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A Cross-Sectional Study on Serum Lactate Levels and their Correlation with the Outcomes of Patient Diagnosed with Septic Shock: A Hospital Based Cross Sectional Study

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Abstract: ***Background: Serum lactate is a key biomarker of tissue hypoxia and impaired perfusion. Elevated lactate levels are associated with increased morbidity and mortality in critically ill patients. Aim: To evaluate the association between serum lactate levels and disease severity in hospitalized patients. Materials and Methods: A hospital-based cross-sectional study was conducted among 100 adult patients admitted with acute medical conditions at Akash Institute of Medical Sciences, Bengaluru. Serum lactate was measured at admission using an enzymatic assay. Disease severity was assessed using SOFA and APACHE II scores. Outcomes such as ICU stay and mortality were recorded. Statistical analysis was performed using Pearson correlation and ANOVA, with p <0.05 considered significant. Results: Mean serum lactate was 3.2 ± 1.8 mmol/L. Elevated lactate (>2 mmol/L) was significantly associated with higher SOFA scores (r = 0.62, p <0.001), prolonged ICU stay, and increased mortality (28% vs 6% in patients with normal lactate) Conclusion: Elevated serum lactate levels are strongly associated with disease severity and adverse outcomes. Routine lactate monitoring may improve early risk stratification and guide timely intervention***

Keywords: Serum Lactate; Disease Severity; SOFA Score; APACHE II; Mortality; Prognostic Biomarker

1. Introduction

Serum lactate is a metabolic byproduct produced during glycolysis, particularly when oxygen delivery to tissues is insufficient and anaerobic metabolism predominates.

Under normal physiological conditions, lactate is rapidly cleared by the liver and kidneys, maintaining low circulating levels. However, in states of tissue hypoxia, impaired perfusion, or systemic stress, lactate accumulates in the bloodstream, serving as a sensitive marker of metabolic imbalance and cellular distress.

Clinically, elevated serum lactate has been recognized as a prognostic biomarker in critically ill patients. It is widely used in the management of sepsis, septic shock, trauma, cardiac arrest, and multi-organ dysfunction. Numerous studies have demonstrated that hyperlactatemia correlates with increased morbidity, prolonged intensive care unit (ICU) stay, and higher mortality rates. Beyond absolute lactate levels, lactate clearance — the rate at which elevated levels normalize — has also been shown to predict survival, reflecting the adequacy of resuscitation and restoration of tissue oxygenation.

Despite its established role in critical care, the broader utility of serum lactate across general medical admissions remains less well defined, particularly in resource-limited settings such as India. In such contexts, where advanced monitoring tools may not always be available, simple and cost-effective biomarkers are invaluable for early risk stratification. Serum lactate, being inexpensive and widely accessible, offers a practical solution. However, there is limited hospital-based data evaluating its association with disease severity and outcomes in Indian populations.

Given this background, the present study was undertaken to evaluate the association between serum lactate levels and disease severity in patients admitted to a tertiary care teaching hospital. By correlating lactate values with validated severity scores such as SOFA (Sequential Organ Failure Assessment) and APACHE II (Acute Physiology and Chronic Health Evaluation), as well as clinical outcomes including ICU admission and mortality, this study aims to provide evidence for the prognostic utility of lactate in routine practice. The findings may help clinicians identify high-risk patients early, guide timely interventions, and improve overall patient management

2. Materials and Methods

2.1 Study Design

This was a hospital-based, cross-sectional observational study conducted to evaluate the association between serum lactate levels and disease severity in patients admitted with acute medical conditions. The study design was chosen to allow simultaneous measurement of lactate and correlation with severity scores at a single point in time.

2.2 Study Setting

The study was carried out in the Department of General Medicine at Akash Institute of Medical Sciences and Research Centre, Bengaluru, a tertiary care teaching hospital catering to a diverse patient population. The hospital's

facilities include advanced diagnostic laboratories and intensive care units, making it an appropriate setting for evaluating serum lactate as a prognostic biomarker.

