Original Article

Vehicle-induced Multiple Trauma: Serum Lactate Level and Prognosis

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Abstract

Background and Objectives: Early assessment of the severity and prognosis of multiple trauma injuries is crucial for the improvement of prognosis. Therefore, defining the parameters related to mortality and severity of multiple trauma injuries needs to be considered. The current study aims to investigate the serum lactate level and prognosis of these patients. **Materials and Methods:** This is a cross-sectional study conducted on 150 motor-vehicle-induced multiple trauma patients who were admitted to the Babol Trauma Center for 15 months. The serum lactate level was measured at the time of admission, 24 h, and 72 h after admission. The outcome of the patients was evaluated as death, hospitalization, or discharge. **Results:** Overall, 150 motor vehicle-induced trauma patients were enrolled in the study. Hyperlactatemia was seen in 33 (22%) patients in 24 h and 78 (52%) patients in 72 h after admission ($P < 0.001$). There was a clinically significant correlation between lactate level at the time of admission and the outcome of the patients (5.22 ± 3.41 expired, 2.69 ± 1.67 hospitalized, and 1.83 ± 1.09 discharged, $P < 0.00$). There was a clinically significant correlation between the serum lactate level at 24 h after admission and the outcome of the patients (6.81 ± 3.51 expired, 1.35 ± 0.79 hospitalized, and 0.83 ± 0.23 discharged, $P < 0.001$). There was also a clinically significant correlation between the outcome of the patients (discharge or hospitalization, or death) and the serum lactate level at the time of the admission and 24 h after the admission ($P = 0.035$). **Conclusions:** The baseline lactate, the lactate level at 24 h after admission, and the difference between these two can be used as a prognostic factor in the evaluation of multiple trauma patients. It is suggested to check the difference between the serum lactate level at the time of admission and 24 h later in trauma centers.

Keywords: Iran, lactic acid, Multiple trauma, prognosis

Introduction

According to the World Health Organization, road traffic accidents, suicides, and homicides are the three-leading causes of injuries and deaths.[1] Trauma is one of the leading causes of mortality worldwide.[2] In accordance with the report of the Institute for Health Metrics and Evaluation, multiple trauma could cause acute disability in about fifty million people each year in the world. However, the rate of mortality in developed countries is reported <10%. Somehow, more than 90% of them would happen in less-developed countries. Epidemiological studies on multiple trauma have shown that the combination of multiple injuries aggravates the outcome even more.[3]

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Evaluating multiple trauma patients is challenging. As multiple trauma could significantly increase mortality, all patients who have multiple trauma need a systematized evaluation and treatment. Proper patient care needs impressive and organized transmission and specialized medical group work. When the body has severe trauma, it loses a lot of blood and reduces the circulating blood volume, which leads to absolutely insufficient hemoglobin content and hypoxia of tissue cells. The plasma lactate content increases at this time. Due to this issue, lactate can be used as an important prognostic parameter for patients with multiple trauma.[3] Early assessment of the severity and prognosis of multiple injuries is crucial for treatment and improving the prognosis. Hence, defining the parameters related to mortality and severity of multiple trauma should be considered.[4]

Since few studies have examined the lactate level and its relation to time after admission.[5-8] There is a lack of information that necessarily needs to clarify the ambiguities with new research. Due to the importance of the trauma issue and limited studies, this study was conducted. This study aims at determining the lactate levels of multiple trauma patients who were admitted to the emergency department and assessing the relationship with the severity of these injuries.

Materials and Methods

This cross-sectional study was conducted on 150 motor-vehicle-induced multiple trauma patients who were admitted to the Babol Trauma Center (Shahid Beheshti Hospital) affiliated with the Babol University of Medical Sciences, North of Iran. All patients that were referred to this center from March 21, 2018 to June 21, 2019 for 15 months were enrolled. Inclusion criteria were individuals (age range, 15-70 years) with trauma in the scalp, chest, abdominal, and hip who were admitted to Shahid Beheshti Hospital. Patients should not have a history of cancer in the past 6 months, no liver, renal or heart failure, no severe systemic disease which can cause disability, no adrenal dysfunction, no history of diabetes or Chronic obstructive pulmonary disease, no diuretics use, lack of the previous history of arrhythmia and any electrolyte disturbance at the admission time or length of hospitalization and absence of immunodeficiency disease and AIDS that taking medication. Exclusion criteria were not willing to participate in the study or not filling out the informed consent form.

