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Assessment of Serial Lactate Levels as Predictors of Outcome in Hemodynamically Unstable Patients Presenting to the Emergency Department

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Abstract

Background: Hemodynamic instability is a life-threatening condition frequently encountered in emergency departments, requiring rapid assessment and management. Blood lactate level has emerged as a key biomarker for evaluating tissue hypoxia and predicting patient outcomes. **Objective:** To evaluate whether initial and serial blood lactate levels after presentation to the emergency department are helpful in predicting outcomes in patients presenting with hemodynamic instability. **Material and Methods:** This prospective observational study included 50 patients presenting with hemodynamic instability to the emergency department of a tertiary care centre over 15 months. Lactate levels were measured at admission and after six hours. Patients were followed for outcomes including in-hospital mortality and duration of hospital stay. Data were analyzed using SPSS version 25, with p-values <0.05 considered statistically significant. **Results:** Elevated lactate levels (>4 mmol/L) at admission were observed in 34% of patients and were significantly associated with higher mortality (41.2%) compared to lower lactate groups. Persistently elevated lactate levels at six hours were also linked to poorer outcomes. Patients with higher lactate levels showed significantly lower systolic blood pressure, higher heart and respiratory rates, and lower oxygen saturation at admission. Length of hospital stay was significantly longer in patients with elevated lactate levels. **Conclusion:** Elevated admission and persistent lactate are significantly associated with increased mortality and prolonged hospital stay in hemodynamically unstable patients. Serial lactate monitoring serves as a valuable prognostic tool to guide early intervention and improve outcomes in emergency settings.

Keywords: *Lactate, Hemodynamic instability, Mortality, Emergency department, Prognosis.*

Introduction

Hemodynamic instability is a critical condition commonly encountered in emergency departments (ED), characterized by inadequate tissue perfusion and oxygenation, leading to organ dysfunction and potentially death if not promptly managed [1]. Early identification of patients at risk of deterioration is essential to guide timely interventions and improve outcomes [2]. Blood lactate level has emerged as a valuable biomarker reflecting the balance between oxygen delivery and utilization, serving as an indicator of global tissue hypoxia and severity of illness [3].

Traditionally, elevated lactate levels have been associated with increased mortality in septic, traumatic, and cardiogenic shock patients [4]. However, recent evidence suggests that not only the initial lactate concentration but also its clearance over time provides prognostic information, with persistent hyperlactatemia correlating with poor outcomes [5]. Serial measurements of lactate may thus offer better predictive accuracy than a single measurement at admission [6].

Studies have demonstrated that lactate clearance within the first few hours of resuscitation is associated with improved survival, underscoring its role as a dynamic marker of response to treatment [7]. In emergency settings, where rapid risk stratification is crucial, monitoring serial lactate levels could help guide resuscitation efforts and clinical decision-making [8]. Moreover, lactate monitoring has been incorporated into sepsis management protocols, emphasizing its prognostic utility beyond infectious etiologies [9].

Despite its recognized value, the application of serial lactate monitoring in a heterogeneous population of patients presenting with hemodynamic instability in the ED remains underexplored. This

study aims to evaluate whether initial and serial blood lactate levels can reliably predict outcomes in such patients, potentially aiding in early identification of those requiring aggressive interventions [10].

Materials and Methods

This prospective observational study was conducted over 15 months, from January 2023 to April 2024, in the Department of Emergency Medicine, Dr. M.K. Shah Medical College and Research Centre, and Smt. S.M.S. Multispecialty Hospital, Chandkheda, Ahmedabad. Both institutions are tertiary care centers providing high-quality and affordable healthcare services.

Patients were eligible for inclusion if they or their relatives provided informed consent, were aged above 18 years, and presented to the emergency department with hemodynamic instability. Hemodynamic instability was clinically defined as systolic blood pressure less than 90 mm hg with one or more of following parameter: Heart rate below 50 or above 100 beats per minute, respiratory rate over 24 breaths per minute or oxygen saturation (spo2) below 94%at FIO2 0.21. Patients were excluded if they or their relatives declined consent or if the patient was pregnant. A total of 50 patients meeting the eligibility criteria were enrolled in the study.

Data were collected using a pre-designed, semi-structured proforma, capturing demographic details, clinical history, examination findings, vital signs, laboratory investigations, and electrocardiographic data. Each patient underwent arterial blood gas analysis to measure blood lactate levels at admission (zero hours) and six hours after admission. Additional investigations performed included complete blood count, serum creatinine, serum electrolytes, and random blood sugar. Lactate levels were measured using cartridge-based blood gas analysis with the GEM Premier 3000 machine, which utilizes disposable reagent cartridges.

