**Research Article**

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# Investigation of laboratory parameters as mortality marker in patients with blunt multi-trauma

## *Künt çoklu travmalı hastalarda mortalite belirleyicisi olarak laboratuvar parametrelerinin araştırılması*

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**Abstract**

**Purpose:** In trauma patients, vital signs may not be beneficial in patient management. Therefore, evaluating vital signs, some laboratory parameters, and imaging methods is essential in managing trauma patients. Based on the hypothesis that lactate and base excess (BE) is an early marker of morbidity and mortality in the evaluation in blunt multi-trauma patients, we aimed to investigate the value of lactate albumin ratio and lactate dehydrogenase (LDH) albumin ratio in addition to lactate and BE in predicting mortality in blunt multi-trauma patients.

**Materials and methods:** This was a single-centre, retrospective study. Prior to data collection, approval was obtained from the local ethics committee. Patients admitted with multi-trauma to the emergency department of a tertiary education and research hospital in Türkiye between January 1, 2018, and December 31, 2021, who did not meet the exclusion criteria, were included in the study. This study examined the predictive value of Lactate, BE, Lactate-to-albumin ratio, and LDH-to-albumin ratio in predicting mortality in blunt multi-trauma patients.

**Results:** The lactate cut-off value for mortality was 4.2, exhibiting 73.3% sensitivity and 89.2% specificity. The BE cut-off value for mortality was -3, exhibiting 80.0% sensitivity and 76.9% specificity. The lactate-albumin ratio cut-off value for mortality was 0.11, exhibiting 73.3% sensitivity and 90.8% specificity. The LDH-albumin ratio cut-off value for mortality was 7.2, exhibiting 86.7% sensitivity and 58.5% specificity.

**Conclusion:** Lactate albumin ratio was more specific in predicting mortality than lactate and BE, while LDH albumin ratio was more sensitive in predicting mortality than lactate and BE.

**Keywords:** Lactate albumin ratio, lactate dehydrogenase albumin ratio, multi-trauma.

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**Öz**

**Amaç:** Travma hastalarında vital bulgular hasta yönetiminde yeterli olmayabilir. Bu nedenle travma hastalarının yönetiminde yaşamsal bulguların, bazı laboratuvar parametrelerinin ve görüntüleme yöntemlerinin değerlendirilmesi esastır. Künt multi-travma hastalarının değerlendirilmesinde laktat ve baz fazlalığının (BE) morbidite ve mortalitenin erken bir belirteci olduğu hipotezinden yola çıkarak, künt multi-travma hastalarında mortaliteyi öngörmede laktat ve BE'ye ek olarak laktat albümin oranı ve laktat dehidrogenaz (LDH) albümin oranının değerini araştırmayı amaçladık.

**Gereç ve yöntem:** Bu tek merkezli, retrospektif bir çalışmadır. Veri toplanmadan önce yerel etik kuruldan onay alınmıştır. Çalışmaya, 1 Ocak 2018 ile 31 Aralık 2021 tarihleri arasında Türkiye'deki üçüncü basamak bir eğitim ve araştırma hastanesinin acil servisine çoklu travma ile başvuran ve dışlama kriterlerini karşılamayan hastalar dahil edildi. Bu çalışmada, künt çoklu travma hastalarında, mortaliteyi öngörmede Laktat, BE, Laktat / albümin oranı ve LDH / albümin oranının tanısal değerliliği hesaplanmıştır.

**Bulgular:** Mortalite için laktat kesme değeri 4,2 olup %73,3 duyarlılık ve %89,2 özgüllük sergilemektedir. Mortalite için BE kesme değeri -3 olup %80,0 duyarlılık ve %76,9 özgüllük sergilemektedir. Mortalite için laktat albümin oranı kesme değeri 0,11 olup %73,3 duyarlılık ve %90,8 özgüllük sergilemektedir. Mortalite için LDH albümin oranı kesme değeri 7,2 olup %86,7 duyarlılık ve %58,5 özgüllük sergilemektedir.

