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Correlation of Serum Lactate and Shock Index as Mortality Predictor in Polytrauma Patients

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ABSTRACT

In polytrauma patients, serum lactate and hypovolemic shock are critical biomarkers for prognosis and treatment guidance. Elevated lactate levels indicate tissue hypoperfusion and anaerobic metabolism, often correlating with increased mortality. **Objective:** To analyze the correlation between serum lactate levels and shock index as predictors of in-hospital mortality in polytrauma patients. **Methods:** A Cohort study was conducted from August 2022 to July 2023 at a single tertiary care hospital in Karachi. Patients were chosen via consecutive sampling techniques and included adult patients with polytrauma injuries (ISS ≥ 15) who survived at least 24 hours. Patients with a history of diabetes were excluded. The serum lactate levels and shock index at the time of admission and over the first 24 hours were the exposures while in-hospital mortality, was the primary outcome. Statistical analyses were conducted using Stata 16.0. Categorical variables were analyzed using the chi-square test. Multivariable logistic regression evaluated mortality risk, adjusting for age, ISS, and shock index. **Results:** The in-hospital mortality rate in the study was 6.4% with significant predictors of mortality included increasing age (47.05 vs. 27.62 years, $p<0.001$), higher Injury Severity Scores (ISS) (24 vs. 19, $p= 0.02$), and elevated shock index at admission (0.84 vs. 0.71, $p<0.001$). Lactate metrics were strongly associated with mortality, showing significant correlations. **Conclusions:** Higher serum lactate levels and shock index are strong predictors of mortality in polytrauma patients. Greater age and injury severity also contribute to poorer outcomes.

INTRODUCTION

Trauma is a leading global health issue, responsible for approximately 5 million deaths annually and a significant cause of disability-adjusted life years, particularly in low- and middle-income countries such as Colombia [1-3]. Young, economically active men are disproportionately affected, which highlights the socioeconomic burden of trauma [3]. The metabolic response to trauma often results in hypoxia and anaerobic metabolism, with lactate production as a key consequence. Lactate, produced from pyruvate via lactate dehydrogenase, is elevated in patients experiencing shock and serves as a critical marker of oxygen supply-demand imbalance [4, 5]. Elevated serum lactate levels are well-established predictors of mortality in trauma patients and have been shown to correlate with injury severity and the need for resuscitative interventions such as blood product administration [6, 7]. When considered alongside vital signs like blood pressure, lactate levels provide valuable prognostic information about injury severity and patient outcomes [7-9]. Research has shown that patients with lactate levels exceeding 4 mmol/L face significantly higher mortality risks, emphasizing the importance of early lactate measurement in trauma settings [7-11]. Additionally, lactate clearance is a useful parameter for evaluating the effectiveness of resuscitation efforts and predicting early mortality in trauma patients [8]. Similarly, the shock index

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(SI)—calculated as the ratio of heart rate to systolic blood pressure serves as an important predictor of trauma-related mortality. The SI is a rapid, non-invasive tool that aids in assessing trauma severity and detecting early hemorrhagic shock, providing critical guidance in prehospital and emergency care settings [12, 13]. Despite early recognition and treatment efforts, morbidity and mortality associated with shock remain high, often due to delayed diagnosis and treatment. Rapid identification of mortality predictors like serum lactate and SI can facilitate early intervention, improving patient outcomes and reducing irreversible damage caused by hypoperfusion [14-16]. However, the comparative effectiveness of these predictors remains unclear, highlighting a gap in the current literature.
This study aimed to fill this gap by analyzing the correlation between serum arterial lactate levels at admission, 12-hour lactate clearance, and polytrauma mortality, in conjunction with the shock index.

METHODS

A cohort study was conducted at one Tertiary Care Hospital from August 2022 to July 2023. Approval for the project was obtained from the institutional review board (IRB)(F.2-81/2022-GENL/205/JPMC). Informed written consent was taken from each participant/guardian. The study included 500 adult patients, chosen via consecutive sampling, aged 18 to 85 years who had sustained a blunt injury, had an injury severity score (ISS) of 15 or higher, were hospitalized, and survived for at least 24 hours. Sample size were computed via open-epi sample size calculator with 4% margin of error and 95% confidence interval with expected frequency of poly trauma as 29.57% having hypovolemic shock [17]. Baseline characteristics, including patient demographics (age, ethnicity, gender, smoking status, presence of hypertension), trauma mechanism, and vital signs, were recorded. The shock index was computed by dividing the patient's heart rate by systolic blood pressure (mmHg) [14]. Serum lactate (mmol/L) levels were measured using blood gas analysis (BGA) from arterial blood samples collected upon at admission and 24 hours post-admission.
The following lactate metrics were calculated:

- Lac_{adm}: First lactate at admission
- $Lac_{24hMean}$: Mean lactate over the first 24 hours
- Lac_{24hTW}: Time-weighted lactate over 24 hours

Time-weighted measurements reduce surveillance bias by accounting for irregular sampling intervals. The steps included measuring the time between data points, averaging the values, multiplying the average by the time interval, summing these products, and dividing by the total elapsed time. The main endpoint was death during the hospital stay. Patients who were released within 24 hours were not included in the analysis. Descriptive statistics characterized the study population, presenting categorical variables as frequencies and percentages, which were analyzed using the x^2 test. Continuous variables were examined for normal distribution. Symmetric data were analyzed using the Student's t-test and reported as mean with standard deviation (SD). Whereas, the non-symmetric data were assessed using the Kruskal-Wallis test and presented as median with interquartile range (IQR). Univariate analysis tested the association between patient demographics, injury severity, glucose, lactate metrics, and mortality. Spearman correlation assessed relationships between glucose and lactate metrics. Chi-square goodness of fit was used for model fitting. Multivariable logistic regression models evaluated the association between these metrics and adjusted mortality risk, considering confounders like age, ISS, and admission shock index. Lactate metrics were scaled and tested in separate models with confounders. All statistical analyses were performed using Stata version 16.0 (StataCorp, College Station, TX). P value <0.05 was considered as statistically significant while P value < 0.001 was regarded as highly statistically significant.

RESULTS

The cohort consisted of 500 patients. The study population was predominantly male (367, 73.40%) with a median age of 34 years (IQR: 18-60). The largest ethnic group belonged to the Muhajir community (219, 43.80%) and 34 patients (6.4%) died in the course of treatment. In-hospital mortality was observed at an average of 8.23 days (SD: 7.62)

Table 1: Overview of the Study Population

Parameters (n=500)	Values n (%) / Mean ± SD
Age (Years) (IQR)	34 (18-60)
Male (Sex)	367 (73.40)
Muhajir Ethnicity	219 (43.80)
ISS (IQR)	20 (16-30)
Smoking	291 (58-20)
Hypertension	211 (42.20)
BMI, kg/m^2 (IQR)	23.9 (18.2-31.1)
SBP, mmHg	104.25 ± 25.81
HR, bpm	129.48 ± 28.13

Mortality was associated with increasing age (47.05, SD: 18.18 vs 27.62, SD: 13.03, p<0.001), increasing severity score of the injury (24, IQR 20-30 vs 19, IQR 16-24, p=0.02), and admission shock index (0.71, SD: 0.24 vs 0.84, SD 0.39) among other parameters (Table 2).

Table 2: Analysis of the Study Population by Mortality Status: Deceased vs. Survived

Variable n (%) / Mean ± SD	Alive (n=466)	Dead (n=34)	p-Value
Age (Years)	27.62 ± 13.03	47.05 ± 18.18	<0.001
ISS (IQR)	19 (16-24)	24 (20-30)	0.02
Muhajir Ethnicity	204 (43.77)	15 (44.11)	0.12
Male (Sex)	332 (71.24)	5 (14.70)	<0.001

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Admission SI	0.71 ± 0.24	0.84 ± 0.39	<0.001
Smoking	269 (57.72)	22 (64.70)	<0.001
Hypertension	188 (40.34)	23 (67.64)	<0.001
Lac_{adm}, mmol/L	3.25 ± 1.22	5.65 ± 2.21	<0.001
$Lac_{24h-mean}$, mmol/L	2.67 ± 1.18	4.15 ± 2.03	<0.001
Lac_{24hTW}, mmol/L	2.59 ± 1. 06	4.02 ± 1.89	<0.001

Multivariate logistic regression analysis was used for the analysis of multiple independent variables on mortality

