

Association of Admission Serum Lactate Levels with Disease Severity and In-Hospital Outcomes among Critically Ill Adult Patients: A Cross-Sectional Study

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ABSTRACT

Background: Serum lactate is an important marker of tissue hypoperfusion and metabolic stress in critically ill patients. Assessment of disease severity and prediction of poor outcomes in intensive care units (ICUs) remain major clinical challenges. This study evaluated the relationship between admission serum lactate levels, severity of illness, and hospital outcomes in critically ill adults.

Methods: This observational cross-sectional study was conducted in the ICU of a tertiary care hospital and included 120 adult patients. Admission serum lactate levels were recorded, and patients were categorized into three groups: <2 mmol/L, 2–4 mmol/L, and >4 mmol/L. Disease severity was assessed using APACHE II and SOFA scores. Clinical outcomes, including mechanical ventilation, vasopressor requirement, ICU and hospital stay, and in-hospital mortality were analyzed. Statistical analysis was performed to determine the association between lactate levels and study outcomes.

Results: Higher admission serum lactate levels were significantly associated with greater disease severity and poorer clinical outcomes. Patients with lactate >4 mmol/L had significantly higher APACHE II (27.6±6.2) and SOFA scores (12.4±3.1) compared to lower lactate groups (p<0.001). Requirement for mechanical ventilation and vasopressor support increased significantly with rising lactate levels (p<0.001). Mortality was highest in patients with lactate >4 mmol/L (63.2%), compared with 31.8% in the 2–4 mmol/L group and 13.2% in the <2 mmol/L group (p<0.001). Lactate levels showed a strong positive correlation with severity scores.

Conclusion: Admission serum lactate levels are one of the best markers to assess the disease severity and in-hospital patient outcomes in adult intensive care patients. Increased serum lactate has been proven to be a significant predictor of death or worsening of the patient's condition in the case of acute diseases. Besides, having information on lactate levels is beneficial to doctors in recognizing high-risk patients and making treatment decisions in the ICU.

Key-words: Serum lactate, Critical illness, Disease severity, APACHE II score, Intensive care unit, In-hospital mortality

INTRODUCTION

Lactate levels in blood serum have been among the main indicators of critical illness for decades. They show the balance between how much oxygen is delivered and the tissues' metabolic needs.

Extremely elevated lactate levels are generally indicative of tissue hypoxia, impaired cellular respiration, and the extent of the main disease processes.

Among these, the situations of sepsis and shock are the most typical examples. In ICUs monitoring closely those patients who will probably be at risk right from the start and carrying out the right interventions at that time, are the hallmarks of not only saving more lives but also achieving better results overall; and that's the reason why testing for lactate repeatedly is continually being regarded as an easy and very useful clinical method^[1].

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Many studies have demonstrated that having high lactate levels in the blood is a major indicator of poor clinical outcomes, including death, longer hospitalization, and the need for higher levels of organ-support therapies in patients admitted to the hospital. For instance, patients in shock with elevated lactate levels were shown to have significantly worse hospital outcomes, thereby validating the use of this biomarker for prognosis prediction [2]. Apart from lactate levels alone, other factors, such as lactate clearance, the lactate-to-albumin ratio, or their combination with well-known scoring systems like the Acute Physiology and Chronic Health Evaluation II (APACHE II) score, have been shown to predict mortality in critically ill patients more accurately [3,4]. Similarly, we have examined prognostic physiological markers and multi-parameter indices that represent the complex pathophysiology of life-threatening conditions [5].

Early warning scores, such as the National Early Warning Score (NEWS), play a role in emergency and critical care environments. They serve as indicators of the potential results of septic patients, very frequently in conjunction with biochemical markers like lactate [2]. However, recent discoveries are uncovering the value of other physiological and biochemical factors, such as glycemic variability, inflammatory cytokines, and ventilatory mechanics, as these factors guide prognostication, implying that the intensity of the disease is determined by the complex combination of the body's systemic responses [6-8]. Despite these advancements, serum lactate remains one of the most readily accessible and frequently employed biomarkers for the initial risk assessment.

Yet, admission lactate levels' ability to predict outcomes varies among different patient populations and clinical scenarios. Besides, how tightly connected initial lactate levels are to disease severity and hospital mortality in heterogeneous groups of critically ill adults is an area requiring further investigation.

