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ORIGINAL RESEARCH

A prospective observational study to assess serum lactic acid levels as a predictor of outcome in cases of trauma

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ABSTRACT

Background: Trauma significantly contributes to global morbidity and mortality. Serum lactate variation reflects the balance between oxygen demand and supply, making it a valuable prognostic tool in trauma resuscitation. This study examines serum lactate levels in predicting outcomes in trauma patients. **Methods:** Trauma patients with an Injury Severity Score (ISS) >15 were included. Serum lactate levels were measured at admission and 2 hours post-resuscitation using the ATLS protocol. Patient outcomes were documented at discharge. **Statistical Analysis:** SPSS Version 21.0 and Microsoft Excel 2010 were used for analysis and graphical representation. ROC (Receiver Operating Characteristic) curve analysis assessed the predictive accuracy of ISS and lactate levels for mortality. **Results:** The mean patient age was 39.9 years, with road traffic accidents accounting for 72.3% of injuries. The overall mortality rate was 26.2%, with 10.8% occurring within 48 hours. Median lactate levels declined from 1.10 mmol/L at admission to 0.80 mmol/L after 2 hours ($p<0.01$). Higher ISS and lactate levels correlated with mortality. ROC analysis showed ISS (AU-ROC 0.957) and lactate levels at 2 hours (AU-ROC 0.94) as strong predictors of mortality. ISS >35 demonstrated 100% sensitivity and 83.3% specificity, while lactate >1.1 mmol/L at 2 hours had 100% sensitivity and 72.9% specificity. **Conclusion:** Elevated ISS and lactate levels at admission and 2 hours predict higher mortality, especially within 48 hours. ROC analysis highlights the utility of ISS and lactate for early risk stratification in trauma patients.

Keywords: Trauma; Lactate levels; Injury Severity Score (ISS).

INTRODUCTION

The top causes of death for all people between the ages of 15 and 39 are trauma and unintentional injury, which place a significant financial strain on the healthcare system[1]. Traffic accidents, slips and falls, drownings, accidents involving weapons, exposure to smoke, fire, and flames, hostility, and self-inflicted injuries are the main causes of the same[2]. In addition to enormous expenses for public assistance, medical treatment, and emotional effects on families, victims who do not pass away may experience motor and neurological problems that may be either transient or permanent. Thus, it is essential to identify severe injuries and hypovolemic shock as soon as possible[3].

The most recent research demonstrates the effectiveness and cost-effectiveness of early diagnosis and adequate therapy. It has been demonstrated that in-hospital lactate is a predictor of injury severity and outcome following trauma[5], and serum lactate levels have been proven to help predict outcomes in patients who are extremely unwell or injured[4].

Under typical, healthy, oxygen-rich conditions, lactate generation occurs in all tissues, including skeletal muscles, brain, RBCs, and kidneys, even at baseline levels[6]. Lactate is quickly eliminated in healthy human beings, at a rate of roughly 320 millimoles per litre per hour, primarily by liver metabolism and lactate's conversion back to pyruvate. This aids in preventing basal lactate levels in the blood from rising above 1 millimole per litre [6].

When tissue perfusion is insufficient, anaerobic metabolism takes over. Pyruvate is converted to lactate, which produces fewer adenosine triphosphate (ATP) molecules than the typical aerobic process through the tricarboxylic acid cycle route (2 vs. 36)[6].

After severe trauma or polytrauma, persistent lactic acidosis is linked to greater risks of respiratory failure, multiple system organ failure, and mortality.

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In patients with musculoskeletal injuries, lactic acidosis may therefore indicate the existence of overt or covert pulmonary tissue injury, leading to an increase in morbidity and death[6]. As a result, even in patients with stable vital signs, lactate levels can be employed as a signal between the demand and supply of oxygen, and its level variations can be used as an effective marker in resuscitation procedures. Thus, the purpose of the current study was to determine how well serum lactic acid levels might be used to predict how trauma patients would do.

AIM AND OBJECTIVES

AIM

To assess Serum Lactic Acid levels as a predictor of outcome in cases of trauma.

OBJECTIVES

To determine the Correlation of Serum Lactic Acid levels with the outcome in patients of trauma.

METHODS

Study Design

A prospective observational study was conducted to evaluate serum lactate levels as a predictor of outcomes in trauma patients.

Setting

The study was carried out in the Department of Surgery at a tertiary care hospital in India, from September 2020 to August 2022.

Selection of Participants

Inclusion Criteria

- Trauma patients aged >18 years with an Injury Severity Score (ISS) >15 who provided informed consent.