**Sonuç:** Laktat albümin oranı mortaliteyi öngörmede laktat ve BE'ye göre daha spesifik iken, LDH albümin oranı mortaliteyi öngörmede laktat ve BE'ye göre daha duyarlıydı.

**Anahtar kelimeler:** Laktat albumin oranı, laktat dehidrogenaz albumin oranı, çoklu-travma.

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## Introduction

Trauma patients represent a significant proportion of emergency department (ED) presentations [1]. Trauma-related deaths are the leading cause of death in young people [2]. Emergency management of trauma patients is based on a general evaluation of anamnesis, physical examination, vital signs, laboratory results, and imaging findings. This patient management is based on advanced trauma life support (ATLS) guidelines [3]. In trauma patients, vital signs may not be beneficial in patient management. Therefore, evaluating vital signs, some laboratory parameters, and imaging methods is essential in managing trauma patients [4]. In this direction, some laboratory parameters may arouse the clinician's suspicion of possible organ damage and play a key role in using appropriate imaging tests in this direction [5]. Laboratory tests performed during follow-up can help prevent morbidity and mortality that can occur after trauma.

Hemorrhagic shock is an important cause of morbidity and mortality in trauma patients. Intravascular volume loss and vasoconstriction due to hemorrhage cause tissue hypoxia and lactic acidosis. This triggers the development of morbidity and mortality. Consequently, it is essential to limit these findings [6, 7]. Accordingly, early detection of hemorrhagic shock should be possible. Laboratory parameters that can be used in the early detection of hemorrhagic shock were investigated. Serum lactate and base excess (BE) are more sensitive markers of morbidity and mortality compared to other measured laboratory parameters in multi-trauma [8-10].

Based on the hypothesis that lactate and base deficit is an early marker of morbidity and mortality in the evaluation of hemorrhagic shock in blunt multi-trauma patients, we aimed to investigate the value of lactate albumin ratio and lactate dehydrogenase albumin ratio in addition to lactate and BE in predicting mortality in blunt multi-trauma patients.

## Materials and methods

### Study design and population

This was a single-center, retrospective study. Prior to data collection, approval was obtained from the local ethics committee and the principles outlined in the Declaration of Helsinki have been followed.

Patients admitted with multi-trauma to the emergency department of a tertiary education and research hospital in Türkiye between January 1, 2018, and December 31, 2021, who did not meet the exclusion criteria, were included in the study. Patients under 18 years of age, pregnant women, patients with penetrating trauma, patients transferred to another institution, patients not considered as multi-trauma, patients who refused diagnosis and treatment, patients with incomplete laboratory parameters, patients with a history of disease affecting laboratory parameters, and patients admitted to the emergency department with arrest were excluded. The study population (N:450) was constructed considering the inclusion and exclusion criteria. The patient flow chart is shown in Figure 1.

### Study protocol

The study population was formed after applying the inclusion and exclusion criteria. Demographic data, trauma mechanisms, laboratory parameters, and clinical outcomes of the patients included in the study were planned to be analyzed. All these patient data were obtained from the hospital's digital archive.

Laboratory parameters at the time of ED admission included hemoglobin (HGB) (mg/dl), Platelets (10^3/uL), Alanine transaminase (ALT) (U/L), Aspartate transaminase (AST) (U/L), Lactate dehydrogenase (LDH) (U/L), Albumin (g/L), Creatine (mg/dL), BE (mmol/L), Lactate (mmol/L). In addition, the lactate albumin ratio and LDH albumin ratio were calculated with laboratory parameters.