Therefore, the primary focus of the study is to explore the correlation between the level of serum lactate at the time of admission and the severity of the disease. Besides, the study aims to evaluate their effectiveness in predicting the in-hospital outcomes of severely ill adult patients. Besides, it is hoped that the study of this relationship will result in more accurate risk assessment and clinical decision-making for ICU patients.

MATERIALS AND METHODS

Study Design and Setting- We conducted a cross-sectional observational study in a tertiary care hospital's ICU over 1 year. The main aim of this study was to determine whether serum lactate levels at the time of admission are indicative of disease severity and in-hospital outcomes among adult patients in critical condition. The intensive care unit is capable of caring for a wide variety of medical and surgical patients who require advanced monitoring and support of various body functions. We obtained institutional ethical clearance before the commencement of the study and adhered to established ethical norms throughout the study period.

Study Population- Any adult patient aged 18 or over who was admitted to the ICU at any time during the study period was eligible for enrollment. Aiming at minimizing selection bias, patients were recruited consecutively. Only patients with serum lactate levels measured within the first 6 hours of ICU admission were considered for the study. To ensure data accuracy, we excluded from the study patients with incomplete clinical information, those discharged or died before the initial assessment could be performed, and those with diseases that significantly alter lactate metabolism independently of critical illness.

Data Collection- Relevant demographic, clinical, and laboratory data were abstracted by using a standardized data collection sheet from hospital records. Baseline variables, such as age, sex, primary diagnosis, comorbidities, and vital signs at admission, were among the data collected. The major exposure variable was the serum lactate concentration at ICU admission. In addition, several other laboratory and clinical parameters typically associated with disease severity were recorded. The clinical scoring systems, which are the most common ones in critical care, were used in assessing the severity of the disease. The use of this method not only assisted in aligning the results with other similar studies that have determined prognostic factors in critically ill patients but also made it easier to perform the final evaluation of patients' conditions.

Assessment of Outcomes- Primary focus for outcomes was the level of illness at the time of hospital admission

and the hospital outcomes, including death, length of ICU stays, and requirement of organ support such as mechanical ventilation or vasopressor therapy, etc. During the hospital stay, patients were followed up till discharge or death. Disease severity was assessed using clinical parameters and scoring systems that facilitated comparison across severity levels.

Statistical Analysis- The data were entered into a statistical software package and analyzed using the most appropriate statistical methods. Continuous variables were presented as mean \pm standard deviation or median \pm interquartile range, depending on the data distribution, whereas categorical variables were presented as frequencies and percentages. Patients were divided into groups based on their admission serum lactate levels to determine whether there were differences in disease severity and outcomes. To compare the groups, appropriate statistical tests were used, and to examine the link between lactate levels and severity scores, correlation analyses were conducted. Multivariate analysis was used to control for potential confounders and identify independent predictors of in-hospital outcomes. If the p-value was less than 0.05, the result was considered statistically significant.

Ethical Considerations- Confidentiality of patient data was accorded the highest level of protection throughout the research period. Because it was a retrospective, non-interventional study based on clinical data routinely collected, informed consent was addressed in accordance with local regulations. Moreover, the study was conducted in accordance with the ethical standards set out in the Declaration of Helsinki for medical research involving human subjects.

RESULTS

Eventually, researchers focused on 120 adults who were in critical conditions and were admitted to ICU. The average age of the participants was 56.8 \pm 15.2 years, a majority of them were males (62.5%). At entry, most of the patients' main diagnoses were sepsis and septic shock. They were then followed by acute respiratory failure and various cardiovascular problems. Based on their admission serum lactate levels, the patients were categorized into three groups: low lactate (<2 mmol/L), intermediate lactate (2-4 mmol/L), and high lactate (>4 mmol/L). It has been revealed that disease severity and instances of leading to harmful clinical results were becoming more likely as lactate levels rose.

Table 1: Baseline Characteristics of Study Population According to Admission Serum Lactate Levels

Variables	<2 mmol/L (n=38)	2–4 mmol/L (n=44)	>4 mmol/L (n=38)	Total (n=120)
Age (years, mean \pm SD)	52.3 \pm 14.1	57.6 \pm 15.8	60.8 \pm 14.9	56.8 \pm 15.2
Male, n (%)	22 (57.9)	28 (63.6)	25 (65.8)	75 (62.5)
Sepsis/Septic shock, n (%)	14 (36.8)	22 (50.0)	27 (71.1)	63 (52.5)
Diabetes mellitus, n (%)	12 (31.6)	16 (36.4)	15 (39.5)	43 (35.8)
Hypertension, n (%)	15 (39.5)	19 (43.2)	18 (47.4)	52 (43.3)
Mean arterial pressure (mmHg)	78.5 \pm 10.2	72.4 \pm 11.6	66.2 \pm 12.1	72.4 \pm 12.0

Older patients who developed sepsis or septic shock had a markedly higher incidence of elevated lactate levels than the other patients. A progressively falling mean arterial pressure was associated with higher lactate levels, indicating a worsening hemodynamic status.

