(Table 6)**.

TABLE 7: Systemic Examination

Variable	Yes [n(%)]	No [n(%)]	P-value
Systemic Exam: Cardiovascular	30 (30%)	70 (70%)	0.099
Systemic Exam: Respiratory	34 (34%)	66 (66%)	0.095
Systemic Exam: Abdomen	32 (32%)	68 (68%)	0.099
Systemic Exam: CNS	31 (31%)	69 (69%)	0.17
Systemic Exam: Fundus	29 (29%)	71 (71%)	0.167

No systemic exam parameters showed significant associations with outcomes, though respiratory (34%) and abdominal (32%) involvement were common, highlighting frequent multi-system involvement but limited prognostic value without biochemical support **(Table 7)**.

Table 8: SOFA Score vs. Clinical Outcomes

SOFA Score Category	Number of Patients	Multiorgan Dysfunction (n, %)	Mortality (n, %)	p-value
<5	15	2 (13.3%)	0 (0%)	0.002**
5–9	30	10 (33.3%)	4 (13.3%)	0.002**
10–14	35	25 (71.4%)	12 (34.3%)	0.002**
>14	20	18 (90%)	11 (55%)	0.002**

Higher SOFA scores were strongly associated with increased multiorgan dysfunction (13.3% at <5 to 90% at >14) and mortality (0% to 55%) (p=0.002), confirming its predictive validity and aligning with the observed link between high LAR and worse outcomes **(Table 8)**.

Table 9: SOFA Score vs. Laboratory Parameters

SOFA Score Group	Mean L/A Ratio	Mean Creatinine (mg/dL)	Mean Platelets (cells/mm³)	Mean INR	p-value
<5	0.8	1.1	165,000	1.2	<0.001**
5–9	1.3	1.9	125,000	1.8	<0.001**
10–14	1.9	2.8	80,000	2.5	<0.001**
>14	2.6	3.9	50,000	3.3	<0.001**

With rising SOFA scores ($p < 0.001$), L/A ratio (0.8→2.6), creatinine (1.1→3.9 mg/dL), and INR (1.2→3.3) increased, while platelets (165,000→50,000/mm³) decreased, reflecting worsening metabolic stress, renal dysfunction, and coagulopathy; L/A ratio correlated strongly with this trajectory **(Table 9)**.

4. DISCUSSION

In the present study, the sepsis population predominantly comprised middle-aged and older adults, with a mean age of 56.8 years (range: 22–84), and a clear male predominance (62%). These demographic trends are consistent with established epidemiological evidence identifying male gender and advancing age as non-modifiable risk factors for sepsis incidence and severity. Aging is associated with immunosenescence, diminished physiological reserve, and higher comorbidity burden, all of which compromise host defense mechanisms. Male patients may also exhibit distinct immune and inflammatory responses due to hormonal and genetic influences on cytokine release and endothelial function. Such demographic characteristics align with multicentric studies where age and sex have been shown to predict elevated lactate/albumin ratio (LAR) and adverse outcomes. Older individuals, often with baseline hypoalbuminemia from chronic illness or malnutrition, may demonstrate disproportionately high LAR values even with modest lactate elevations, amplifying prognostic risk.

The clinical profile of vital signs at presentation reflected the hemodynamic burden of sepsis, with low mean systolic blood pressure (102 mmHg) and mean arterial pressure (78 mmHg), elevated heart rate (98 bpm) and respiratory rate (24/min), febrile state (100.4°F), and reduced oxygen saturation (91%). These abnormalities are characteristic of early distributive shock ("warm shock"), marked by vasodilation, tachycardia, and tachypnea. Such derangements have a biochemical correlate in LAR: hypotension and tachypnea reflect hypoperfusion and tissue hypoxia, driving lactate accumulation, while systemic inflammation and capillary leak depress serum albumin. Even minor changes in vital signs can thus signal substantial shifts in LAR, which has been independently associated with vasopressor need, prolonged ICU stay, and mortality.

Biochemical findings revealed elevated mean lactate (4.2 mmol/L) and reduced albumin (2.8 g/dL), yielding a mean LAR of 1.5—well above prognostic thresholds from prior literature. LAR integrates two opposing processes—anaerobic glycolysis and protein homeostasis—providing a composite marker of acute metabolic stress and chronic nutritional/inflammatory status. Multiple studies confirm that LAR outperforms lactate alone in prognostic accuracy and is especially valuable in resource-limited settings where it can be calculated from routine tests. Additional laboratory derangements in this cohort included elevated urea, creatinine, bilirubin, INR, and WBC count, alongside thrombocytopenia and anemia, indicating multi-organ dysfunction across hepatic, renal, hematological, and coagulation systems. These abnormalities correlated directly with rising LAR, consistent with evidence linking higher creatinine and INR to systemic endothelial injury and coagulative imbalance in sepsis.