Exclusion Criteria

- Pregnant trauma patients.
- Patients treated previously at other facilities or not presenting primarily to the hospital.

A total of 65 consecutive patients were included.

Interventions

Patients were resuscitated according to the Advanced Trauma Life Support (ATLS)[7] protocol, with vital parameters monitored continuously. Serum lactate levels were measured at admission and 2 hours post-resuscitation.

Methods of Measurement

Plasma lactate levels were analysed using commercial kits supplied by Randox (UK) on a semi-automated system (5010), following standardized quality control protocols.

Data Collection and Outcomes

Data on clinical parameters and lactate levels were collected. Patient outcomes were categorized as:

1. Recovery and discharge.
2. Early death (within 48 hours).
3. Death after 48 hours.

Loss of Data

No dropouts or loss to follow-up were reported.

Statistical Methods

Data were analysed using SPSS Version 21.0, with Receiver Operating Characteristic (ROC) curve analysis to assess the predictive accuracy of ISS and lactate levels. Sensitivity and specificity for mortality prediction were calculated.

Ethical Guidelines

The study adhered to the Declaration of Helsinki[8]. Institutional Ethical Committee approval was obtained before the study. Informed consent was secured from all participants or their next of kin after explaining the study objectives and procedures.

RESULTS

Table 1 Median lactate comparison at baseline and 2 hours

Variables	Time	N	Median	SD	p- value
Lactate (mmol/l)	Admission	65	1.10	2.81	<0.01
	2 hrs	65	0.80	2.13	

Table 2. Correlation of Injury severity score and lactate levels

Pearson co-relation		
ISS	r- value	p- value
Lactate at admission	0.50	<0.01
Lactate at 2 hrs	0.55	<0.01

The present study observed a significant correlation between injury severity score and lactate levels at admission and 2 hours (p<0.01).

Table 3. Comparison of lactate levels at admission among survivors and non-survivors

Variables	Mortality	N	Median	SD	p- value
Lactate at admission (mmol/l)	No	48	0.75	1.49	<0.01
	Yes	17	3.40	4.28	

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Table 4. Comparison of lactate levels at 2 hours among survivors and non-survivors

Variables	Mortality	N	Median	SD	p- value
Lactate at 2 hrs (mmol/l)	**No**	48	0.60	1.03	**<0.01**
	Yes	17	2.80	3.18	

Table 5. Comparison of Injury Severity Score among survivors and non-survivors

Variables	Mortality	N	Median	SD	p- value
ISS	**No**	48	24.00	10.67	**<0.01**
	Yes	17	42.00	23.87	

Median ISS score (42.0 vs 24.0; p<0.01), lactate levels at admission (3.4 vs 0.75; p<0.01) and at 2 hours (2.8 vs 0.6 mmol/lit; p<0.01) were significantly higher among non-survivors as compared to survivors.

Table-6. Comparison of ISS and lactate levels among patients who were discharged and who died within 48 hours and after 48 hours

Variables	Group	N	Mean	SD	p- value	post-hoc Tukey
ISS	**Discharged**	48	24.0	10.67	**<0.01**	**Sig. diff for discharge vs died in 48 hrs**
	Died in 48 hrs	7	56.0	18.81		
	Died after 48 hrs	10	35.0	21.51		
Lactate at admission	**Discharged**	48	0.75	1.49	**<0.01**	**Sig. diff for discharge vs died in 48 hrs**
	Died in 48 hrs	7	5.81	5.71		
	Died after 48 hrs	10	2.77	2.24		
Lactate at 2 hrs	**Discharged**	48	0.60	1.03	**<0.01**	**Sig. diff for discharge vs died in 48 hrs**
	Died in 48 hrs	7	5.45	3.92		
	Died after 48 hrs	10	2.02	1.74		

On comparing, the median ISS score, lactate levels at admission and at 2 hours (we observed that values were significantly higher among cases who succumbed to death within 48 hours. The values were comparable between cases who were discharged and those who died after 48 hours. This shows that higher ISS scores and lactate values signifyan immediate risk of mortality among trauma cases.