Illness severity scores were evidently related to lactate levels at admission. The high lactate patients showed a markedly elevated severity index compared to the lower lactate groups, which means they were more seriously ill at the time of arrival.

Table 2: Association of Admission Serum Lactate Levels with Disease Severity

Parameters	<2 mmol/L	2–4 mmol/L	>4 mmol/L	p-value
APACHE II Score (mean ± SD)	14.2 ± 4.5	20.3 ± 5.8	27.6 ± 6.2	<0.001
SOFA Score (mean ± SD)	5.8 ± 2.1	8.9 ± 2.7	12.4 ± 3.1	<0.001
Need for mechanical ventilation (%)	12 (31.6)	26 (59.1)	32 (84.2)	<0.001
Vasopressor requirement (%)	10 (26.3)	24 (54.5)	33 (86.8)	<0.001

There was a statistically significant rise in APACHE II and SOFA scores across lactate categories. Also, the requirement for mechanical ventilation and vasopressor went up as lactate levels increased. In-hospital results

showed stark differences among the groups. Those with high levels of lactate spent more time in the ICU and their mortality rates were significantly higher than those with lower levels of lactate.

Table 3: Association of Admission Serum Lactate Levels with In-Hospital Outcomes

Outcomes	<2 mmol/L	2–4 mmol/L	>4 mmol/L	p-value
ICU Length of stay (days)	4.2 ± 2.1	6.8 ± 3.4	9.5 ± 4.2	<0.001
Hospital Length of stay (days)	8.5 ± 3.6	12.3 ± 5.1	15.7 ± 6.8	<0.001
In-hospital mortality, n (%)	5 (13.2)	14 (31.8)	24 (63.2)	<0.001
Discharge rate, n (%)	33 (86.8)	30 (68.2)	14 (36.8)	<0.001

Fig. 1 shows the classification of critically ill patients into three groups based on admission serum lactate levels: <2 mmol/L, 2–4 mmol/L, and >4 mmol/L. Fig. 1

demonstrates the distribution pattern of study participants across different lactate categories.

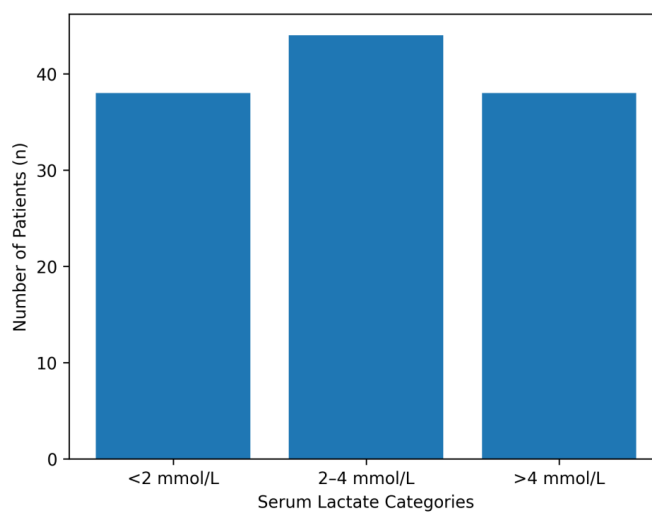


Fig. 1: Distribution of study participants according to serum lactate levels at admission.

Fig. 2 illustrates the relationship between increasing serum lactate levels and severity of illness scores. Higher lactate levels were associated with significantly elevated

APACHE II and SOFA scores, indicating greater disease severity among critically ill patients.