We examined the outcome of mortality, hospitalization, and discharge of patients 72 h after admission with lactate at baseline according to their gender. We had previously divided the lactate levels into two groups (normal lactate = 2.3) and hyperlactatemia (lactate > 2.4) and then examined the outcome of each group separately by sex. First, the vital signs of each patient (heart rate [HR], respiratory rate, blood pressure, and temperature) were measured. A rapid reassessment after the primary assessment was performed to evaluate the patient's response to resuscitation efforts and to identify any respiratory failure. The severity of trauma was assessed by Kampala Trauma Score (KTS). According to this scale, the higher trauma score shows a better prognosis, and the lower score shows a poor prognosis. All other necessary therapeutic measures were performed, and the serum lactate level was re-evaluated 24 h after admission. Finally, 72 h after admission, the outcome of patients, such as death, hospitalization, or discharge, was evaluated.

Considering the 2-unit increase in serum lactate level in patients with poor prognosis in comparison to hospitalized patients with 95% confidential Interval and power of 80% patients, the sample size was determined to be 150 individuals (two groups of 75) according to other studies and statistics consult.[8-10] At the admission time, motor-vehicle-induced multiple trauma patients were recruited to the emergency department after intravenous line and before serum therapy in conditions with a 2-cc syringe of 0.5 cc blood samples were taken from the patients. Serum lactate levels were measured after a few seconds. The device used to measure serum lactate levels was the US-based GEM premier 3000 device. The data were obtained from the Patient Record and the Laboratory Department of Shahid Beheshti Hospital under the supervision of the laboratory science team.

Statistical analysis

The obtained data were entered into SPSS version 23 for Windows (SPSS, Chicago, IL, USA) and STATA (version 14, IC; Stata Corporation, College Station, TX, USA). The Kolmogorov–Smirnov test was used to ensure that the distribution of samples was normal. The results of the study were expressed as mean (M) and standard deviation and $P < 0.05$ was considered significant. Data were analyzed by Chi-Square and *t*-test. Serum lactate levels were classified in to the normal range (under 2/3) and hyperlactatemia (upper 2/4). In this study, a primary lactate means lactate at admission, and a secondary lactate means lactate 24 h after admission. Patient's outcome was reported based on the patient's status at 72 h after admission, which was divided into three categories (discharge, hospitalization, and death patients).

Ethical considerations

This study was approved by the Ethics Committee of Babol University of Medical Sciences) IR.MUBABOL.HRI.REC.1398.006). The purpose of the current study was explained to each patient or his/her companion, and informed consent was obtained. Patients' information was kept confidential by the Helsinki legal agreement, data were not provided to the real or legal person, and no additional costs were imposed on the patient.

Results

In the current study, after inclusion and exclusion criteria, 150 induced-motor vehicle trauma patients were enrolled. The outcome of these patients (after 72 h of admission) was 96 cases (64%) hospitalized, 24 (16%) cases discharged, and 30 (20%) cases expired. Moreover, 80 (53.3%) cases had trauma scores between 7 and 10, 70 (46.7%) cases had trauma scores between 3 and 7 and no cases with trauma scores between 0 and 3. There was a significant difference between the trauma score and outcome ($P < 0.001$). In trauma patients with trauma scores between 3 and 7, 43 (61.4%) cases remained hospitalized 72 h after admission and 27 (38.5%) patients expired. None of the patients with these trauma scores were discharged. All discharged patients had a trauma score higher than 7. According to the level of consciousness, most patients (74 patients [49.3%]) had Glasgow Coma Scale (GCS) between 13 and 15. There was a significant difference between the patients' level of consciousness and the patients' outcome ($P < 0.001$). In patients with GCS 3 and 8, 31 patients (54.3%) remained hospitalized 72 h after admission and 26 patients (45.6%) unfortunately expired with this level of consciousness. Furthermore, none of these patients with level 3 and 8 consciousness were discharged within 72 h of presentation [Table 1].

The minimum respiratory rate per minute was 10 and the maximum was 40. The mean respiratory rate per minute in patients was 17.97 ± 4.5. The mean respiratory rates in the expired patient was 17.27 ± 6.19, in hospitalized patients was 18.08 ± 4.37 and in discharged patients was18.38 ± 1.68. According to statistical tests, there was a significant difference between the mean respiratory rates per minute in patients with discharge, death, and hospitalization ($P < 0.05$).