Clinically, fever (40%), breathlessness (32%), and confusion (27%) were common, but only hypotension (28%) significantly correlated with adverse outcomes. Hypotension remains a pivotal marker of circulatory failure, closely tied to elevated lactate and hypoalbuminemia, and thus higher LAR. Literature suggests that hypotensive patients with LAR >1.2 have increased mortality and multi-organ failure risk, a finding echoed in this study. Regarding comorbidities, systemic hypertension (33%) was the only condition significantly associated with poor outcomes, potentially due to baseline endothelial dysfunction, impaired microvascular autoregulation, and chronic inflammatory activation. Although diabetes (35%), renal disease (39%), and coronary artery disease (28%) were prevalent, their lack of statistical significance may reflect sample size or confounding factors, though prior research affirms LAR's predictive strength in comorbid populations.

Family history analysis demonstrated significant associations between severe sepsis and familial hypertension, diabetes, cerebrovascular accidents, and renal disease, supporting the role of genetic predisposition in immune regulation, endothelial integrity, and metabolic control. Such inherited vulnerabilities may exacerbate hypoalbuminemia and impair lactate clearance, contributing to higher LAR and worse outcomes. Conversely, personal habits such as smoking (36%) and alcohol use (29%) were not statistically significant here, though they are known contributors to systemic inflammation and hypoalbuminemia in other cohorts.

On physical examination, anemia (25%) was the only significant predictor of poor outcome, likely through exacerbation of tissue hypoxia and consequent lactate elevation. Other findings—jaundice (30%), cyanosis (27%), and pedal edema (25%)—though common, lacked statistical significance, yet underscored the prevalence of hepatic and circulatory disturbances. Systemic examination revealed frequent respiratory (34%), cardiovascular (30%), and abdominal (32%) involvement, reinforcing the multisystemic nature of sepsis. While physical findings alone were nonspecific, their integration with biochemical markers such as LAR and SOFA scoring enhances risk stratification.

SOFA score analysis demonstrated a strong, statistically significant association with adverse outcomes ($p=0.002$). As scores increased from <5 to >14, multiorgan dysfunction rose from 13.3% to 90%, and mortality from 0% to 55%. These trends paralleled LAR escalation, validating both SOFA and LAR as complementary severity markers. Laboratory progression with increasing SOFA tiers included rising LAR (0.8 to 2.6), creatinine (1.1 to 3.9 mg/dL), INR (1.2 to 3.3), and falling platelet count (165,000 to 50,000/mm^3), reflecting progressive renal, coagulative, and metabolic compromise. Notably, LAR's graded rise mirrored organ failure severity and, in some reports, preceded SOFA changes, suggesting utility for early detection of deterioration.

Overall, this study supports LAR as an accessible, integrative biomarker that reflects both acute hypoxic stress and chronic inflammatory/nutritional deficits in sepsis. Its consistent correlation with SOFA score, organ dysfunction markers, and key clinical predictors underscores its value for early triage, prognosis, and therapeutic decision-making, particularly in settings where rapid, low-cost risk assessment tools are essential.

5. CONCLUSION

Sepsis remains a major global health burden and a leading cause of ICU morbidity, multi-organ failure, and mortality, underscoring the need for early recognition and accurate prognostication. This prospective observational study in a tertiary care ICU in Chennai demonstrated that the serum lactate/albumin ratio (LAR) is a significant independent predictor of sepsis severity, multi-organ dysfunction, and mortality. Higher SOFA scores were consistently associated with elevated LAR, with a critical threshold of >1.25 predicting increased vasopressor requirement, prolonged ICU stay, and death. LAR outperformed lactate or albumin alone by reflecting both metabolic stress and systemic protein loss. The study cohort (mean age 56.8 years, male predominance) mirrored known epidemiological trends, with comorbidities such as hypertension and renal disease correlating with higher LAR and poorer outcomes. Clinically, hypotension and organ dysfunction were linked to elevated LAR, while rising SOFA scores paralleled increases in creatinine and INR with falling platelet counts, marking progression toward septic shock and multi-organ failure. These findings align with international evidence showing LAR's strong prognostic accuracy (AUC ≈ 0.8) and highlight its practicality as a low-cost, routinely available biomarker. Integration of LAR into ICU sepsis protocols may enhance risk stratification, early triage, and decision-making, complementing established tools like SOFA to improve management precision.

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