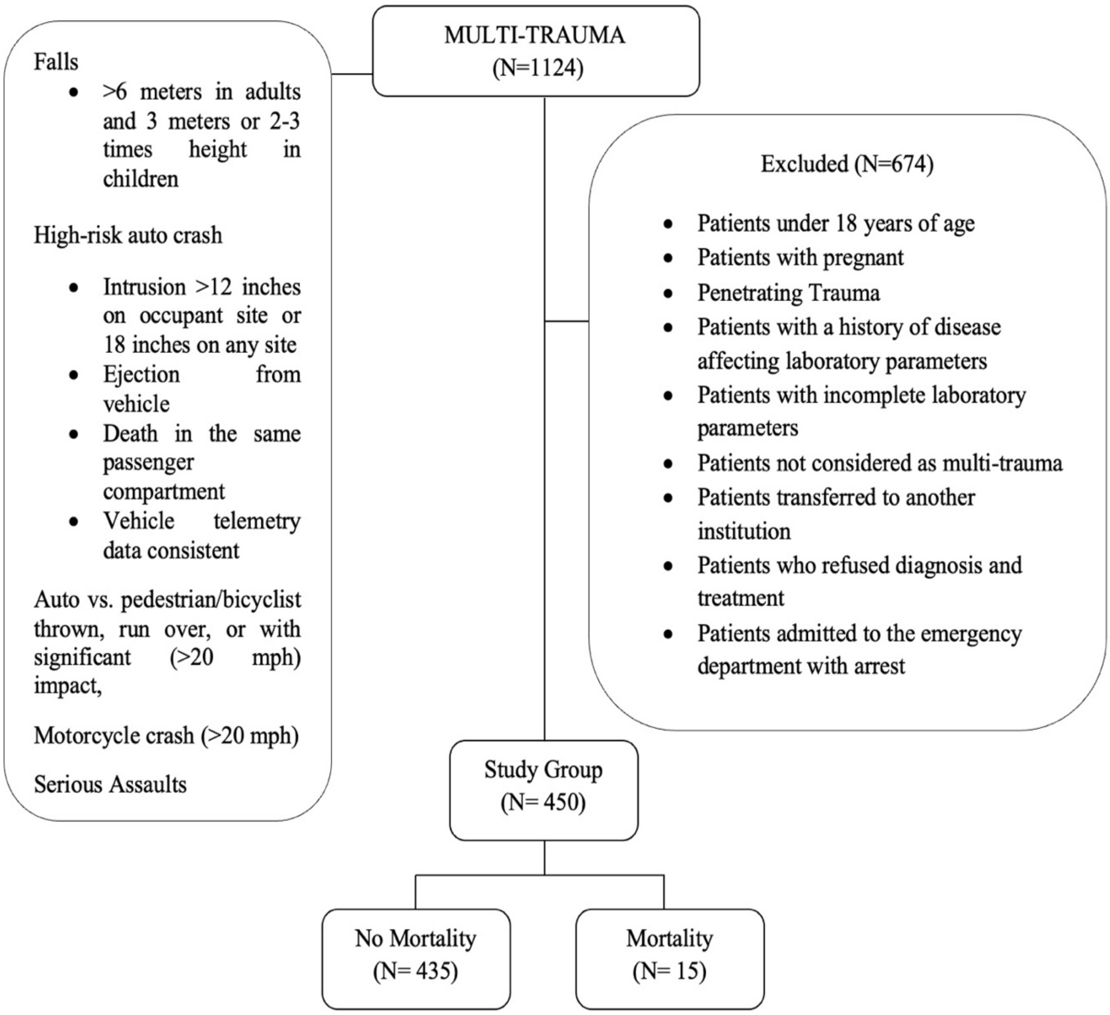


**Figure 1.** Patient flow chart

Shock staging of the patients included in the study was performed in accordance with ATLS guidelines. Admission Glasgow Coma Score (GCS), hospitalization status and clinical outcome (mortality and non-mortality) were recorded.

**Endpoints**

The primary endpoint of this study was the predictive value of Lactate, BE, Lactate-to-albumin ratio and LDH-to-albumin ratio in predicting mortality in blunt multi-trauma patients. The secondary endpoint was to evaluate the association of laboratory parameters between the mortality and non-mortality groups.