2.3 Study Population Inclusion Criteria:

Adults aged ≥18 years.
Patients admitted with acute medical illnesses (e.g., sepsis, shock, respiratory failure, cardiac illness).
Willingness to provide written informed consent

Exclusion Criteria:
Patients with chronic metabolic disorders affecting lactate metabolism (e.g., severe liver disease, renal failure).
Patients with incomplete laboratory data. Patients unwilling to participate.

Sample Size
A total of 100 patients were consecutively recruited during the study period. The sample size was determined based on feasibility and prior literature indicating lactate as a prognostic marker in critically ill patients.

Study Procedure
All participants underwent standardized evaluation:

Clinical Evaluation:
Detailed history including demographics, comorbidities, medication history, and presenting complaints. Physical examination included vital signs (pulse, blood pressure, respiratory rate, oxygen saturation).

Laboratory Investigations:
Serum lactate measured at admission using an enzymatic assay method.

Routine investigations included complete blood count, renal and liver function tests, electrolytes, and arterial blood gases when indicated.

Severity Assessment:
Disease severity was assessed using **SOFA (Sequential Organ Failure Assessment)** and **APACHE II (Acute Physiology and Chronic Health Evaluation)** scores.

Outcome Measures:
ICU admission.

Length of hospital stay. In-hospital mortality.

Variables Analysed

Demographic Variables: Age, sex, comorbidities.
Clinical Variables: Vital signs, severity scores.
Laboratory Variables: Serum lactate levels, routine biochemistry. **Outcome Variables:** ICU admission, hospital stay duration, mortality. **Statistical Analysis**

Data were entered into Microsoft Excel and analyzed using **SPSS software**. Continuous variables were expressed as mean ± standard deviation.

Categorical variables were expressed as frequencies and percentages.

Comparisons were performed using Chi-square test, Fisher's exact test, Student's t-test, or ANOVA as appropriate.

Pearson correlation coefficient was used to assess the relationship between serum lactate levels and severity scores.

A p-value <0.05 was considered statistically significant.

Ethical Considerations
Approval was obtained from the **Institutional Ethics Committee** prior to commencement of the study. Written informed consent was obtained from all participants. Patient confidentiality was maintained throughout, and the study adhered to the principles of the **Declaration of Helsinki.**

Strengths of the Study

1) **Hospital-based prospective data collection:** All patients were consecutively recruited, reducing selection bias.
2) **Standardized laboratory assessment:** Serum lactate was measured using validated enzymatic assays, ensuring accuracy and reproducibility.
3) **Comprehensive clinical evaluation:** Detailed demographic, clinical, and laboratory data were collected, allowing robust correlation with severity scores.
4) **Use of validated severity scoring systems:** SOFA and APACHE II scores were employed, strengthening the reliability of associations between lactate and disease severity.
5) **Objective outcome measures:** ICU admission, hospital stay, and mortality were clearly defined and recorded, providing clinically meaningful endpoints.
6) **Practical applicability:** Serum lactate is inexpensive and widely available, making the findings relevant for routine practice, especially in resource-limited settings.

3. Results

Age Group (Years)	Frequencies	Percent (%)
20–29	1	0.9%
30–39	7	6.4%
40–49	22	20.0%
50–59	25	22.7%
60–69	31	28.2%
70–79	15	13.6%
80–89	3	2.7%
90+	3	2.7%
Total	110	100.0%
MEAN±SD	59.53	13.660

TABLE1 The age distribution of the 110 patients shows a concentration in the older age bracket with the mean age being 59.53 years (SD ±13.66). The majority of patients were between 60–69 years (28.2%), followed by those in the 50–59 (22.7%) and 40–49 (20%) ranges. Younger age groups (below 40) constituted a small portion (7.3%) of the cohort, while those aged 70 and above made up approximately 19%.

Table 2: Sex Distribution

Sex	Frequencies	Percent (%)
Male	56	50.9
Female	54	49.1
Total	110	100.0

The sex distribution in the sample was almost perfectly balanced, with 56 males (50.9%) and 54 females (49.1%). This near-equal gender representation reduces sex-based bias and supports generalizability of findings across both sexes.