According to Table 2, the minimum oxygen saturation was 50% and the maximum was 100%. The mean oxygen saturation was 93.18 ± 7.6. The mean oxygen saturation percentage was 85.77% in expired patients, 94.39% in hospitalized patients and 97.63% in discharged patients. There was a significant difference between the mean percentage of oxygen saturation with the outcome of these patients ($P < 0.001$). In our study population, there were 72 (48%) patients in the normal lactate interval and 78 (52%) patients in the hyperlactatemia interval. Twenty-four hours after lactate screening, 117 (78%) patients had normal lactate levels and 33 (22%) had high lactate levels at 24 h follow-up. Most of the cases, 78 (52%), were hyperlactatemia. Among the discharged patients, 20 (41%) cases were normal lactate. None of the patients with hyperlactatemia were discharged 24 h after admission. According to statistical tests, there was a significant difference between the serum lactate level at baseline and discharge and hospitalization results ($P < 0.001$). One hundred seventeen cases had normal lactate after 24 h, and fewer were in the hyperlactatemia group (33 cases). Most of the expired patients were hyperlactatemia. On the other hand, in the hospitalized and discharged patients, most had a normal lactate level. There was a significant difference between the serum lactate level at admission and patients' outcome ($P < 0.05$).

There was a significant difference between the level of serum lactate 24 h after admission and the outcome of patients ($P < 0.001$). The highest and the lowest serum lactate levels were seen in the expired and discharged patients, respectively. The difference between the admission lactate level and the patients' outcome was statistically significant

Table 1: The difference of charactristics and lactate serum levels with the outcome of multiple trauma patients

Variable	Category, *n* (%)	Discharge, *n* (%)	Hospitalized, *n* (%)	Expired, *n* (%)	Total, *n* (%)	*P*
Gender	Male	17 (15.7)	72 (66.6)	19 (17.5)	108 (100)	0.45
	Female	7 (16.6)	24 (57.1)	11 (26.9)	42 (100)	
Age	15–30	12 (17.4)	47 (68.1)	10 (14.5)	69 (100)	0.26
	30–50	5 (9.8)	32 (62.7)	14 (27.4)	51 (100)	
	50–70	7 (23.3)	17 (56.7)	6 (20)	30 (100)	
KTS	0–3	0	0	0	0	<0.001
	3–7	0	43 (61.4)	27 (38.5)	70 (100)	
	7–10	24 (30)	53 (66.2)	3 (3.7)	80 (100)	
Glasgow coma scale	Mild	22 (29.7)	48 (64.8)	4 (5.4)	74 (100)	<0.001
	Moderate	2 (10.5)	17 (89.4)	0	19 (100)	
	Severe	0	31 (54.3)	26 (45.6)	57 (100)	
Lactate serum level admission	Normal	20 (27.8)	46 (63.9)	6 (8.3)	72 (100)	<0.001
	Increased	4 (5.1)	50 (64.1)	24 (30.8)	78 (100)	
Lactate serum level 24 h	Normal	24 (20.5)	90 (76.9)	3 (2.6)	117 (100)	<0.001
	Increased	0	6 (18.2)	27 (81.8)	33 (100)	
Lactate serum level admission (male)	Normal	14 (25.5)	37 (67.3)	4 (7.3)	55 (100)	<0.001
	Increased	3 (5.7)	35 (66)	15 (28.3)	53 (100)	
Lactate serum level admission (female)	Normal	6 (35.3)	9 (52.9)	2 (11.8)	17 (100)	0.01
	Increased	1 (4)	15 (60)	9 (36)	25 (100)	
Lactate serum level 24 h (male)	Normal	17 (19.5)	67 (77)	17 (19.5)	87 (100)	<0.001
	Increased	0	5 (23.8)	16 (76.2)	21 (100)	
Lactate serum level 24 h (female)	Normal	7 (23.3)	23 (76.7)	0 (0)	17 (100)	<0.001
	Increased	0	1 (8.3)	11 (91.7)	12 (100)	

KTS: Kampala Trauma Score

($P < 0.001$). In addition, there was a significant difference between the 24-h after admission lactate and the outcome of patients ($P < 0.001$).

According to statistical tests, there was a significant difference between the serum lactate level at baseline and 24 h after admission with discharge, hospitalization or death ($P = 0.035$).

The difference between vital signs in the two groups (normal and hyperlactatemia) was not statistically significant ($P > 0.05$) except O2 saturation, which was statistically significant (95.18 ± 5.68 normal lactate vs. 91.33 ± 8.64 increased lactate, $P < 0.001$) [Table 3].