Table 7. ROC curve analysis for a predictor of mortality in trauma cases within 48 hours

Area Under the Curve: Mortality in 48 hrs					
Test Result Variable(s)	**Area**	**SE**	**p- value**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
ISS	0.957	0.031	**<0.01**	0.896	1
Lactate at admission	0.897	0.053	**<0.01**	0.793	1
Lactate at 2 hrs	0.940	0.041	**<0.01**	0.86	1

Parameter	Ideal Cut-off	Sensitivity	Specificity	PPV	NPV	Youden's Index
ISS	>35	100.0%	83.3%	31.8 %	100.0 %	0.83
Lactate at admission (mmol/l)	>1.2	100.0%	64.6%	28.0 %	100.0 %	0.65
Lactate at 2 hrs (mmol/l)	>1.1	100.0%	72.9%	31.6 %	100.0 %	0.73

On ROC curve analysis, both ISS and lactate values can significantly predict mortality within 48 hours (p<0.01). The area under the ROC curve was observed to be highest for ISS (AU-ROC – 0.957; 0.896-1.00; p<0.01) followed by lactate levels at 2 hours (AU-ROC – 0.94; 0.86-1.00; p<0.01). The sensitivity and specificity of ISS> 35 was 100% and 83.3% with Youden's index of 0.83 while for that of lactate levels at 2 hours > 1.1 mmol/ lit was 100% and 72.9% with Youden's index of 0.73.

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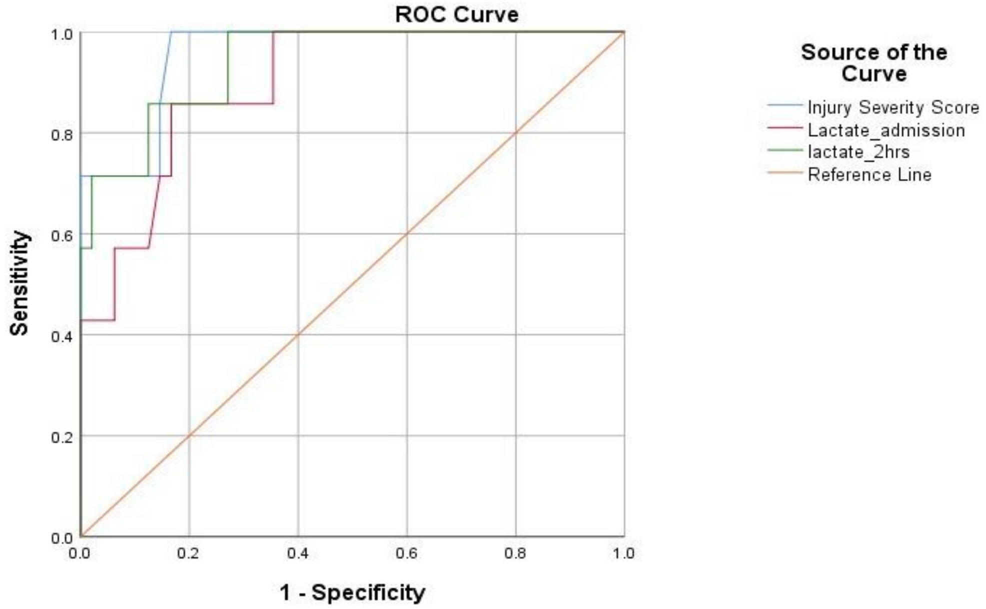

Table 8. ROC curve analysis for the predictor of mortality in trauma cases after 48 hours

Area Under the Curve: Mortality after 48 hrs					
Test Result Variable(s)	**Area**	**SE**	**p- value**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
ISS	0.700	0.098	**0.048**	0.509	0.891
Lactate at admission	0.739	0.076	**0.018**	0.589	0.888
Lactate at 2 hrs	0.751	0.079	**0.013**	0.596	0.906

Parameter	Ideal Cut-off	Sensitivity	Specificity	PPV	NPV	Youden's Index
ISS	>25	80.0%	50.0%	31.8%	91.7%	0.30
Lactate at admission (mmol/l)	>1	80.0%	60.4%	30.8%	93.8%	0.40
Lactate at 2 hrs (mmol/l)	>0.75	80.0%	62.5%	35.0%	93.8%	0.43

For mortality prediction beyond 48 hours, the area under ROC curve was observed to be highest for lactate levels at 2 hours (AU-ROC – 0.751; 0.5960.906; p-0.013). The sensitivity and specificity of lactate levels at 2 hours >0.75 mmol/ lit was 80% and 62.5% with Youden's index of 0.43. This showed that, although lactate values can significantly predict mortality after 48 hours (p<0.01), the diagnostic accuracy is low.