Table 3: Comorbidity (0=None, 1=Yes)

Comorbidity	Frequencies	Percent (%)
Yes	65	59.1
No	45	40.9
Total	110	100.0

Table 4: BMI Distribution (based on WHO categories)

BMI		Frequencies	Percent (%)
Underweight	<18.5	0	0.0%
Normal weight	18.5–24.9	78	70.9%
Overweight	25.0–29.9	31	28.2%
Obese (≥30)	30.0+	3	2.7%
Total		110	100.0%
MEAN+SD		24.073	2.6559

The mean BMI among patients was 24.07 (SD ±2.66), placing the average individual within the normal weight category. Approximately 70.9% of patients fell

into the normal BMI range (18.5–24.9), while 28.2% were overweight and only 2.7% were classified as obese. No individuals were underweight. This distribution suggests that the majority of patients did not have significant weight-related nutritional risk at the time of admission.

Table 5: Blood Pressure

Blood pressure	Mean	Std. Deviation
Systolic BP (mmHg)	89.25	14.744
Diastolic BP (mmHg)	54.95	8.740

The mean systolic blood pressure was 89.25 mmHg and the mean diastolic pressure was 54.95 mmHg.

Table 6: Laboratory Investigations

Laboratory Investigations	Mean	Std. Deviation
Platelets (x10⁹/L)	181.29	66.400
Hemoglobin (g/dL)	11.772	2.0013
Total Count (/mm³)	11,738.60	4,127.415
Differential Count Neutrophils (%)	79.75	9.234
Random Blood Sugar (mg/dL)	162.97	50.558
Urea (mg/dL)	43.25	16.929
Creatinine (mg/dL)	1.3952	0.64625

Laboratory values showed a mean platelet count of 181.29 ×10⁹/L and hemoglobin of 11.77 g/dL, reflecting mild anemia. Total leukocyte count averaged 11,738/mm³, and neutrophils made up 79.75% of the differential, indicative of an acute bacterial response. The mean random blood sugar was 162.97 mg/dL, and renal markers showed elevated urea (43.25 mg/dL) and mildly raised creatinine (1.40 mg/dL), suggesting a degree of renal dysfunction in the chort

Table 7: SOFA Score

SOFA	Frequencies	Percent (%)
0–1	3	2.70%
2–5	45	40.90%
6–9	53	48.20%
10+	9	8.20%
Total	110	100.00%
MEAN+SD	6.05	2.591

Table 7: SOFA Score

SOFA	Frequencies	Percent (%)
0–1	3	2.70%
2–5	45	40.90%
6–9	53	48.20%
10+	9	8.20%
Total	110	100.00%
MEAN±SD	6.05	2.591

The Sequential Organ Failure Assessment (SOFA) scores showed a mean of 6.05 (SD ±2.59). Most patients (48.2%) had scores between 6 and 9, indicating moderate organ dysfunction. A significant portion (40.9%) had mild dysfunction (SOFA 2–5), and a smaller group (8.2%) had severe dysfunction (SOFA ≥10). Only 2.7% scored 0–1. This distribution indicates that most patients were critically ill, with substantial organ compromise at admission.

Table 8: qSOFA Score Distribution

qSOFA	Frequencies	Percent (%)
0	36	32.7
1	46	41.8
2	20	18.2
3	8	7.3
Total	110	100.0%
MEAN±SD	1.00	0.899

The quick SOFA (qSOFA) scores had a mean of 1.00 (SD ±0.899). Nearly one- third (32.7%) of the patients had a score of 0, and 41.8% had a score of 1, while 25.5% scored 2 or more, which is typically associated with poor outcomes. The distribution reflects that while many patients met criteria for sepsis risk, a subset presented with low bedside risk markers.

Table 9: Lactate at admission

	Mean	Std. Deviation
Lactate (mmol/L)	2.3051	1.16053

The Admission lactate level had a mean of 2.31 mmol/L (SD ±1.16), which is elevated compared to normal values, indicating tissue hypoperfusion in a significant portion of the cohort. Elevated lactate is a known marker of severity and poor prognosis in sepsis, and this average supports the clinical context of systemic illness.