Patients were followed daily until discharge or death, with no interference in their ongoing management. Patient treatment continued according to established hospital protocols. The serial lactate levels were correlated with patient outcomes to determine their predictive value.

The primary outcome of the study was the association of initial and serial blood lactate levels with patient outcomes in hemodynamic instability. Secondary outcomes included the correlation between blood lactate levels and in-hospital mortality, length of hospital stay, and the association between the severity of elevated lactate and the degree of hemodynamic instability.

Data were entered in Microsoft Excel and analyzed using SPSS version 25. Quantitative variables were expressed as mean ± standard deviation (SD) or median ± interquartile range (IQR) depending on normality, while qualitative data were presented as percentages or proportions. Appropriate statistical tests were applied to determine associations, with a p-value of less than 0.05 considered statistically significant. Anonymity and confidentiality of data were ensured throughout.

The study protocol was approved by the Institutional Ethics Committee (IEC) of Dr. M.K. Shah Medical College & Research Centre, Ahmedabad. Written informed consent was obtained from all participants or their legal representatives. Patients were provided an information sheet clarifying that their participation was voluntary and that refusal would not affect their treatment. No financial incentives were provided for participation, and the study was not funded by any pharmaceutical company or institution.

Results

Table 1 shows the distribution of patients according to lactate levels at the time of admission. Among the total 50 patients, 32% had lactate levels below 2 mmol/L, while 34% each had lactate levels between 2-4 mmol/L and greater than 4 mmol/L. This indicates that a considerable proportion of patients presented with elevated lactate levels upon arrival to the emergency department.

Table 2 depicts the distribution of patients based on lactate levels measured at the sixth hour after admission. It was observed that 42% of patients achieved normal lactate levels (<1.6 mmol/L) by six hours, while 28% had persistently high lactate levels (>4 mmol/L). This reflects the trend in lactate clearance or persistence among the hemodynamically unstable patients over time.

Table 3 summarizes the descriptive statistics for vital parameters stratified by lactate levels at the time of admission. Patients with lactate levels >4 mmol/L had lower mean systolic and diastolic blood pressures, higher heart rate and respiratory rate, and lower oxygen saturation compared to those with lower lactate levels. The differences in systolic blood pressure, heart rate, respiratory rate, and SpO_2 were statistically significant, indicating that higher lactate levels were associated with worsening vital signs.

Table 4 presents the descriptive statistics for laboratory parameters according to lactate levels at admission. Patients with lactate levels >4 mmol/L showed higher total leukocyte count and serum creatinine levels, both statistically significant, suggesting an association between elevated lactate and markers of inflammation and renal dysfunction. Other parameters like hemoglobin, platelet count, sodium, potassium, and random blood glucose did not show significant differences across groups.

Table 5 compares patient outcomes (survival vs. mortality) based on lactate levels at admission. All patients with lactate <2 mmol/L survived, while mortality increased with rising lactate: 11.8% mortality in the 2-4 mmol/L group and 41.2% mortality in the >4 mmol/L group. This association was statistically significant, indicating that higher admission lactate levels were predictive of poorer outcomes.

Table 1: Distribution of Patients According to Lactate Levels at the Time of Admission

Lactate Level (mmol/L)	Frequency (n)	Percentage (%)
< 2 mmol/L	16	32%
2 – 4 mmol/L	17	34%
> 4 mmol/L	17	34%
Total	50	100%

Table 2: Distribution of Patients According to Lactate Levels at the Sixth Hour After Admission

Lactate Level (mmol/L)	Frequency (n)	Percentage (%)
< 1.6 mmol/L	21	42%
1.6 – 2 mmol/L	06	12%
2 – 4 mmol/L	09	18%
> 4 mmol/L	14	28%
Total	50	100%

Table 3: Descriptive Statistics for Vital Parameters Based on Lactate Levels at Admission

Parameter	< 2 mmol/L (Mean ± SD)	2–4 mmol/L (Mean ± SD)	> 4 mmol/L (Mean ± SD)	p-value
Systolic BP (mmHg)	83.25 ± 3.33	80.23 ± 5.28	77.88 ± 7.56	0.03*
Diastolic BP (mmHg)	61.62 ± 5.57	61.29 ± 5.10	58.35 ± 5.16	0.15
Heart Rate (bpm)	111.76 ± 5.45	118 ± 7.8	124.9 ± 9.8	0.002*
Respiratory Rate (bpm)	25.94 ± 1.06	27.47 ± 2.23	28.94 ± 2.38	0.001*
SpO$_2$ (%)	91.69 ± 1.14	89.12 ± 2.73	87.53 ± 5.10	0.004*

Statistically significant (p < 0.05)

Table 4: Descriptive Statistics for Laboratory Parameters Based on Lactate Levels