**Statistical analysis**

All statistical analyses were performed on Jamovi v. 1.6 software (Jamovi Project Computer Software, version 1.6. Sydney, Australia). Type 1 errors were regarded as 5% for all comparisons. The Shapiro-Wilk test was applied to evaluate normality of data distribution. Non-normally distributed data for continuous variables were expressed as median and interquartile range (IQR) and normally distributed data as mean and minimum-maximum values. Categorical data were expressed as frequency (n) and percentage (%) values. Comparisons of continuous variables were performed using the t-test for normally distributed groups and the Mann-Whitney U test for non-normally distributed groups. A receiver operating curve (ROC) was produced to determine the cut-off levels of the Lactate, BE, Lactate albumin ratio, and LDH albumin ratio value for mortality. Youden's index (maximum value) in ROC analysis was used to select the cut-off value. Finally, sensitivity, specificity, likelihood ratios (+LR and -LR), and positive and negative predictive values were calculated for the Lactate, BE, Lactate albumin ratio, and LDH albumin ratio value.

## Results

The study population comprised 450 patients, meeting the inclusion and exclusion criteria. Three hundred thirty-four (74.2) patients were men and 116 (25.8%) women. The patients' median age was 39 years (IQR 28.3-53). The mechanisms of trauma were 279 (62.0%) vehicle traffic accidents, 139 (30.9%) falls and rolls, and 32 (7.1%) accidents caused by objects falling on. While shock was not observed in 359 (79.8%) patients, stage 1 shock was observed in 39 (8.7%), stage 2 shock in 30 (6.7%), stage 3 shock in 14 (3.1%), and stage 4 shock in 8 (1.7%) patients. The median value of the patients' GCS was 15, with a range of 15-15. Of the patients, 155 (3.4%) were hospitalized and 15 (3.3%) died. Demographic data, mechanism of trauma, hospitalization and mortality rates are summarized in Table 1.

**Table 1.** The patients' demographic data and baseline characteristics

| Characteristics, n=450 | Value |
|---|---|
| **Gender** | |
| Male, n (%) | 334 (74.2%) |
| Female, n (%) | 116 (25.8%) |
| **Age** (years), median (IQR) | 39.0 (IQR 28.3-53.0) |
| **Trauma Mechanisms** | |
| Vehicle Traffic Accident | 279 (62.0%) |
| Fall and Roll | 139 (30.9%) |
| Accident by Object Falling on | 32 (7.1%) |
| **Laboratory Indices** | |
| HGB (mg/dl), median (IQR) | 13.7 (IQR 12.2-15.2) |
| Platelet (10^3/uL), median (IQR) | 248 (IQR 210-293) |
| ALT (U/L), median (IQR) | 27.0 (IQR 19.0-49.5) |
| AST (U/L), median (IQR) | 33.0 (IQR 25.8-63.0) |
| LDH (U/L), median (IQR) | 300 (IQR 241-398) |
| Albumin (g/L), median (IQR) | 42.0 (IQR 38.8-45.0) |
| Creatine (mg/dL), median (IQR) | 0.90 (IQR 0.76-1.02) |
| Base Excess (mmol/L), median (IQR) | -1.65 (IQR (-5.5)-0.7) |
| Lactate (mmol/L), median (IQR) | 2.4 (IQR 1.7-3.9) |
| Lactate/Albumin Ratio (%), median (IQR) | 0.06 (IQR 0.03-0.1) |
| LDH/Albumin Ratio (%), median (IQR) | 7.21 (IQR 5.86-9.86) |
| **Shock Stage** | |
| None, n (%) | 359 (79.8%) |
| Stage 1, n (%) | 39 (8.7%) |
| Stage 2, n (%) | 30 (6.7%) |
| Stage 3, n (%) | 14 (3.1%) |
| Stage 4, n (%) | 8 (1.7%) |
| **GCS** (score), median (IQR) | 15 (IQR 15-15) |
| **Hospitalization,** n (%) | 155 (34.4%) |
| **Mortality,** n (%) | 15 (3.3%) |

