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Prognostic Value of Lactate Levels in Trauma Patients' Outcomes in Emergency Department

Sayyed Majid Sadrzadeh[1], Vahid Talebzadeh[2], Seyed Mohammad Mousavi[1], Behrang Rezvani Kakhki[1], Elnaz Vafadar Moradi[1], Hamideh Feiz Disfani[1]*

[1]*Department of Emergency Medicine, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran*
[2]*Department of Emergency Medicine, School of Medicine, Gonabad University of Medical Sciences, Gonabad, Iran*

*Corresponding author: Hamideh Feiz Disfani
Address: Department of Emergency Medicine, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran. **Tel:** +98 9155183548;
e-mail: feyzh@mums.ac.ir

ABSTRACT

Objectives: This study aimed to investigate the prognostic role of lactate clearance in predicting outcomes among trauma patients admitted to the emergency department.
Methods: This retrospective cohort study was conducted on patients referred to the Emergency Department. Serum lactate levels were measured at admission and 2 hours later. The patients were followed up for 72 hours to assess outcomes, including discharge, hospitalization in other wards, and mortality.
Results: The results showed a significant difference between the mean age, Glasgow Coma Scale (GCS), systolic blood pressure (SBP), pulse rate (PR), and oxygen saturation (O_2 Sat) of the trauma patients in relation to mortality prognosis ($p<0.05$). Additionally, significant differences were found in primary lactate, lactate levels two hours post-admission, and lactate clearance levels based on the patient's prognosis ($p<0.01$). Multivariate logistic regression analysis revealed that lactate clearance was associated with a reduced mortality rate among trauma patients (OR=0.907, $p<0.05$).
Conclusion: The findings of this study showed that lactate clearance, as an independent predictive factor, was associated with poorer prognosis and increased mortality rates in trauma patients.

Keywords: Lactate, Trauma, Lactate clearance, Mortality, Emergency Department.

Introduction

Trauma is defined as any injury or damage caused by physical or chemical agents affecting body tissues [1]. Such injuries can lead to severe in major organs, including the skull, chest, abdomen, pelvis, and upper and lower extremities. Trauma is considered a significant public health challenge, impacting societies regardless of their health, economic, or social status [2].

Individuals under 40 years of age are the most frequently affected group, exhibiting both a high incidence of and associated mortality rates. Trauma is also one of the leading causes of disability, in developing and less-developed countries [3, 4]. Despite advancements in intensive care, trauma

remains a major cause of death worldwide [5]. Consequently, the use of a reliable and accurate system to assess the severity of injury and classify trauma patients plays a critical role in predicting patient outcomes [6, 7]. However, most of these systems have limitations in accurately predicting and estimating the prognosis of trauma patients [5].

In recent years, several factors have been investigated to determine the prognosis of trauma patients [8]. One such factor is serum lactate, which has been increasingly associated with adverse outcomes, including higher mortality rates and prolonged stay in the intensive care unit (ICU) [9, 10]. The serum lactate level serves as a sensitive and reliable indicator in conditions such as sepsis, trauma, various types of shocks, and burns, often correlating with increased mortality and morbidity. Notably, even in patients with normal vital signs, lactate levels can help differentiate between minor and major injuries [11].

A serum lactate level higher than 2 mmol/L is generally considered a reliable marker of tissue hypoperfusion and can be significant in patients with acute and critical conditions who are at risk of shock for any reason [12]. Furthermore, studies on trauma patients demonstrated that lactate clearance, the reduction in lactate levels over time, could serve as a prognostic factor associated with mortality rates and the length of hospital stay [13, 14]. However, due to limited evidence in this field, particularly in eastern Iran, the present study was conducted to investigate the prognostic role of lactate in predicting outcomes among trauma patients admitted to the Emergency Department.

Materials and Methods

This retrospective cohort study was conducted after obtaining approval from the Ethics Committee of Mashhad University of Medical Sciences (Approval Code: IR.MUMS.fm.REC.1396.90; Date: 25/8/2018). The study included patients who were referred to the Emergency Department of Imam Reza Hospital with high-energy traumas between 2016 and 2018. All trauma patients (involving trauma to the head, face, thorax, abdomen, or other organs) aged 18 years or older were included in the study. On the other hand, patients with underlying conditions such as diabetes, kidney disease, liver disease, malignancy, acquired immunodeficiency syndrome(AIDS), severe anemia, severe asthma, hypoglycemia, and shock were excluded. Additionally, patients with a history of alcohol or cocaine use, or carbon monoxide (CO) poisoning, or those who had received partial treatment at other hospitals or clinics before referral were excluded.