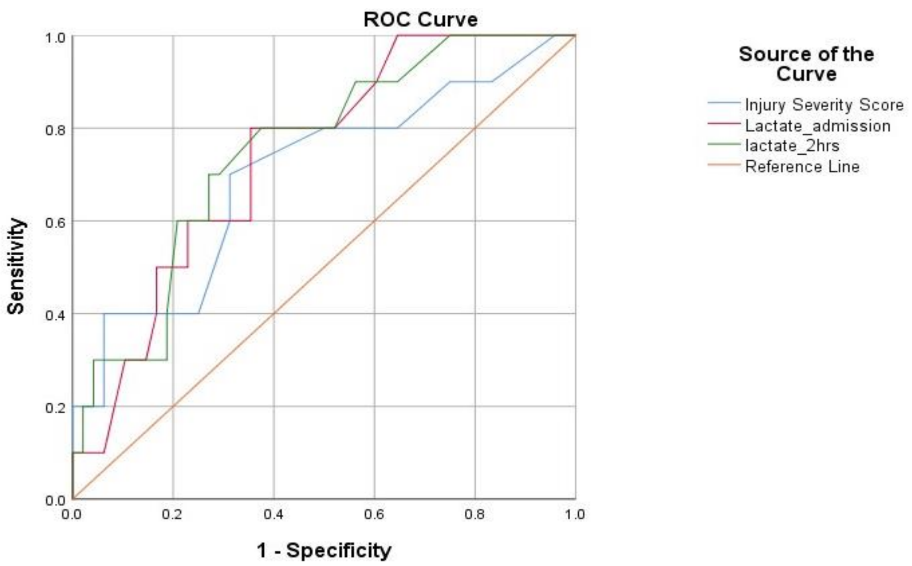

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Table9. ROC curve analysis for the predictor of overall mortality in trauma cases

Area Under the Curve: overall Mortality					
Test Result Variable(s)	**Area**	**SE**	**p- value**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
ISS	0.806	0.068	**<0.01**	0.673	0.938
Lactate at admission	0.804	0.058	**<0.01**	0.691	0.917
Lactate at 2 hrs	0.829	0.057	**<0.01**	0.718	0.94

Parameter	Ideal Cut-off	Sensitivity	Specificity	PPV	NPV	Youden's Index
ISS	>25	82.4%	68.8%	48.3%	91.7%	0.51
Lactate at admission (mmol/l)	>1.15	88.2%	64.6%	45.5%	93.8%	0.53
Lactate at 2 hrs (mmol/l)	>0.9	82.4%	72.9%	50.0%	89.7%	0.56

For overall mortality, ROC curve analysis showed that both ISS and lactate values can significantly predict mortality (p<0.01). The area under ROC curve was observed to be highest for lactate levels at 2 hours (AU-ROC – 0.829; 0.718- 0.94; p<0.01). The sensitivity and specificity of 2-hour lactate > 0.9 mmol/ lit was 82.4% and 72.9% with Youden's index of 0.56. Cases with lower lactate values (<1.15 mmol/ lit) at admission and at 2 hours after trauma (<0.9 mmol/lit.) have a high chance of survival (NPV – 93.8% and 89.7%).

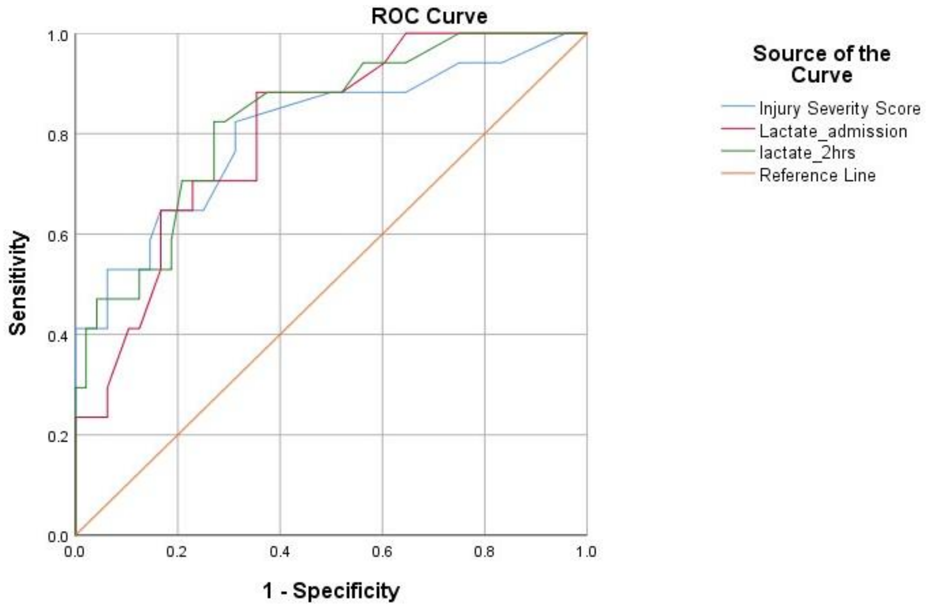

Table 10. Binary Logistic Regression analysis for prediction of mortality

Regression Analysis (Mortality)							
Variables	**Odds ratio**	**S.E.**	**Stand. Beta**	**t value**	**p-value**	**95% CI**	
						Lower	**Upper**
Constant	1.64	0.27		2.28	**0.03**	0.88	13.16
ISS	1.80	0.17	0.37	3.20	**<0.01**	1.10	4.78
Lactate at baseline	1.75	0.17	0.39	3.32	**<0.01**	1.09	4.41
Lactate at 2 hrs	1.69	0.18	0.39	3.36	**<0.01**	1.06	4.18