Parameter	< 2 mmol/L	2–4 mmol/L	> 4 mmol/L	p-value
Hemoglobin (gm/dL)	11.54	11.79	10.31	0.15
Total Leukocyte Count (/mm³)	13011.50	15080.23	16525.32	0.02*
Platelet Count (lakhs/mm³)	2.04	2.18	1.91	0.82
Random Blood Glucose (mg/dL)	111.31	112.94	112.35	0.98
Sodium (mEq/L)	137.44	134.88	135.53	0.26
Potassium (mmol/L)	4.24	4.32	4.57	0.25
Serum Creatinine (mg/dL)	1.17	1.82	2.31	0.003*

Statistically significant (p < 0.05)

Table 5: Comparison of Outcome According to Lactate Levels at Admission

Outcome	< 2 mmol/L n (%)	2–4 mmol/L n (%)	> 4 mmol/L n (%)	p-value
Survived	16 (100%)	15 (88.2%)	10 (58.8%)	0.006*
Died	0 (0%)	2 (11.8%)	7 (41.2%)	
Total	16	17	17	

Statistically significant (p < 0.05)

Discussion

This study evaluated the prognostic significance of initial and serial blood lactate levels in patients presenting to the emergency department with hemodynamic instability. Elevated lactate levels were observed in a significant proportion of patients on admission, with 34% having lactate between 2-4 mmol/L and another 34% exceeding 4 mmol/L. This finding aligns with previous research emphasizing the prevalence of hyperlactatemia in critically ill patients at presentation [11].

The relationship between lactate levels and patient outcomes was clearly demonstrated in our results. Mortality increased substantially with rising lactate, reaching 41.2% in patients with lactate >4 mmol/L at admission, compared to zero mortality in those with lactate <2 mmol/L. Similar trends have been reported, with high lactate at admission associated with poor prognosis and increased risk of death in critically ill populations [12]. The statistically significant correlation between high lactate and mortality in our study further supports lactate's role as a prognostic marker.

Serial lactate measurements showed that despite initial elevation, 42% of patients normalized lactate levels by the sixth hour, indicating lactate clearance in response to resuscitation. However, 28% continued to exhibit lactate >4 mmol/L at six hours, suggesting ongoing tissue hypoxia or inadequate perfusion. Persistent hyperlactatemia has been linked to poor outcomes in earlier studies, underscoring the prognostic value of lactate clearance beyond a single measurement [13].

Vital signs and laboratory parameters demonstrated worsening hemodynamic and metabolic status in patients with elevated lactate. Patients with >4 mmol/L had significantly lower systolic blood pressure, higher heart and respiratory rates, and lower oxygen saturation at admission. These findings are consistent with the physiological derangements expected in shock states leading to lactate accumulation [14]. Laboratory parameters like leukocytosis and elevated serum creatinine were also significantly associated with

higher lactate, reflecting inflammatory and renal dysfunction contributions to critical illness.

Interestingly, despite aggressive management, length of hospital stay was longer in patients with elevated lactate, and mortality remained high even with interventions, reinforcing lactate's value as an indicator of underlying disease severity. Lactate-guided resuscitation strategies have been proposed in literature to improve outcomes by targeting lactate normalization, yet real-world practice variability remains [15]. Our study supports the incorporation of serial lactate monitoring as a simple, rapid, and effective tool in emergency settings to stratify risk and guide clinical decisions.

Conclusion

This study highlights that elevated admission and persistent lactate levels are significantly associated with increased mortality and prolonged hospital stay in patients presenting with hemodynamic instability. Serial lactate monitoring provides valuable prognostic information, and its routine use in emergency care may enhance early risk stratification and guide resuscitation efforts to improve outcomes.

List of Abbreviations

ED: emergency departments

SD: Standard Deviation

IEC: Institutional Ethics Committee

spo2: Oxygen Saturation

Declarations

Ethics approval and consent to participate

Ethical clearance for this study was obtained from the Institutional Ethics Committee of Dr. M.K. Shah Medical College and Research

Centre, and Smt. S.M.S. Multispecialty Hospital, Chandkheda, Ahmedabad, Gujrat, India.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request. Due to privacy concerns, individual-level data are not publicly available.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Funding Statement

Authors' contributions

NKK: conceptualized the study, designed the methodology, supervised the research, and contributed significantly to manuscript writing. JCP: Coordinated data collection, managed the data, and assisted in statistical analysis. SC: Supported data interpretationand helped draft sections of the manuscript. CTS: conducted literature review and contributed to identifying barriers and discussing results. SJV: Helped refine the questionnaire and supported data handling.

Acknowledgments

Supplementary Materials

NIL

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