IQR: Interquartile Range (25p, 75p), HGB: Hemoglobin, ALT: Alanine Transaminase, AST: Aspartate Transaminase
LDH: Lactate dehydrogenase, GCS: Glasgow Coma Score

Laboratory parameters were analyzed: The median value of the HGB was 13.7 mg/dl (IQR 12.2-15.2); The median value of the platelet was 248 10^3/uL (IQR 210-293); the median value of the ALT was 27.0 U/L (IQR 19.0-49.5); the median value of the AST was 33.0 U/L (IQR 25.8-63.0); the median value of the LDH was 300 U/L (IQR 241-398); the median value of the albumin was 42.0 g/L (IQR 38.8-45.0); the median value of the creatine was 0.90 mg/dL

(IQR 0.76-1.02); the median value of the BE was -1.65 mmol/L (IQR (-5.5)-0.7); the median value of the lactate was 2.4 mmol/L (IQR 1.7-3.9); the median value of the lactate albumin ratio was 0.06 (IQR 0.03-0.1); the median value of the LDH albumin ratio was 7.21 (IQR 5.86-9.86). The median AST, LDH, albumin, creatine, BE, lactate, lactate albumin ratio, and LDH albumin ratio values measured in the included a statistically significant difference at mortality and non-mortality. (*p*=0.037 for AST, *p*=0.040 for LDH, *p*=0.007 for albumin, *p*=0.005 for creatine, *p*=0.001 for BE, *p*=0.001 for lactate, *p*=0.001 for lactate albumin ratio, and *p*=0.003 for LDH albumin ratio). An evaluation of the measurements and a statistical summary are shown in Table 1 and Table 2.

The lactate, BE, lactate albumin ratio, and LDH albumin ratio cut-off values were calculated to predict mortality. The Area Under the Curve (AUC) value for lactate was 0.819±0.03, and the cut-off value for mortality was 4.2, exhibiting 73.3% sensitivity and 89.2% specificity. The AUC value for BE was 0.843±0.04, and the cut-off value for mortality was -3, exhibiting 80.0% sensitivity and 76.9% specificity. The AUC value for lactate albumin ratio was 0.829±0.04, and the cut-off value for mortality was 0.11, exhibiting 73.3% sensitivity and 90.8% specificity. The AUC value for LDH albumin ratio was 0.747±0.04, and the cut-off value for mortality was 7.2, exhibiting 86.7% sensitivity and 58.5% specificity. The ROC analysis is shown in Table 3 and Figure 2.

**Table 2.** Patients' laboratory indices statistics

| **Laboratory Indices** | **No Mortality (n=435)** | **Mortality (n=15)** | **All Patients (n=450)** | ***p* Value** |
|---|---|---|---|---|
| HGB (mg/dl) | 13.9 (IQR 12.7-15.2) | 10.9 (IQR 10.5-15.1) | 13.7 (IQR 12.2-15.2) | 0.068 |
| Platelet (10^3/uL) | 248 (IQR 211-283) | 247 (IQR 167-306) | 248 (IQR 210-293) | 0.763 |
| ALT (U/L) | 27 (IQR 18.8-45.5) | 35 (IQR 19.5-81.5) | 27.0 (IQR 19.0-49.5) | 0.468 |
| AST (U/L) | 31 (IQR 24-60) | 38 (IQR 32-140) | 33.0 (IQR 25.8-63.0) | 0.037 |
| LDH (U/L) | 295 (IQR 237-360) | 361 (IQR 282-471) | 300 (IQR 241-398) | 0.040 |
| Albumin (g/L) | 43 (IQR 39-45) | 38 (32.5-41) | 42.0 (IQR 38.8-45.0) | 0.007 |
| Creatine (mg/dL) | 0.86 (IQR 0.75-0.98) | 1.13 (IQR 0.99-1.23) | 0.90 (IQR 0.76-1.02) | 0.005 |
| Base Excess (mmol/L) | -0.6 (IQR (-2.9)-0.9) | -6.1 (IQR (-9.75)-(-3.15)) | -1.65 (IQR (-5.5)-0.7) | 0.001 |
| Lactate (mmol/L) | 2.2 (IQR 1.5-3.3) | 5.7 (IQR 3.9-7.4) | 2.4 (IQR 1.7-3.9) | 0.001 |
| Lactate/Albumin Ratio (%) | 0.05 (IQR 0.03-0.08) | 0.17 (IQR 0.09-0.2) | 0.06 (IQR 0.03-0.1) | 0.001 |
| LDH/Albumin Ratio (%) | 6.7 (IQR 5.6-9.5) | 9.8 (IQR 7.4-12.9) | 7.2 (IQR 5.86-9.86) | 0.003 |