The receiver operating characteristic curve was conducted, and the patient's outcome was divided into two modes of death and survival. Based on statistical analysis results, if the serum lactate level at the admission was ≥2.35 mmol/L, this prognostic parameter has a sensitivity of 80%, specificity of 55%, and accuracy of 0.79 [Figure 1]. Furthermore, the serum lactate level 24 h after admission was ≥2.7 mmol/l; this prognostic parameter has a sensitivity of 90%, specificity of 96.7%, and accuracy of 0.96 for death outcome [Figure 2].

Discussion

The main findings of our study show that there is a significant difference between the mean serum lactate level at admission, lactate 24 h after the admission, and the outcome of these patients. Furthermore, this finding is associated with gender differences.

The first and foremost impression from our study is that by measuring lactate levels at admission and 24 h later, we can greatly predict the probability of patients dying within 72 h. Hence, by measuring lactate, we will be able to get an overall assessment of the clinical condition of patients and possibly their course. Since, in many cases, the patient's clinical condition is not rapidly assessable and serum lactate measurement is rapid and easy to perform, serum lactate levels upon arrival at the emergency room can serve as a warning of damage to one of the organs.

In Husain *et al*.'s study, baseline and 24-h lactate levels were significantly higher in patients who died than in patients who recovered.[10] There was a significant difference between baseline serum lactate levels and 24 h after with patient mortality. That was similar to the current study; in our study, 30.8% of patients with high lactate levels died

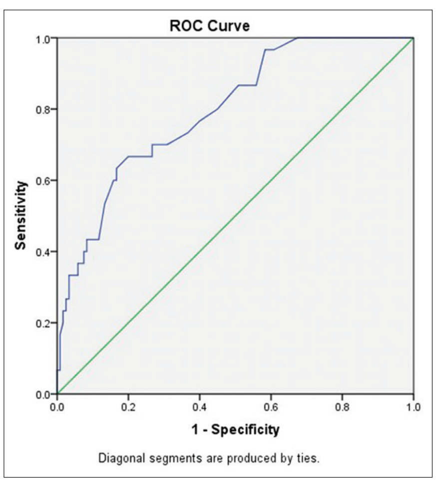

Figure 1: ROC diagram for forecasting death outcome with serum lactate level at admission. ROC: Receiver operating characteristic

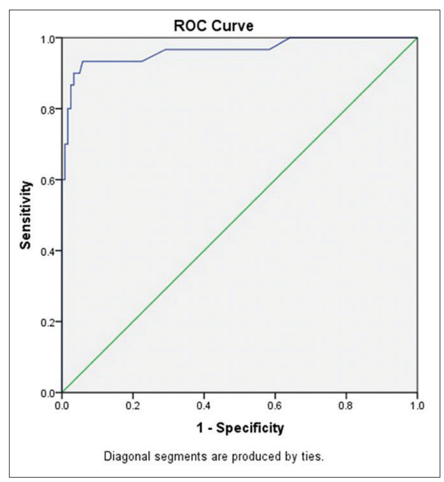

Figure 2: ROC diagram for forecasting death outcome with the serum lactate level in 24 h after admission. ROC: Receiver operating characteristic

Table 2: The difference of vital signs with the outcome of trauma patients

Parameters	Mean±SD				*P*
	Discharge	Hospitalized	Expired	Total	
PR	82.04±7.01	88.04±16.45	91.77±24.66	87.83±17.52	0.08
RR	18.38±1.68	18.08±4.37	17.27±6.19	17.97±4.5	0.04
T	36.8±0.27	36.70±0.32	36.59±0.35	36.69±0.32	0.12
SBP	117.71±11.79	121.85±23.33	120.53±41.50	120.93±26.57	0.55
DBP	75.42±9.73	73.83±14.54	72.33±23.04	73.79±15.92	0.71
O_2 saturation	97.63±1.95	94.39±5.78	85.77±10.30	93.18±7.60	<0.001
Admission lactate	1.83±1.099	2.69±1.67	3.41±5.22	3.06±1.92	<0.001
72 h lactate	0.83±0.23	1.35±0.79	6.81±3.51	2.36±1.70	<0.001
Lactate interval	0.99±1.03	1.43±1.41	2.17±2.29	1.43±1.04	0.03

PR: Pulse rate, RR: Respiration rate, T: Temperature, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SD: Standard deviation

