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Original Research Article

Lactate Levels on Arterial Blood Gas Analysis in Critically Ill Patients in a Tertiary Care Hospital: A Descriptive Study

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Abstract

Introduction: Lactate is an important marker of severity of illness and tissue hypoperfusion in critically ill patients. Elevated or persistently high lactate is associated with increased mortality. This study evaluated admission arterial blood lactate levels and their relationship with clinical outcomes in critically ill patients.

Methodology: After getting approval from Ethics Committee and Institutional Research Committee, a Cross-sectional, Institutional based prospective study was carried out in the Department of Respiratory Medicine. Admission lactate levels measured by arterial blood gas (ABG) analysis were recorded and outcomes were noted in proforma.

Result: Among 116 critically ill patients, 26 (22.4%) had hyperlactatemia (≥2 mmol/L). Higher lactate levels were significantly associated with respiratory failure, cardiogenic shock, hypovolemic shock ($p \leq 0.05$) but not with gender, sepsis, altered sensorium and postoperative conditions ($p > 0.05$). ICU mortality was significantly higher among patients with hyperlactatemia than among those with normal lactate levels (46.2% vs. 8.9% respectively).

Conclusion: Elevated admission ABG lactate is a clinically important marker in critically ill patients and is significantly associated with ICU mortality.

Keywords: Lactate, Critical Care.

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Introduction

Arterial blood gas analysis is commonly done in critically ill patients. Among the various parameters obtained from ABG analysis, lactate is an important marker of tissue hypoperfusion and disease severity. A rising lactate level usually indicates inadequate tissue perfusion. Lactate level is elevated in hypoxia, anaerobic metabolism, sepsis, shock, or trauma. [1,3,6] Blood lactate levels may increase due to increased production or impaired clearance. [1,6] Timely lactate monitoring may help guide the clinical decision-making. Increasing lactate level can be an indicator of worsening clinical condition. [2,4] As lactate measurement is routinely available as part of ABG analysis, no additional blood sample or laboratory investigation is usually required. Lactate has become one of the most important markers for the assessment of critically ill patients. [2.4] Lactate is produced by anaerobic glycolysis in tissues like, muscles and the brain. In normal physiological condition, lactate is metabolized and excreted by the liver and kidneys [1,6]. But in critically ill patients this balance is disrupted and resulting in elevated blood lactate levels.

Therefore, monitoring the lactate level may provide an important insight into the metabolic state of patients, aiding clinicians in assessing the severity of illness and guiding therapeutic decisions. [1,4,6]

Several studies have shown that patients with higher lactate values, or those whose lactate does not come down with treatment, tend to do worse. [4,5,7,8,9,10] This has been observed across different kinds of critically ill patients. There is not much data available on the ABG lactate level and the outcome of critically ill patients, in eastern India. In this hospital based observational prospective study, an attempt was made to find out

the importance of lactate value as an indicator of ICU outcome.

Materials and Methods: After getting approval from Ethics Committee and Institutional Research Committee, a hospital-based prospective observational study was carried out in the Department of Respiratory Medicine, Gouri Devi Institute of Medical Sciences and Hospital over a period of 3 months, from April 2026 to June 2026. The primary aim was to determine admission ABG lactate levels among critically ill patients and describe their relationship with major clinical conditions and ICU mortality.

A total of 116 eligible patients were included in the study. Sample size (n) was estimated with the Cochrane's formula $n=z^2pq/d^2$, where Z = 1.96 (Confidence Interval 95%), P = Prevalence of Hyperlactatemia, Q = 1-p, E = allowable error (absolute precision). Mikkelsen et al. (2009) reported that approximately 36% of critically ill patients had elevated serum lactate levels, and that even mildly elevated lactate was associated with increased in-hospital mortality. So, prevalence was taken as 36%.

The study population included adult patients (aged ≥ 18 years) admitted to the ICU who had arterial blood gas analyses performed at the time of ICU admission. Patients were included regardless of their underlying diagnosis or the primary reason for ICU admission. Patients unwilling to participate in the study were excluded from the study. Patients with ICU stay < 24-hour were also excluded. Demographic information and ABG lactate values were noted and tabulated in the prescribed proforma.

Blood samples were collected using standardized protocols and analysed using ABG machine i-Smart care 10 (i-SENS Inc South Korea) in the ICU. Lactate levels were expressed in mmol/L. Hyperlactatemia was defined as an admission arterial blood lactate concentration ≥2 mmol/L. The primary outcome of the study was noted as survived or death occurring during the ICU stay.