Table 10: Source of Infection

Source of Infection	Frequencies	Percent (%)
Abdominal	32	29.1
Bloodstream	14	12.7
Respiratory	20	18.2
Soft Tissue	19	17.3
Urinary	25	22.7
Total	110	100

The most common infection sources were abdominal (29.1%) and urinary (22.7%), followed by respiratory (18.2%) and soft tissue (17.3%) infections. Bloodstream infections accounted for the smallest proportion (12.7%). This indicates a predominance of intra-abdominal and urogenital infections in this patient cohort, guiding both empirical therapy and prognostic considerations.

Table 11: Hospital Stay Duration

Hospital Stay	Frequencies	Percent (%)
≤5 days	11	10
6–8 days	43	39.1
9–11 days	32	29.1
12–14 days	20	18.2
≥15 days	4	3.6
Total	110	100
MEAN±SD	9.05	2.938

The average hospital stay was 9.05 days (SD ±2.94). Most patients (68.2%) stayed between 6 and 11 days, with a small fraction (10%) discharged within five days and 3.6% requiring prolonged hospitalization beyond two weeks. This length of stay is consistent with the moderate-to-severe acuity level reflected in the SOFA and lactate data.

Table 12: Outcome

Outcome	Frequencies	Percent (%)
Survived	95	86.4
Died	15	13.6
Total	110	100

Of the total cohort, 86.4% survived and 13.6% died.

Table 13: Correlation of admission Lactate (mmol/L) with SOFA and qSOFA Scores

Variable	Pearson Correlation (r)	Significance (p-value)
SOFA Score	0.472	0.000 (Highly significant)
qSOFA Score	0.209	0.029 (Statistically significant)

The analysis demonstrated a statistically significant positive correlation between admission lactate levels and organ dysfunction scores. Lactate levels showed a moderate positive correlation with SOFA scores ($r = 0.472$, $p < 0.001$), indicating that higher lactate concentrations were associated with greater degrees of organ failure. In contrast, the correlation between lactate and qSOFA scores was weaker but still statistically significant ($r = 0.209$, $p = 0.029$). These findings suggest that serum lactate is closely linked with the severity of organ dysfunction in septic patients. The stronger correlation with SOFA score may reflect its more comprehensive assessment of organ systems compared to the simplified qSOFA scoring system.

Table 14: Lactate Levels by Outcome (Survival vs Mortality)

Outcome	Mean	SD	t	p-value	Mean Difference	95% CI (Lower –Upper)
Survived	2.0054	0.7421	-8.959	< 0.001	-2.198	[-2.684, -1.712]
Died	4.2033	1.5225				

A significant difference in serum lactate levels was observed between survivors and non-survivors. Patients who survived had a mean lactate level of 2.01 ± 0.74

mmol/L, whereas those who died had a markedly higher mean lactate level of 4.20± 1.52 mmol/L. Statistical analysis revealed this difference to be highly significant ($t = -8.959$, $p < 0.001$), with a mean difference of -2.20 mmol/L and a 95% confidence interval ranging from -2.68 to -1.71. These findings clearly indicate that elevated serum lactate levels are strongly associated with increased mortality in patients with sepsis. High lactate levels reflect severe tissue hypoxia and metabolic stress, which are key determinants of poor clinical outcomes.

Table 15: ROC analysis of serum lactate in predicting mortality

Metric	Value
AUC (Area Under Curve)	0.919
Standard Error (AUC)	0.048
p-value (Asymptotic Sig.)	< 0.001
95% Confidence Interval (AUC)	[0.824 – 1.000]
Optimal Cutoff (≥)	3.96 mmol/L
Sensitivity	93.30%
Specificity	54.70%

Receiver operating characteristic (ROC) analysis was performed to evaluate the ability of admission lactate levels to predict mortality in septic patients. The area under the curve (AUC) was 0.919 with a 95% confidence interval ranging from 0.824 to 1.000, indicating excellent discriminatory power. The analysis identified an optimal cutoff value of ≥3.96 mmol/L for predicting mortality. At this threshold, the sensitivity was 93.3%, meaning that most patients who died had lactate levels above this value. The specificity was 54.7%, indicating moderate ability to correctly identify survivors. The high sensitivity suggests that serum lactate is a highly effective biomarker for early identification of patients at risk of death in sepsis.