The demographic and clinical data of the trauma patients was collected and recorded using standardized checklists at admission and two hours post-admission. The patient's clinical information,

including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse rate (PR), oxygen saturation (O2 Sat), Glasgow Coma Scale (GCS) score, and respiratory rate (RR), was documented in the study checklists. Blood samples were collected at admission and two hours later to measure the lactate levels. Lactate clearance levels were calculated using the following formula: *Equation (1)*:

$$\text{Lactate Clearance} = \frac{\text{primary Lactate} - \text{secondary Lactate}}{\text{primary Lactate}} * 100$$

The patients were followed up for 72 hours to assess outcomes, including admission to general wards, admission to the intensive care unit (ICU), or death.

Statistical Analysis

Descriptive statistics were used to summarize the data. The Fisher exact test was employed to examine differences in the frequency distribution of qualitative variables, while the Kruskal-Wallis test was used to assess the difference in mean values of quantitative variables. To investigate the prognostic role of lactate clearance in trauma patients, univariate and multivariate logistic regression analyses were conducted. Thus, the variables with a significance level of $p < 0.2$ in the univariate model were included in the final multivariate model. The area under the receiver operating characteristic (ROC) curve was used to investigate the fit of the model. All statistical analyses were performed using the Stata software (version 12, Corp, College Station, Texas). A significance level of $p < 0.05$ was considered statistically significant.

Results

In this study, 270 trauma patients with a mean age of 40.96±14.86 years were examined, of whom 59.26% (n=160) were men. Among these patients, 11 died within 72 hours of admission to the emergency department. The results showed significant differences in the mean age ($p=0.01$), GCS ($p=0.001$), SBP ($p=0.002$), PR ($p=0.039$), and O$_2$ Sat ($p=0.001$) between patients who survived and those who died (Table 1). However, no significant relationship was observed between the mechanism of trauma and mortality prognosis ($p=0.92$).

The initial serum lactate levels were 3.08 mmol/L and 6.16 mmol/L, for survivors and non-survivors, respectively, showing a statistically significant difference ($p < 0.01$). In addition, the lactate levels measured two hours post-admission were 2.69 mmol/L and 8.12 mmol/L, for survivors and non-survivors, respectively, which also demonstrated a significant difference ($p < 0.01$; Table 1).

The lactate clearance levels of the survived and dead trauma patients were 14.21% and -31.90%, respectively, indicating a significant difference in relation to mortality prognosis ($p < 0.01$).

Table 1. Clinical and basic characteristics of the patients studied

Groups	Total (n=270)	Survivors (n=259)	None-Survivors (n=11)	*p* value
Age (year)	40.96±14.86	40.48±14.51	52.18±19.18	0.01
Sex (%)				
Male	160 (59.26%)	152 (58.69%)	8 (72.73%)	0.53
Female	110 (40.74%)	107 (41.31%)	3 (27.27%)	
GCS score	13.50±2.27	13.76±1.93	7.45±0.82	0.001
SBP (mmHg)	124.98±13.02	125.50±13.01	112.72±4.42	0.002
DBP (mmHg)	76.03±8.71	76.18±8.70	72.36±8.47	0.15
PR (n)	79.92±6.30	80.08±6.27	76.09±6.17	0.03
RR (n)	16.25±4.11	16.30±4.15	15.09±2.62	0.33
O_2 Sat (%)	96.01±5.56	96.32±5.46	88.90±2.11	0.001
Lactate 0 hr (mmol/L)*	3.21±1.26	3.08±1.12	6.16±0.81	0.001
Lactate 2 hr (mmol/L)**	2.91±1.71	2.69±1.33	8.12±1.42	0.001
Mechanism of Trauma				
Motorcycle crash	83 (30.74%)	79 (30.51%)	4 (36.36%)	0.92
Pedestrian crash	114 (42.22%)	110 (42.47%)	4 (36.36%)	
Car crashes, etc.	73 (27.04%)	70 (27.02%)	3 (27.28%)	
Lactate Clearance %	12.33±17.97	14.21±15.30	-31.90±19.95	0.001

SBP: Systolic blood pressure; DBP: Diastolic blood pressure; PR: Pulse rate; RR: Respiratory rate; O_2 Sat: O_2 saturated; GCS: Glasgow Coma Scale; [a]Lactate at the beginning of the study; [b]Lactate at the 2 hours.