Prevalence of hyperlactatemia was expressed as percentage. Associations between admission hyperlactatemia and clinical variables, as well as ICU mortality, were evaluated using Pearson's chi-square test. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for the association between hyperlactatemia and ICU mortality. A two-tailed p-value <0.05 was considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics version 29.

Results

A total of 116 critically ill patients admitted to the intensive care unit (ICU) were enrolled in the study. There were 72 (62.1%) males and 44 (37.9%) females. The mean age of the study population was 56.89 ± 14.21 years. Of the 116 patients, 90 had lactate levels <2 mmol/L, whereas 26 had hyperlactatemia (≥2 mmol/L). Distribution of admission arterial blood lactate levels described in Table 1.

Table 1: Distribution of admission arterial blood lactate levels

Lactate category	Frequency	Percent
<2 mmol/L	90	77.6
≥2 mmol/L	26	22.4
Total	116	100

Respiratory failure was observed in 68 patients (58.6%), while 48 patients (41.4%) did not develop respiratory failure. Similarly, 16 patients (13.8%) had sepsis, 35 (30.2%) developed cardiogenic shock, 17 (14.7%) had hypovolemic shock, and 29 (25.0%) presented with altered sensorium.

Table 2: Distribution of major clinical conditions among critically ill patients (Patients had more than one clinical condition; therefore, percentages do not total 100%.)

Cause	Present (%)	Absent (%)
Respiratory failure	68 (58.6)	48 (41.4)
Sepsis	16 (13.8)	100 (86.2)
Cardiogenic shock	35 (30.2)	81 (69.8)
Hypovolemic shock	17 (14.7)	99 (85.3)
Altered sensorium	29 (25.0)	87 (75.0)
Post-operative care	1(0.9)	115(99.1)
Others	21(18.1)	95(81.9)

There was no statistically significant association between gender and admission ABG hyperlactatemia (lactate ≥2 mmol/L). The chi-square test showed $\chi^2 = 1.175$ with 1 degree of freedom and a p-value of 0.278 ($p > 0.05$). Thus, the distribution of male and female patients did not differ significantly between patients with lactate <2 mmol/L and those with lactate ≥2 mmol/L. A statistically significant association was observed between respiratory failure and admission ABG

hyperlactatemia (lactate ≥2 mmol/L). The chi-square test showed $\chi^2 = 5.651$ with 1 degree of freedom and a p-value of 0.017 ($p < 0.05$). This indicates that the occurrence of respiratory failure differed significantly between patients with lactate <2 mmol/L and those with lactate ≥2 mmol/L.

There was no statistically significant association between sepsis/septic shock and admission ABG hyperlactatemia (lactate ≥2 mmol/L). The chi-square value was 1.527 with 1 degree of freedom and the p-value was 0.217 ($p > 0.05$). Therefore, in this study, the presence of sepsis/septic shock did not differ significantly between the two lactate groups. A statistically significant association was observed between cardiogenic shock and admission ABG hyperlactatemia (lactate ≥2 mmol/L). The chi-square test showed $\chi^2 = 7.525$ with 1 degree of freedom and a p-value of 0.006 ($p < 0.05$). This suggests that cardiogenic shock occurred significantly differently between patients with lactate <2 mmol/L and those with lactate ≥2 mmol/L. There was a statistically significant association between hypovolemic shock and admission ABG hyperlactatemia (lactate ≥2 mmol/L). The chi-square value was 5.396 with 1 degree of freedom and the p-value was 0.020 ($p < 0.05$). Thus, the occurrence of hypovolemic shock differed significantly between patients with lactate <2 mmol/L and those with lactate ≥2 mmol/L.

There was no statistically significant association between altered sensorium and admission ABG hyperlactatemia (lactate ≥2 mmol/L). The chi-square test showed $\chi^2 = 0.264$ with 1 degree of freedom and a p-value of 0.607 ($p > 0.05$). Therefore, altered sensorium was not significantly different between the two lactate groups. No statistically significant association was observed between post-operative care and admission ABG hyperlactatemia (lactate ≥2 mmol/L). The chi-square value was 0.441 with 1 degree of freedom and the p-value was 0.506 ($p > 0.05$). Hence, the proportion of patients receiving post-operative care did not differ significantly between the two lactate groups.