HGB: Hemoglobin, ALT: Alanine Transaminase, AST: Aspartate Transaminase, LDH: Lactate dehydrogenase

**Table 3.** The cut-off values of laboratory indices for mortality

| | **Lactate** | **Base Excess** | **Lactate/Albumin Ratio** | **LDH/Albumin Ratio** |
|---|---|---|---|---|
| **AUC + SD** | 0.819±0.03 | 0.843±0.04 | 0.829±0.04 | 0.747±0.04 |
| **Cutoff** | 4.2 | -3 | 0.11 | 7.2 |
| **Sensitivity (%), 95% CI** | 73.3 (44.9-92.2) | 80.0 (51.9-95.7) | 73.3 (44.9-92.2) | 86.7 (59.5-98.3) |
| **Specificity (%), 95% CI** | 89.2 (79.1-95.6) | 76.9 (64.8-86.5) | 90.8 (81.0-96.5) | 58.5 (45.6-70.6) |
| **+ LR, 95% CI** | 6.8 (3.2-14.6) | 3.5 (2.1-5.8) | 7.9 (3.5-18.1) | 2.1 (1.5-3.0) |
| **- LR, 95% CI** | 0.3 (0.1-0.7) | 0.3 (0.1-0.7) | 0.3 (0.1-0.7) | 0.2 (0.1-0.9) |
| **PPV (%),95% CI** | 61.1 (42.3-77.1) | 44.4 (32.4-57.1) | 64.7 (44.7-80.7) | 32.5 (25.3-40.6) |
| **NPV (%),95% CI** | 93.6 (86.2-97.1) | 94.3 (85.7-97.8) | 93.7 (86.4-97.2) | 95.0 (83.7-98.6) |
| **Accuracy (%), 95% CI** | 86.3 (76.7-92.9) | 77.5 (66.8-86.1) | 87.5 (78.2-93.8) | 63.8 (52.2-74.2) |

AUC: Area Under the Curve, SD: Standard Deviation, LR: Likelihood Ratio, PPV: Positive Predictive Value, NPV: Negative Predictive Value
CI: Confidence Interval, LDH: Lactate dehydrogenase