Binary logistic regression analysis showed that both lactate value at admission and at 2 hours along with ISS score can significantly predict survival or non-survival after trauma (p<0.01). The odds ratio to predict mortality for lactate at admission was 1.75 (1.099-4.41) and at 2 hours was 1.69 (1.06-4.18).

DISCUSSION

The current study aimed to evaluate serum lactic acid levels as a trauma outcome predictor. The study included 65 consecutive trauma patients who met the qualifying requirements and arrived at our emergency department. In each case, the lactate levels upon

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admission and after two hours were computed along with the injury severity score. Discharge, mortality within 48 hours, and mortality after 48 hours made up the outcome measure.

Mortality

There was a 26.2% overall mortality rate among trauma victims. 10.8% of them passed away in the first 48 hours, while the remaining 15.4% died in the next 48. In the study by Mehta N et al.[9], the mortality rate in trauma victims was 10%. According to Singh S et al.[10], trauma victims had a 6.3% mortality rate. A 1% death rate was reported by Jain M. et al.[11]. Because only recent deaths (within 24 hours of admission) were recorded by the authors, the rates were lower. With an overall death rate of 6.2%, 1,941 patients were examined by Parsikia A et al.[12].

Lactate Levels and Outcome

In the current investigation, the median lactate levels were 1.10 mmol/lit at admission and fell to 0.80 mmol/lit after 2 hours (p 0.01). Non-survivors had significantly higher median lactate levels upon admission (3.4 vs 0.75; p=0.01) and after 2 hours (2.8 vs 0.6 mmol/lit; p=0.01).

We found that ROC curve analysis can significantly predict death within 48 hours using both ISS and lactate measurements (p<0.01). The ISS was found to have the largest area under the ROC curve (AU-ROC - 0.957; 0.896-1.00; p0.01), followed by lactate concentrations at 2 hours (AU-ROC - 0.94; 0.861.00; p0.01). With a Youden's index of 0.83, the ISS> 35 sensitivity and specificity were 100% and 83.3%, respectively, whereas lactate levels at 2 hours > 1.1 mmol/lit were 100% and 72.9%, respectively, with a Youden's index of 0.73. The area under the ROC curve was found to be highest for lactate levels at 2 hours for death prediction beyond 48 hours and overall mortality (AU-ROC - 0.751; 0.596-0.906; p-0.013 and AU-ROC - 0.829; 0.718- 0.94; p0.01). With a Youden's index of 0.43, the sensitivity and specificity (> 0.75 mmol/ lit) for prediction beyond 48 hours were 80% and 62.5%, whereas, with a Youden's index of 0.56, the sensitivity and specificity (> 0.9 mmol/ lit) for total mortality were 82.4% and 72.9%. The odds ratio to predict death for lactate was 1.75 (1.099-4.41) at admission and 1.69 after two hours (1.06-4.18).

SUMMARY

1. The present study observed a significant correlation between injury severity score and lactate levels, both at admission and at 2 hours (p<0.01).
2. Median ISS score (42.0 vs 24.0; p<0.01), lactate levels at admission (3.4 vs 0.75; p<0.01) and at 2 hours (2.8 vs 0.6 mmol/lit; p<0.01) were significantly higher among non-survivors as compared to survivors.

Limitations of the study

1. The sample size in our study is small
2. The study should be multicentric with a large sample size to make recommendations.

CONCLUSION

1. The current investigation concluded that greater lactate levels and injury severity scores at admission and after two hours were linked to higher mortality in trauma cases within the first 48 hours.
2. According to ROC analysis, a 2-hour lactate level was the best predictor of mortality after 48 hours and total mortality. In contrast,the Injury severity score was the best predictor of death within 48 hours.
3. The likelihood of survival is higher in cases with lower lactate readings (<1.0 mmol/lit) both at admission and two hours following trauma.

As a result, we conclude that measuring lactate levels is a helpful test to risk-stratify critically sick patients who arrive at the emergency room.

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All authors read and approved the final manuscript.

The data described in the manuscript, code book, and analytic code will be made available upon request.

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