DISCUSSION

This study highlights the importance of early serum lactate measurement in trauma patients, demonstrating its strong association with increased mortality. Elevated lactate levels are a critical biomarker for assessing trauma severity and guiding resuscitation. While Shock Index is also related to mortality, its significance diminishes after adjusting for lactate levels, highlighting lactate as a more reliable indicator of trauma severity. Tracking lactate over time offers valuable insights into the effectiveness of resuscitation and patient prognosis. Evidence from prior studies indicates that elevated lactate levels are linked to greater injury severity, increased rates of multiple organ failure (MOF) [18], and higher mortality rates [19]. Our findings are consistent with this literature, reinforcing the role of lactate as a key prognostic tool in trauma care. Furthermore, trauma is a leading cause of mortality and disability globally, particularly in individuals under 50 years old. Lactate, which reflects anaerobic metabolism and tissue hypoperfusion, emerges as a critical marker even in vitally stable trauma patients [20], aiding in early risk stratification and resuscitation guidance. Clinically, these findings suggest that lactate should be routinely measured and monitored in trauma settings, as its levels can guide interventions aimed at improving tissue perfusion and oxygenation. The dynamic monitoring of lactate over time, rather than relying on a single measurement, provides more comprehensive insights into resuscitation progress and patient outcomes. Our data indicate that mean 24-hour lactate may be a better predictor of mortality than the admission lactate level alone, underscoring the importance of ongoing lactate tracking in clinical decision-making. In addition to lactate, there is evidence that trauma patients with elevated glucose levels also tend to have higher morbidity and mortality [21]. This association between hyperglycemia and worse outcomes mirrors that of lactate, further emphasizing the need to monitor metabolic derangements in trauma patients. The strengths of this study include its prospective longitudinal design, which allows for real-time data collection, a relatively large sample size, and the use of time-weighted measurements to minimize bias. However, several limitations should be considered. The single-center design restricts the generalizability of the findings to broader populations of critically ill patients. Furthermore, the exclusion of diabetic patients limits the application of the results to nondiabetic trauma populations. We also focused on the first 24 hours of admission, potentially missing delayed complications. Additionally, we could not assess the impact of resuscitation techniques, such as intravenous fluids or blood products, on patient outcomes.

CONCLUSIONS

Higher serum lactate levels and shock index are strong predictors of mortality in polytrauma patients. Greater age and injury severity also contribute to poorer outcomes. Obtaining early serum lactate levels in trauma patients offers a valuable tool for early risk stratification, guiding prehospital care, and improving clinical outcomes. As more evidence emerges, integrating this biomarker into standard prehospital protocols could revolutionize trauma care, providing vital information to make informed decisions and enhance patient survival rates.

Authors Contribution

Conceptualization: NUSS
Methodology: NUSS, MA, SS[1], SS[2], SZM, MMK
Formal analysis: MA, SS[1], SS[2], SZM, MMK
Writing-review and editing: NUSS, SM

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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REFERENCES

[1] Alshiakh SM. Role of Serum Lactate as Prognostic Marker of Mortality Among Emergency Department Patients with Multiple Conditions: A Systematic Review. Sage Open Medicine. 2023 Jan; 11: 20503121221136401. doi: 10.1177/20503121221136401.
[2] Woolum JA, Abner EL, Kelly A, Bastin ML, Morris PE, Flannery AH. Effect of Thiamine Administration On Lactate Clearance and Mortality in Patients with Septic Shock. Critical Care Medicine. 2018 Nov; 46(11): 1747-52. doi: 10.1097/CCM.0000000000003311.
[3] Zeng Z, Huang R, Lin H, Peng H, Luo J, Ding N. Serum Lactate is an Indicator for Short-Term and Long-Term Mortality in Patients with Acute Pancreatitis. Digestive Diseases and Sciences. 2024 Apr: 1-2. doi: 10.1007/s10620-024-08419-4.
[4] Callaway DW, Shapiro NI, Donnino MW, Baker C, Rosen CL. Serum Lactate and Base Deficit as Predictors of Mortality in Normotensive Elderly Blunt Trauma Patients. Journal of Trauma and Acute Care Surgery. 2009 Apr; 66(4): 1040-4. doi: 10.1097/TA.0b013e31818

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DOI: https://doi.org/10.54393/pjhs.v5i09.2205