The lactate clearance levels also varied significantly based on the hospitalization status (*p*<0.01). Specifically, patients admitted to the general ward and the intensive care unit (ICU) had lactate clearance levels of -17.24% and -16.88% respectively. In other words, patients admitted to the ICU and those who died had lower lactate clearance levels (Fig. 1).

The results of the univariate logistic regression (Table 2) showed that there was a significant relationship between the mortality prognosis and lactate clearance levels, GCS score, SBP, and age. An increase in the lactate clearance level in trauma patients was associated with a decrease in their mortality rates (OR=0.846, *p*<0.01). Similarly, higher GCS scores and SBP were associated with lower mortality rates (*p*<0.01). The multivariate logistic regression analysis, after controlling for confounding factors, confirmed that the lactate clearance levels were independently associated with a decrease in the mortality rates among trauma patients (OR=0.907, *p*<0.05; Table 2).

Discussion

The results of this study showed that lactate clearance served as an independent prognostic factor in trauma patients. A reduction in lactate clearance was associated with unfavorable prognosis, such as an increased probability of ICU admission and mortality.
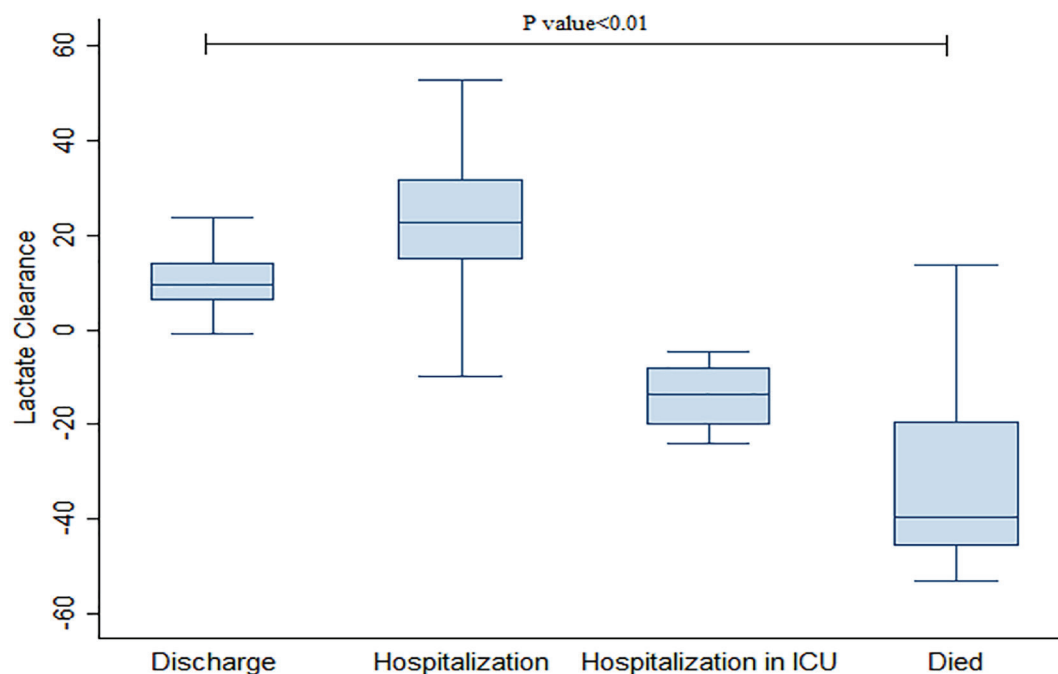
Fig. 1. Prognosis of lactate clearance in trauma patients

Table 2. Univariate and Multivariate logistic regressions between the death prognosis of trauma patients and the studied variables