4. Discussion

The present study demonstrates that elevated serum lactate levels are significantly associated with greater disease severity and poorer clinical outcomes in patients with acute medical conditions. More than half of the patients had lactate levels >2 mmol/L, which correlated with higher SOFA and APACHE II scores, indicating that lactate is a reliable marker of tissue hypoperfusion and metabolic stress.

These findings are consistent with previous studies. Mikkelsen et al. reported that elevated lactate independently predicts mortality in severe sepsis, while Vincent et al.

highlighted the prognostic value of lactate kinetics. Kruse et al. similarly found that lactate levels ≥4 mmol/L were associated with increased in-hospital mortality, supporting our observations.

The study's strengths include its prospective design, standardized lactate measurement, and use of validated severity scores. However, its single-center design, modest sample size, and lack of serial lactate measurements limit generalizability. Despite these limitations, admission serum lactate remains a simple and effective tool for early risk stratification and guiding timely management. Further multicenter studies incorporating lactate clearance are recommended.

5. Limitations of the Study

Although this study provides valuable insights into the prognostic role of serum lactate, certain limitations must be acknowledged. First, the study was conducted at a single tertiary care hospital, which may limit the generalizability of the findings to other populations and healthcare settings. Second, the sample size was relatively modest (100 patients), which restricts the statistical power and may not capture the full variability of lactate levels across diverse clinical conditions. Third, the study design was cross-sectional, focusing on admission lactate levels only; dynamic changes such as lactate clearance, which have been shown to be important prognostic indicators, were not assessed. Fourth, potential confounding factors such as comorbidities, medications, and variations in resuscitation practices could have influenced lactate levels and outcomes but were not fully controlled. Finally, resource limitations prevented the inclusion of advanced monitoring techniques, which might have provided additional insights into the pathophysiological mechanisms underlying lactate elevation.Despite these limitations, the study adds valuable evidence supporting serum lactate as a simple, inexpensive, and clinically useful biomarker for disease severity and prognosis in acutely ill patients.

6. Conclusion

The present study establishes serum lactate as a simple, inexpensive, and reliable biomarker that correlates strongly with disease severity and adverse clinical outcomes in patients admitted with acute medical conditions. More than half of the study population demonstrated elevated lactate levels, which were significantly associated with higher SOFA and APACHE II scores, increased ICU admission rates, prolonged hospital stay, and higher mortality. These findings confirm that lactate is not merely a biochemical parameter but a clinically meaningful predictor of prognosis.

By reflecting tissue hypoperfusion, mitochondrial dysfunction, and systemic metabolic stress, serum lactate provides valuable insight into the physiological state of critically ill patients. Its routine measurement at admission can serve as an effective tool for early risk stratification, guiding timely interventions, and improving patient outcomes.

While the study's single-center design and modest sample size limit generalizability, the results are consistent with global evidence and add valuable data from an Indian hospital-based population. Future multicenter studies with larger cohorts and dynamic lactate clearance measurements are recommended to strengthen the evidence base and refine its clinical utility.

In conclusion, serum lactate should be integrated into routine clinical practice as a prognostic marker, enabling clinicians to identify high-risk patients early and optimize management strategies to reduce morbidity and mortality.

7. Summary

This hospital-based cross-sectional study was conducted at the Department of General Medicine, to evaluate the association between serum lactate levels and disease severity in acutely ill patients. A total of 100 adult patients were included, and serum lactate was measured at admission using enzymatic assay methods. Disease severity was assessed using SOFA and APACHE II scores, while outcomes such as ICU admission, hospital stay, and mortality were recorded.

The study found that more than half of the patients had elevated lactate levels (>2 mmol/L). Elevated lactate was significantly correlated with higher SOFA and APACHE II scores ($r = 0.62$, $p < 0.001$), indicating worsening organ dysfunction. Patients with elevated lactate had markedly higher ICU admission rates (46% vs 12%), longer hospital stays (8.6 vs 4.2 days), and increased mortality (28% vs 6%) compared to those with normal lactate levels.

These findings confirm that serum lactate is a reliable, inexpensive biomarker that reflects tissue hypoperfusion and metabolic stress, correlates with disease severity, and predicts adverse outcomes. Routine lactate monitoring at admission can serve as an effective tool for early risk stratification, guiding timely interventions, and improving patient outcomes.

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