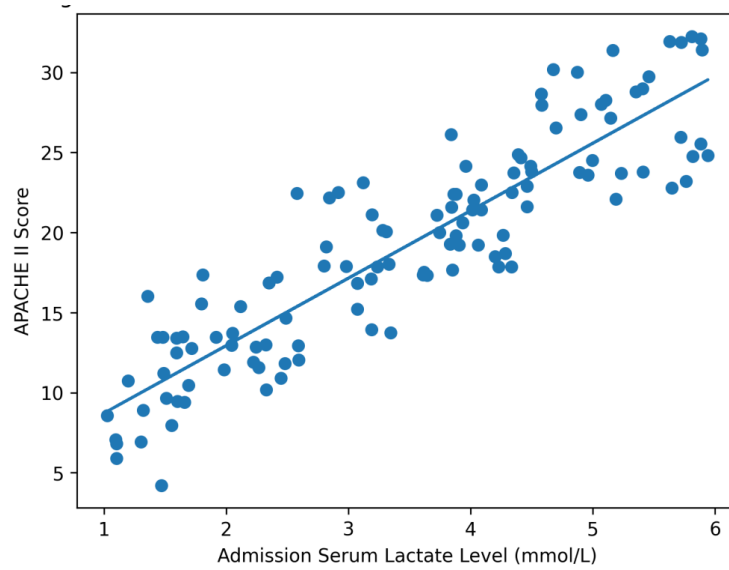


Fig. 2: Correlation of serum lactate levels with APACHE II and SOFA scores.

Fig. 3 depicts the comparison of in-hospital mortality among different serum lactate groups. Patients with serum lactate levels >4 mmol/L showed the highest

mortality rate compared to patients with lower lactate levels.

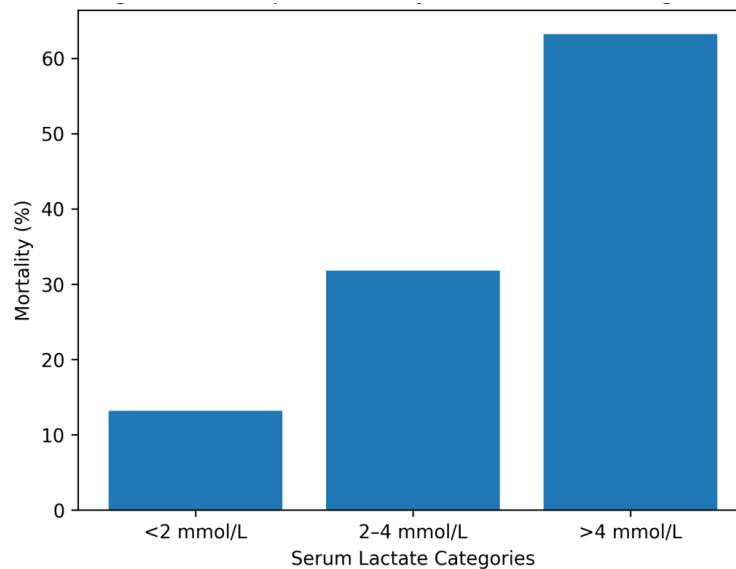


Fig. 3: Association of serum lactate levels with hospital mortality.

DISCUSSION

The research carried out reveals a very close and clinically important association of elevated serum lactate levels on admission with the severity of the disease and the hospital outcomes of critically ill adults. Those with the highest lactate levels were marked by significantly increased APACHE II and SOFA scores, greater needs for organ support, and much higher death rates. This evidence strongly highlights the role of lactate as a highly effective marker of early ischemia, incidentally reflecting the systemic upheaval in critical illness [9-11].

Lactate being linked to higher mortality is something that we have seen in many different studies previously. Several studies have actually used levels of lactate as a way to determine the risk of death in severely ill or septic patients. Moreover, a few studies also showed a strong positive link between the markers of disease severity and lactate levels at admission, which have furthermore been demonstrated to predict mortality independent of other risk factors [12-15]. The detection of a significant level of lactate might mean that the cells have run out of oxygen, that oxygen is being used inefficiently, or that cell

metabolism is under stress - all these can lead to organ failure and deterioration of the patient's condition. Besides, the progressive increase of death rate with elevated lactate levels observed from our study is in line with earlier reports that demonstrated an incremental rise in mortality risk with higher lactate levels ^[1,12].

Besides the fact that lactate by itself can predict prognosis, it has also been assessed in combination with other clinical and biochemical parameters to achieve better predictive results. It was demonstrated previously that adding lactate levels to scoring systems such as APACHE II or SOFA enhanced the risk stratification of the critically ill patients ^[3,12]. The very strong positive correlation that we have observed between lactate levels and severity scores in this study is yet another point of evidence supporting the fact that lactate is a marker representative of the overall physiological stress. In the same way, parameters that vary over time, e.g. lactate clearance, might disclose even more prognostic information as they demonstrate how effective resuscitative efforts have been and how successfully tissue perfusion has been restored ^[4,15].