Variable	Univariate Analysis			Multivariate Analysis		
	Odds Ratio	95% Confidence Interval	*p* value	Odds Ratio	95% Confidence Interval	*p* value
Age	1.046	1.008-1.085	0.015	1.001	0.950-1.055	0.95
Sex (Female)	0.532	0.138-2.05	0.360	-	-	-
GCS score	0.366	0.215-0.624	0.001	0.487	0.221-1.074	0.07
SBP	0.896	0.837-0.959	0.002	0.982	0.881-1.096	0.75
Mechanism of Trauma						
Pedestrian crash	0.718	0.174-2.95	0.647	-	-	-
Car crashes, etc.	0.846	0.183-3.91	0.831	-	-	-
Lactate Clearance	0.886	0.845-0.929	0.001	0.907	0.840-0.980	0.01

SBP: Systolic blood pressure; GCS: Glasgow Coma Scale

These findings suggested that the use of lactate clearance as an independent and effective prognostic factor by clinicians could significantly improve the management and outcomes of trauma patients.

Evidence from experimental studies supported the role of lactate as a prognostic biomarker in trauma patients, even in those with normal vital signs [15, 16]. This aligned with the findings of other recent studies [17, 18]. In different types of shocks, elevated serum lactate levels result from increased lactic acidosis with no significant changes in the lactate clearance process [13, 19]. However, initial serum lactate levels might not accurately predict outcomes in trauma patients with conditions such as alcohol poisoning, and drug abuse who have such conditions [20].

The measurement of serum lactate within two hours of hospitalization is critical, as initial lactate levels alone can predict mortality prognosis [13]. This was consistent with the findings of the present study, which highlighted the importance of lactate clearance within two hours of admission in predicting final outcomes and treatment success. In the case of sepsis, lactate clearance is typically assessed over 2 to 24 hours, reflecting the progression of the disease. However, in trauma patients, the rapid deterioration of their condition and the urgent need for interventions, such as bleeding control, necessitate faster prognostic indicators. Given that trauma-related mortality is the highest within the first 24 hours, reliable and accurate parameters are essential for determining the patient's prognosis. The results of this study strongly supported the prognostic role of lactate clearance in predicting ICU admission and mortality in trauma patients.

The findings indicated that a lactate level of >4 mmol/L was a suitable criterion for assessing trauma patient prognosis. This finding was consistent with other studies showing that patients with elevated lactate levels were at a higher risk of mortality compared to those with normal levels [11, 21]. Similarly, Okello *et al.,* [22] suggested that higher levels of blood lactate in trauma patients indicated the possibility of more severe injuries [16]. Kong *et al.,* [23] also showed that elevated lactate levels could serve as a useful prognostic factor in the ICU for identifying patients with poor outcomes. John

et al., [24] reported that prehospital lactate levels were predictive of the need for resuscitative care in trauma patients with normal blood pressure. Additionally, Davis *et al.,* [25] found that high lactate levels and negative base deficit were positively correlated with mortality and transfusion requirements, which was in line with the findings of the present study regarding the prognostic role of lactate clearance in trauma-related mortality. In this study, lactate clearance levels varied significantly among trauma patients, with markedly lower levels observed in those who died compared to survivors. This underscored the utility of lactate clearance as a prognostic marker.

Trauma remains a leading cause of loss of effective life in human populations. According to available statistics, trauma was the second cause of death in Iran in 2005, regardless of sex, and the leading cause of death among young individuals [26]. Therefore, identifying reliable prognostic factors for trauma patients is of paramount importance. The results of this study suggested that measuring lactate levels and lactate clearance at admission and 2 hours post-admission could effectively predict outcomes, including mortality and ICU admission. Early identification of these factors and prompt intervention might help reduce mortality and morbidity in trauma patients.

Although this study was conducted at a single center and was retrospective in design, the sample size of 270 patients was adequate. However, including data from multiple medical centers that treat trauma patients could enhance the generalizability of the findings. Additionally, comparing different prognostic criteria in trauma patients could provide further insights into the field.

In conclusion, the results of this study demonstrated that the initial and 2-hour-later lactate levels of trauma patients were associated with the prognosis of their death. Furthermore, changes in lactate clearance levels were independently associated with their poorer prognoses and increased mortality rates. Given the ease and cost-effectiveness of measuring serum lactate levels, this biomarker could serve as a valuable tool for predicting mortality in trauma patients, enabling faster therapeutic interventions.

Declaration

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