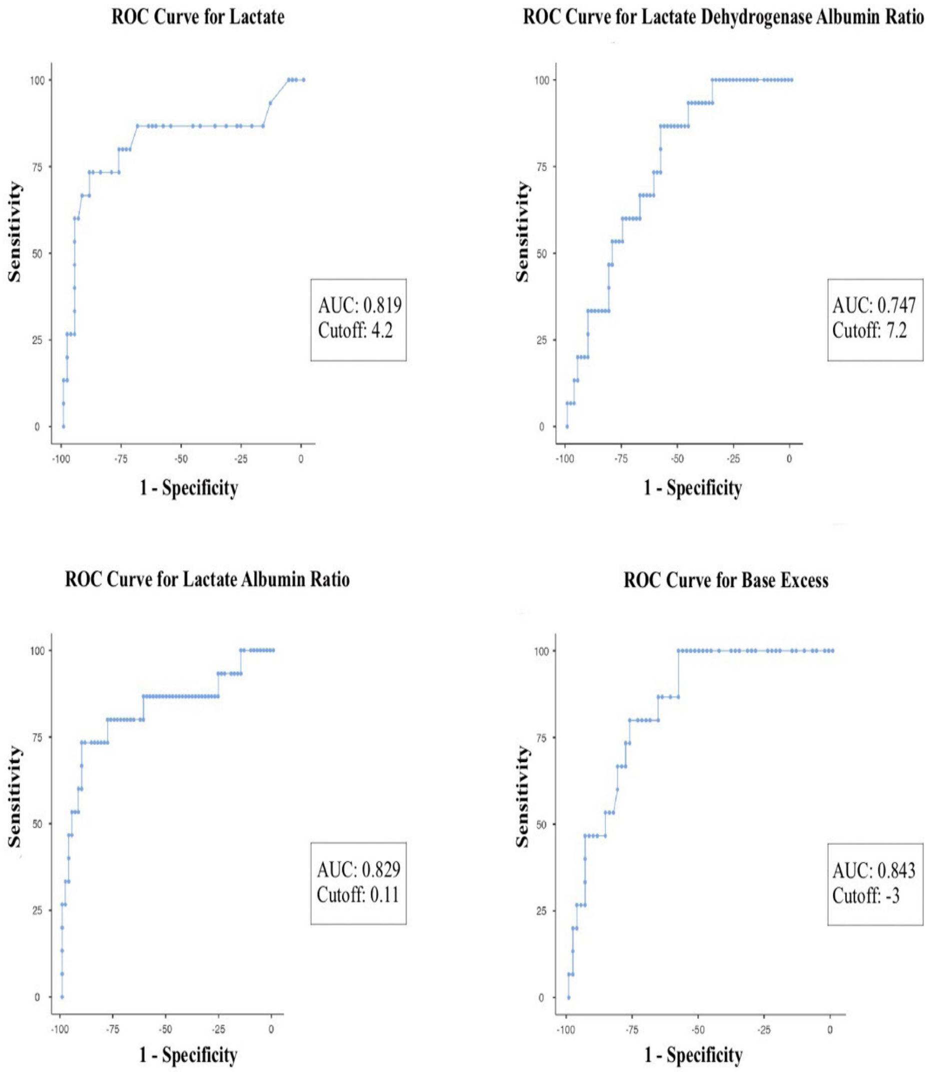


**Figure 2.** Receiver Operating Curve (ROC) analysis

**AUC:** Area Under the Curve

## Discussion

In trauma patients, anamnesis, physical examination, and vital signs may not be beneficial in patient management. Therefore, evaluating anamnesis, physical examination, vital signs, some laboratory parameters, and imaging methods is essential in managing trauma patients [3, 4]. The use of many laboratory parameters as mortality predictors in trauma has been evaluated. Lactate and BE are widely used because they are the most important laboratory indicators of mortality, especially in hemorrhagic shock. In our study, the diagnostic value of both lactate and BE as mortality indicators in the blunt multitrauma was evaluated. In addition, the diagnostic value of lactate albumin ratio and LDH albumin ratio, which were found to be mortality indicators in many critically ill patients [11-13], were evaluated as mortality indicators in the blunt multitrauma. Lactate albumin ratio was more specific in predicting mortality than lactate and BE, while LDH albumin ratio was more sensitive in predicting mortality than lactate and BE. This did not result in a clear superiority in predicting clinical outcome.