Moreover, the findings of this investigation align with the emphasis of hypoperfusion in septic shock treatment effectiveness as the major contributor to various studies. Actually, hypoperfusion usually indicated by an elevation in lactate, has been considered as one of the main determinants of short-term mortality, thus it is further stressed the requirement for early recognition and treatment of these patients ^[9]. Furthermore, it has been established that low oxygen content to body tissues of severely ill patients contributes to the generation of a sequence of inflammatory and metabolic alterations, besides worsening the progression of organ dysfunction. What is more, it is supported by the unveiling of novel biomarkers such as S100A9 and inflammatory mediators that describe the complex connection of metabolic stress with immune dysregulation in sepsis ^[13].

Also, the greater requirement for mechanical ventilation and vasopressor support that we observed in patients who had higher lactate levels in our study aligns with the initial observations that made us see a connection between severe metabolic disorders and organ failures along with long ICU stay. A few very important things associated with longer duration of mechanical ventilation especially in sepsis cases include severity of the illness and metabolic instability, both of which lead

indirectly to raised lactate levels ^[10]. This demonstrates the value of lactate not only as a prognostic biomarker but also as an indicator of resource utilization and clinical trajectory in the ICU.

Recently, research has turned to using predictive modeling and risk stratification by combining laboratory and clinical parameters. Nomogram-based techniques that integrate biomarkers and routine clinical data have been extremely effective in forecasting short-term death in patients with septic shock ^[11,14]. While these models enable more accurate individual risk prediction, the benefits of measuring serum lactate, such as its simplicity, rapid availability, and cost-effectiveness rendering it a necessary instrument in daily clinical practice, particularly in resource-limited settings.

However, the data from this research should be interpreted as a guideline while keeping in mind some limitations. The fact that it was a cross-sectional observational study carried out at a single center is one of the limitations; therefore, the findings may not be representative of all patients or healthcare settings. Furthermore, only the lactate levels measured at admission were considered, whereas serial measurements or lactate clearance, which could have provided more valuable prognostic information, were not taken into account. Besides, there could have been other factors influencing lactate levels, for example, pre-existing metabolic disorders or different resuscitation techniques, which we would not have been able to fully adjust for.

In a nutshell, our findings add to the compelling data that a significantly raised serum lactate level on the initial hospital admission is associated with greatly increased disease severity and poorer hospital outcomes in severely ill adults. Lactate remains a gem among biomarkers: besides being inexpensive and readily available, it is also very reliable for early identification of high risk and making clinical decisions. Incorporating lactate testing as a part of the routine examination will certainly help in the quicker identification of patients who are at a serious risk of deterioration and in the precise administration of the targeted therapy that is most likely to improve the patient's condition.

CONCLUSIONS

To conclude, the data derived from this study demonstrate that serum lactate concentrations at initial

presentation are fundamental to determining the severity of the illness and the therapy effectiveness in the adult critically ill population. High lactate levels at the time of admission reflected the sickest patients through the use of different scoring systems, increased need for organ support, longer hospitalization, and a significantly higher mortality rate. The progressive rise in the proportion of adverse outcomes with increasing lactate levels further highlights the significance of lactate as a prompt and trustworthy marker of physiological disturbance. Since serum lactate is widely accessible, can be measured rapidly, and is relatively inexpensive, it can serve as a very useful and practical tool for early risk assessment of critically ill patients. Besides, its integration with well-established clinical scoring systems may even enhance the prediction of prognosis and aid physicians in identifying high-risk patients in need of immediate and intensive therapy. Overall, determining the lactate level at the time of admission is extremely beneficial in the decision-making process and in changing the patient's therapeutic outcomes in the ICU. Further studies utilizing serial lactate levels and multicenter data are required to validate and extend these findings.

CONTRIBUTION OF AUTHORS

Research concept- Neethu M, Arundas H

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Supervision- Arundas H

Materials- Neethu M, Arundas H

Data collection- Neethu M, Arundas H

Data analysis and interpretation- Arundas H

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Critical review- Arundas H

Article editing- Neethu M, Arundas H

Final approval- Arundas H

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