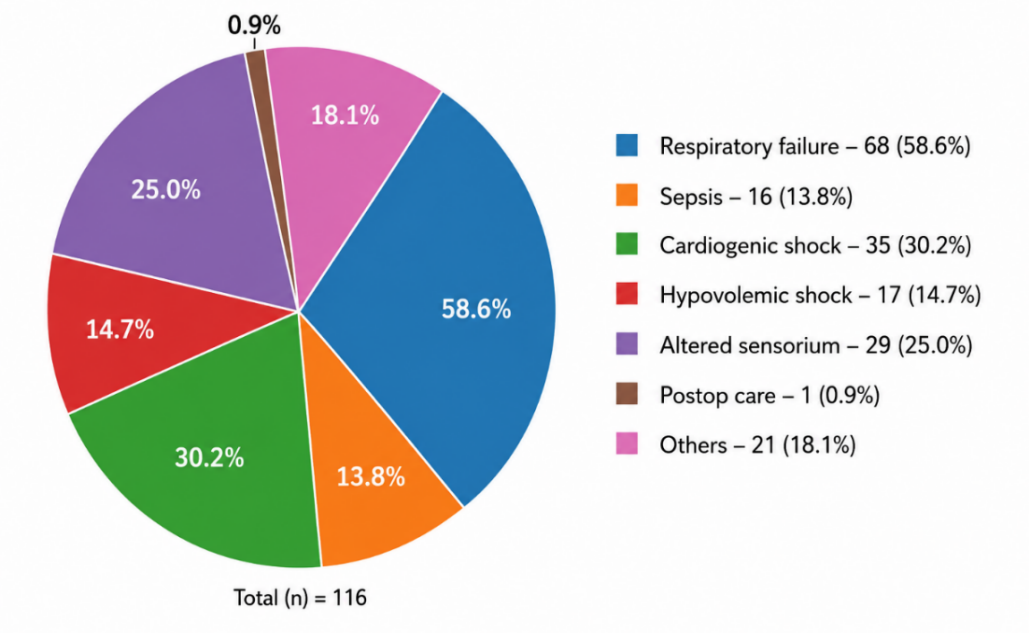

Figure 1: Distribution of major clinical conditions among critically ill patients

The association between admission arterial blood lactate level and ICU mortality was evaluated using Pearson's Chi-square test. Of the 116 critically ill patients included in the study, 26 (22.4%) had admission lactate levels ≥2 mmol/L, while 90 (77.6%) had lactate levels ≤2 mmol/L.

ICU mortality was significantly higher among patients with hyperlactatemia than among those with normal lactate levels (46.2% vs. 8.9% respectively). Pearson's Chi-square analysis demonstrated a highly significant association between admission hyperlactatemia and ICU mortality ($\chi^2 = 19.63$, df = 1, $p < 0.001$). Furthermore, patients with admission lactate levels ≥2 mmol/L had 8.79-fold higher odds of ICU mortality compared with patients having lactate levels <2 mmol/L (Odds Ratio 8.79; 95% Confidence Interval 3.05–25.31).

These findings demonstrate a significant association between admission arterial hyperlactatemia and ICU mortality in the study population. The association between admission arterial blood lactate level and ICU mortality described in table 3 and figure 2.

Table 3: Association between admission arterial blood lactate level and ICU mortality

Admission lactate level	Died, n (%)	Survived, n (%)	Total, n (%)
<2 mmol/L	8 (8.9)	82 (91.1)	90 (77.6)
≥2 mmol/L	12 (46.2)	14 (53.8)	26 (22.4)
Total	20 (17.2)	96 (82.8)	116 (100.0)

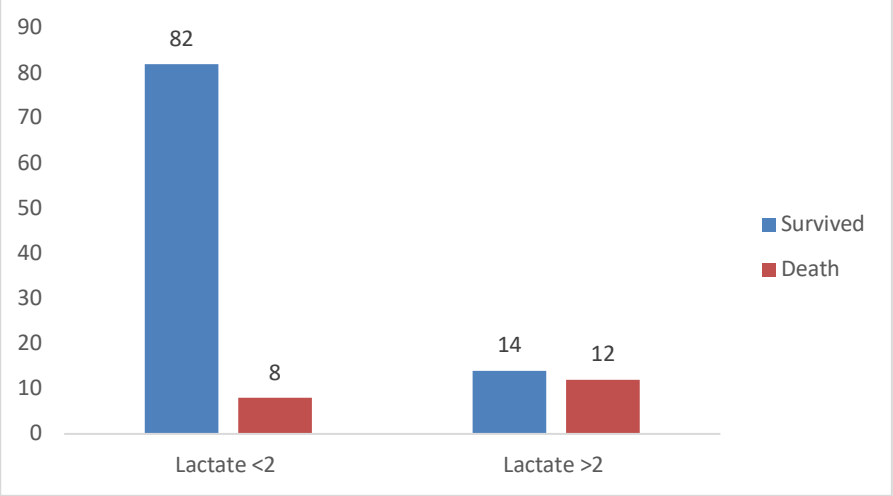

Figure 2: Association between arterial blood lactate level and ICU mortality

Discussion:

Kraut et al. (2014) emphasized that an elevated blood lactate level should be interpreted as a warning sign of underlying physiological stress rather than as a disease itself. They noted that persistent hyperlactatemia is consistently associated with poor clinical outcomes, including higher morbidity and mortality, particularly in critically ill patients. Therefore, management should focus on identifying and correcting the underlying cause of lactate elevation, such as tissue hypoperfusion, sepsis, or metabolic disturbances, instead of attempting to normalize lactate levels alone.[1]

Broder G et al. (1964) observed that a lactate level of more than 4 mmol/L was associated with poor outcomes in patients with undifferentiated shock. Since then, much has been published on the use of lactate in a variety of patient populations. Moreover, causes of elevated lactate levels apart from tissue hypoperfusion have been recognized and should be considered in the appropriate clinical context.[3]

Fuller BM et al. (2012) reviewed the role of blood lactate as a hemodynamic marker in critically ill patients. This review focuses on the use of lactate as a marker for risk stratification, lactate clearance as a hemodynamic endpoint, and its use compared to mixed venous oxygenation as a resuscitation goal. He concluded that, Lactate clearance is associated with improved outcome across several critically ill patients. [4] Vincent JL et al**.** (2016) described lactate clearance as the reduction of lactate levels in the blood over time. They explained that this reduction depends on two processes: how much lactate is being produced and how effectively the body removes it. Lactate is metabolized predominantly by the liver and kidneys, with smaller contributions from the heart and skeletal muscles. Urinary excretion accounts for only a negligible proportion. A falling lactate level usually indicates that tissue oxygen delivery is improving and the patient is responding well to treatment. He concluded that, monitoring lactate clearance can help clinicians assess the effectiveness of resuscitation and the overall progress of critically ill patients.[5]

Andersen et al. (2013) reviewed the causes and management of elevated lactate levels in critically ill patients. They emphasized that hyperlactatemia may result from tissue hypoperfusion, increased catecholamine activity, impaired hepatic clearance, or other metabolic causes. The study highlighted the importance of identifying the underlying cause and using serial lactate measurements to guide management.[6]

Nguyen et al. evaluated the relationship between early lactate clearance and outcomes in patients with severe sepsis and septic shock. They found that greater lactate clearance during the early treatment period was associated with improved survival. The study supported serial lactate measurement as a useful marker of response to therapy and prognosis.[7]

Cao et al. conducted a retrospective cohort study of critically ill patients and assessed lactate level, lactate clearance, and APACHE II score as predictors of short-term outcomes. Higher initial lactate and poorer lactate clearance were associated

with increased mortality. The combination of lactate parameters with APACHE II provided better prognostic prediction than individual parameters alone.[8]

Doğan et al. investigated the prognostic value of initial and 24-hour lactate and methaemoglobin levels in ICU patients. They found that lactate levels and their changes over 24 hours were associated with mortality. The study emphasized the potential value of serial lactate assessment in critically ill patients.[9]

Schork et al. examined the course of lactate, pH, and base excess in medical ICU patients and their ability to predict mortality. Lactate and pH showed significant prognostic value, with higher lactate and lower pH associated with increased mortality. The study demonstrated that abnormalities in these parameters during the first 24 hours can help identify patients at higher risk of death.[10]

Unlike these studies, the present study evaluated only admission arterial blood lactate levels and did not assess serial lactate measurements or lactate clearance.

Conclusion

Admission ABG lactate levels ≥2 mmol/L were significantly associated with increased ICU mortality among critically ill patients. Mortality was substantially higher in patients with lactate levels ≥2 mmol/L compared with those with levels <2 mmol/L (46.2% vs. 8.9%; $p<0.001$). Higher lactate levels were significantly associated with respiratory failure, cardiogenic shock, hypovolemic shock ($p\leq0.05$) but not with gender, sepsis, altered sensorium and postoperative conditions ($p>0.05$). Thus, elevated lactate levels are an important ICU parameter and are significantly associated with increased ICU mortality. Measuring lactate on admission may serve as a simple and readily available marker for early risk stratification and identification of critically ill patients at increased risk of mortality.

Ethical Approval: Approved

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