Javali et al. [14] compared the lactate and BE laboratory parameters with vital findings from the blood gas analysis of trauma patients taken at the time of the first admission to the ED and 24 hours of follow-up. They found that a 4 mmol/L increase in lactate (100% sensitive, 85.9 specific) and 12 mEq/L change in BE (85.7% sensitive, 82.6% specific) were more sensitive than vital signs in demonstrating 24-hour mortality. They recommended using lactate and BE as essential indicators for 24-hour mortality, intensive care unit admission, and blood transfusion. Qi et al. [15] evaluated the predictive value of BE, lactate, and pH for 72-hour mortality in patients with multi-trauma. They found that the AUC of BE, lactate and pH were 0.693 (95% CI:0.675-0.712), 0.715 (95% CI:0.697-0.733), 0.670 (95% CI:0.651-0.689), respectively. Jyoti et al. [16] evaluated the relationship between serum lactate concentration, BE and mortality as a prognostic factor in patients with polytrauma. They found that serum lactate and BE were simple, rapid, and independent biochemical predictors of 48-hour mortality in polytrauma patients. In our study, lactate and BE were considered to be predictors of mortality. When mortality and non-mortality groups were analyzed, lactate and BE were found to be statistically significant between the two groups. Also, in the ROC analysis, the lactate cut-off value for mortality was 4.2, exhibiting 73.3% sensitivity and 89.2% specificity. The BE cut-off value for mortality was -3, exhibiting 80.0% sensitivity and 76.9% specificity. In conclusion, similar to the literature, we can say that lactate and BE are strong predictors of mortality in patients with blunt multitrauma.

Wang et al. [17] evaluated the relationship between lactate albumin ratio and mortality in patients with moderate and severe traumatic brain injury. Lactate albumin ratio was found to be a prognostic marker of mortality in patients with moderate and severe traumatic brain injury. In addition, many studies have evaluated the relationship between LDH albumin ratio and mortality. It has been determined that LDH albumin ratio may be a predictor of mortality in sepsis, critically ill patients, and colon cancer [18-20]. In our study, the relationship between lactate albumin ratio and LDH albumin ratio and mortality in blunt multitrauma patients was investigated. Lactate albumin ratio and LDH albumin ratio were found to be predictors of mortality in blunt multitrauma patients. The fact that previous studies have not investigated the predictive value of lactate albumin ratio and LDH albumin ratio for mortality in patients with multi-trauma makes our findings valuable. However, as expected, its predictive sensitivity and specificity are not significantly superior to lactate alone and BE alone.

In our study, we also compared the laboratory parameters at the time of first admission between the groups with and without mortality. AST, LDH, albumin and creatine were found to be statistically related between mortality and non-mortality groups.

This study has some limitations. In particular, the study was small, conducted in a single center, and was retrospective. Patient data cannot be adequately assessed because of the retrospective design. This raises concerns about selection bias, similar to other retrospective studies. However, the study population was designed to address this concern by excluding situations that may cause bias (e.g. Lactate and LDH were excluded in arrest patients because they would be high). Further studies with many patients and more centers are needed to confirm our findings.

In conclusion, the lactate cut-off value for mortality was 4.2, exhibiting 73.3% sensitivity and 89.2% specificity. The BE cut-off value for mortality was -3, exhibiting 80.0% sensitivity and 76.9% specificity. Lactate albumin ratio was more specific in predicting mortality than lactate and BE, while LDH albumin ratio was more sensitive in predicting mortality than lactate and BE.

**Conflicts of interest:** No conflict of interest was declared by the authors.

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**Author contributions**

Literature search: O.B., M.M.Y.; Study design: M.M.Y.; Legislative applications: O.B., M.M.Y.; Data collection: M.M.Y., U.S.C., N.P.; Supervision and quality control: O.B.; Statistical data analysis: M.M.Y.; Data interpretation: M.M.Y., N.P., U.S.C.; Drafting the manuscript: M.M.Y., O.B. All authors were involved in the writing and critical revision of the manuscript and approved the final version. M.M.Y. and O.B. take the whole responsibility for the paper.