Table 3: The difference in vital signs according to the lactate serum levels of trauma patients

Vital Sign	Mean±SD		P
	Normal	Increased lactate	
HR	86.79±15.37	88.78±19.35	0.57
RR	17.44±2.98	18.45±5.52	0.85
T	36.66±0.31	36.72±0.32	0.24
SBP	122.40±22.93	119.56±29.62	0.34
DBP	74.26±13.65	73.35±17.84	0.55
O_2 saturation	95.18±5.68	91.33±8.64	<0.001

HR: Heart rate, RR: Respiration rate, T: Temperature, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SD: Standard deviation

(hyperlactatemia) and 81.8% of patients with high lactate levels died 24 h later.

In Husain *et al*.'s study, patients in the surgical intensive care unit (ICU) were examined and had a prognosis of lactate levels at baseline and 24 h after hospital admission.[10] However, in the present study, deaths were assessed within 72 h after admission of patients with multiple trauma. This is one of the advantages of our study because a more accurate criterion was considered for investigating the relationship between serum lactate levels and mortality due to excluding other causes of trauma and low-energy trauma.

Parsikia *et al*. found that lactate measurement at the time of admission had the potential to predict mortality and the need for surgery, and lactate levels were not significant for predicting the need for surgery and for predicting the need for ICU.[11] That was in contrast with our study. This difference was probably due to the lack of segregation of patients with outpatient and ICU admissions in our study.

Differences in vital signs (respiration rate, HR, systolic blood pressure, and diastolic blood pressure) were not significant with lactate status (normal and hyperlactatemia), but there was a significant relationship between the oxygen saturation percentage and lactate status. Furthermore, in patients with high lactate levels at the time of admission within 72 h of admission, 30.8% died, 64.1% remained hospitalized, and 5.1% were discharged, and in patients with high lactate levels 24 h after admission, 81.8% died, 18.2% were hospitalized, and none were discharged. Furthermore, there was a significant difference between the variables (respiration per minute, GCS, trauma mechanism, the severity of the trauma, Injury Severity Score [ISS], etc.) and mortality, but in regression logistic, it was not statistically significant ($P > 0.05$).[11] In our study, there were no significant differences between vital signs and the outcome.

Jo *et al*. showed that the predictive value of lactate in mortality and organ failure is more than the measurement criteria in surgical procedures.[9] Our study also confirms the findings of Jo *et al*., study. As stated in the statistics section, if the initial lactate level is >2.35 mmol/L, with a sensitivity of 80%, specificity of 55%, and accuracy of 0.797, it can be used as a predictor criterion for detecting the outcome of patient death. Lactate levels >2.7 mmol/L 24 h after referral with 90% sensitivity, 96.7% specificity, and an accuracy of 0.964 can be used as a predictor for diagnosis of patient death outcome.

Jo *et al*.'s study showed trauma score was correlated with patient outcome, which was similar to our study. Although Jo *et al*., use the KTS scoring system for patients with trauma severity 9 and above (moderate and severe trauma),[9] but in our study, patients with severe trauma were evaluated. In the ISS trauma scoring system, the focus is on the anatomical injuries of traumatic patients, but the KTS trauma scoring system incorporates the physiological characteristics of the patients. Given that KTS is a simple and rapid procedure and can be evaluated by emergency physicians and triage staff at the time of admission, it seems better to use this scale to assess the status of multiple trauma patients.

There were many limitations to conducting this study that may be of interest in future studies as a more complete and robust outcome. One of the most important limitations was our ability to track the outcome of patients' deaths. In our study, we performed patient mortality and follow-up within 72 h. However, due to individual differences in patients and the wide range of factors affecting mortality, future studies should use a larger sample size and a longer timeframe to track patient mortality. Another limitation of this study was that all patients from one center and race were studied, which may differ from the physiological and demographic characteristics of other centers and countries. This study was also performed on patients with multiple trauma caused by vehicles and patients with other trauma mechanisms, and single trauma mechanisms were not evaluated.

Conclusions

This study shows that the baseline lactate, 24 h after the admission lactate, and the difference between these two were the prognostic factors in multiple trauma patients. Checking the difference in the serum lactate level between the baseline serum lactate level and serum lactate level 24 h after admission is suggested to be considered in trauma centers. It is recommended that further studies assessing all types of trauma by separating the affected organs and evaluating patients from several trauma centers be conducted.

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Conflicts of interest

There are no conflicts of interest.

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