95e9e.
[5] Guyette F, Suffoletto B, Castillo JL, Quintero J, Callaway C, Puyana JC. Prehospital Serum Lactate as A Predictor of Outcomes in Trauma Patients: A Retrospective Observational Study. Journal of Trauma and Acute Care Surgery. 2011 Apr; 70(4): 782-6. doi: 10.1097/TA.0b013e318210f5c9.
[6] Weinberger J, Klompas M, Rhee C. What is the Utility of Measuring Lactate Levels in Patients with Sepsis and Septic Shock?. Inseminars in Respiratory and Critical Care Medicine 2021 Oct; 42(05): 650-661. doi: 10.1055/s-0041-1733915.
[7] Gharipour A, Razavi R, Gharipour M, Mukasa D. Lactate/Albumin Ratio: An Early Prognostic Marker in Critically Ill Patients. The American Journal of Emergency Medicine. 2020 Oct; 38(10): 2088-95. doi: 10.1016/j.ajem.2020.06.067.
[8] Freire Jorge P, Wieringa N, De Felice E, Van Der Horst IC, Oude Lansink A, Nijsten MW. The Association of Early Combined Lactate and Glucose Levels with Subsequent Renal and Liver Dysfunction and Hospital Mortality in Critically Ill Patients. Critical Care. 2017 Dec; 21: 1-1. doi: 10.1186/s13054-017-1785-z.
[9] Hayashi Y, Endoh H, Kamimura N, Tamakawa T, Nitta M. Lactate Indices as Predictors of In-Hospital Mortality or 90-Day Survival After Admission to an Intensive Care Unit in Unselected Critically Ill Patients. Plos One. 2020 Mar; 15(3): E0229135. doi: 10.1371/journal.pone.0229135.
[10] Iyengar KP, Venkatesan AS, Jain VK, Shashidhara MK, Elbana H, Botchu R. Risks in The Management of Polytrauma Patients: Clinical Insights. Orthopedic Research and Reviews.2023 Dec: 27-38. doi: 10.2147/ORR.S340532.
[11] Richards JE, Mazzeffi MA, Massey MS, Rock P, Galvagno SM, Scalea TM. The Bitter and The Sweet: Relationship of Lactate, Glucose, And Mortality After Severe Blunt Trauma. Anesthesia & Analgesia. 2021 Aug; 133(2): 455-61. doi: 10.1213/ANE.0000000000005335.
[12] Shagana JA, Dhanraj M, Jain AR, Osa TN. Hypovolemic shock-A review. Drug Invention Today. 2018 Jul; 10(7): 1102-05.
[13] Koch E, Lovett S, Nghiem T, Riggs RA, Rech MA. Shock index in the emergency department: utility and limitations. Open Access Emergency Medicine. 2019 Aug: 179-99. doi: 10.2147/OAEM.S178358.
[14] Elbaih AH and Housseini AM. Validity of Shock Index, Modified Shock Index, Central Venous Pressure and Inferior Vena Cava Collapsibility Index in Evaluation of Intravascular Volume among Hypovolemic Egyptians Patients. American Journal of Diagnostic Imaging. 2018 Aug; 4(1): 5-13. doi: 10.5455/ajdi.20180318114502.
[15] Cakir E, Bindal A, Yilmaz PO, Dogu C, Mutlu NM, Turan IO. The relationship of shock index, modified shock index, and age shock index with mortality in the intensive care unit. 2019; 26(10): 2148-53. doi: 10.5455/annalsmedres.2019.07.371.
[16] El-Menyar A, Goyal P, Tilley E, Latifi R. The clinical utility of shock index to predict the need for blood transfusion and outcomes in trauma. Journal of Surgical Research. 2018 Jul; 227: 52-9. doi: 10.1016/j.jss.2018.02.013.
[17] Luo J, Chen D, Tang L, Deng H, Zhang C, Chen S *et al.* Multifactorial shock: a neglected situation in polytrauma patients. Journal of Clinical Medicine. 2022 Nov; 11(22): 6829. doi: 10.3390/jcm11226829.
[18] Richards JE, Scalea TM, Mazzeffi MA, Rock P, Galvagno Jr SM. Does lactate affect the association of early hyperglycemia and multiple organ failure in severely injured blunt trauma patients?. Anesthesia & Analgesia. 2018 Mar; 126(3): 904-10. doi: 10.1213/ANE.0000000000002626.Indurkar Sr SK,
[19] Ghormade PS, Akhade S, Sarma B. Use of the Trauma and Injury Severity Score (TRISS) as a predictor of patient outcome in cases of trauma presenting in the trauma and emergency department of a tertiary care institute. Cureus. 2023 Jun; 15(6). doi: 10.7759/cureus.40410.
[20] Régnier MA, Raux M, Le Manach Y, Asencio Y, Gaillard J, Devilliers C *et al.* Prognostic significance of blood lactate and lactate clearance in trauma patients. The Journal of the American Society of Anesthesiologists. 2012 Dec; 117(6): 1276-88. doi:10.1097/ALN.0b013e318273349d.
[21] Mamtani M, Kulkarni H, Bihari S, Prakash S, Chavan S, Huckson S *et al.* Degree of hyperglycemia independently associates with hospital mortality and length of stay in critically ill, nondiabetic patients: results from the ANZICS CORE binational registry. Journal of Critical Care. 2020 Feb; 55: 149-56. doi: 10.1016/j.jcrc.2019.11.003.

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