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LACTATE–ALBUMIN DIFFERENCE IN MEDICAL AND SURGICAL INTENSIVE CARE UNITS

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ABSTRACT

Objective: *Sequential Organ Failure Assessment (SOFA) score, lactate, and lactate-albumin difference values obtained at admission to surgical and medical intensive care units are evaluated for cutoff values and predictive significance on mortality.*

Material and Method: *Data between 2001 and 2012 were extracted from MIMIC–III database. Adult patients admitted to the medical and surgical intensive care unit for the first time were evaluated. The significances of the SOFA score, maximum lactate, and lactate-albumin difference values in predicting mortality were analyzed, and cutoff values are determined.*

Results: *Non-survivors had higher lactate, higher lactate - albumin difference, and lower albumin values than survivors (p<0.001, for all). In surgical intensive care units, lactate, lactate - albumin difference, length of hospital and intensive care unit stays were higher, but 30– and 90– day mortalities were lower than medical intensive care units. SOFA scores were similar (p=0.30). The area under the receiver operating characteristic curve (AUC) of SOFA score (AUC = 0.776, 95% CI: 0.735–0.817) and the cutoff value were greater in the surgical intensive care unit than the medical one (AUC=0.762, 95% CI: 0.745–0.780). The AUC of overall lactate - albumin difference (AUC=0.713, 95% CI: 0.695–0.731) was larger than overall maximum lactate (AUC=0.680, 95% CI: 0.662–0.699) on the first day. Both the maximum lactate and lactate - albumin difference cutoff values were higher in the surgical intensive care unit.*

Conclusion: *Lactate - albumin difference's predictor value of mortality was superior to initial minimum albumin and maximum lactate values. Different cutoff values of the SOFA score, lactate - albumin difference, and maximum lactate should be used in medical and surgical intensive care units.*

Keywords: *Lactate, albumin, lactate - albumin difference, intensive care unit.*

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DAHİLİ VE CERRAHİ YOĞUN BAKIM ÜNİTELERİNDE LAKTAT-ALBÜMİN FARKI

ÖZET

Amaç: Dahili ve cerrahi yoğun bakım ünitelerine kabul sırasında kaydedilen Sequential Organ Failure Assessment (SOFA) skoru, laktat ve laktat albümin farkı değerlerinin mortaliteyi ön görmedeki önemi ve eşik değerleri araştırıldı.

Materyal ve Metot: MIMIC–III veri tabanından 2001–2012 yılları arasındaki veriler alındı. Medikal ve cerrahi yoğun bakım ünitesine ilk defa yatışı olan erişkin hastalar değerlendirildi. Mortaliteyi öngörmede SOFA skoru, maksimum laktat ve laktat albümin farkı değerlerinin önemi ve eşik değerler belirlendi.

Bulgular: Ölenler, yaşayanlara göre daha yüksek laktat, laktat albümin farkı ve daha düşük albümin değerlerine sahipti (p<0,001, hepsi için). Cerrahi yoğun bakım ünitelerinde laktat, laktat albümin farkı, hastane ve yoğun bakım kalış süreleri medikal yoğun bakım ünitelerinden daha yüksekti ama 30 ve 90 günlük mortalite daha düşüktü. SOFA skorları benzerdi (p=0,30). SOFA skorunun İşlem Karakteristik Eğrisi Altında Kalan Alan (AUC) (AUC=0,776, %95 CI:0,735-0,817) ve eşik değerleri (AUC=0,762, %95 CI:0,745-0,780) cerrahi yoğun bakım ünitelerinde medikal olanlara göre daha yüksekti. İlk gün elde edilen genel laktat albümin farkının AUC değeri (AUC=0,713, %95 CI:0,695-0,731) genel maksimum laktat AUC değerinden (AUC=0,680, %95 CI:0,662-0,699) yüksekti Cerrahi yoğun bakım ünitelerinde hem maksimum laktat hem de laktat albümin farkının eşik değerleri daha yüksekti.

Sonuç: Laktat–albümin farkının mortaliteyi öngörmedeki değeri ilk giriş minimum albümin ve maksimum laktat değerlerinden daha üstündü. Dahili ve cerrahi yoğun bakım ünitelerinde SOFA skoru, laktat albümin farkı ve maksimum laktat değerleri için farklı eşik değerler kullanılmalıdır.

Anahtar kelimeler: Laktat, albümin, laktat–albümin farkı, yoğun bakım ünitesi.

INTRODUCTION

Predicting the outcome of critically ill patients is done by several tests and scores. Scores use variables from different organic systems and can be more accurate but more expensive and time-consuming than a single measurement of a laboratory value. Suspecting sepsis in admission to the intensive care unit (ICU) will enable appropriate treatment and improving outcomes.[1]

Kollef *et al*. studied the ICU specific predictors of mortality in medical, surgical, and cardiovascular ICUs.[2] They concluded that predictive severity scores should be used together with ICU specific predictors to enhance patient care.

Hyperlactatemia is often multifactorial and interchangeable during the disease's course. Certain conditions and complications, i.e., shock, sepsis, cardiac arrest, local ischemia leading to decreased oxygen delivery and utilization, decreased lactate clearance, increased metabolism, drugs, and fluids used in therapy, may lead to a rise in lactate levels.[3] Hypoperfusion leading to tissue hypoxia and/or oxygen debt is considered the main cause of hyperlactatemia in sepsis.[4,5] The source of lactate during sepsis is not exact, but experimental and human studies revealed lungs and muscles as the major organs in lactate production.[6,7] Many of the tissues and organs use lactate as a source of energy, and it's been shown that in sepsis, the splanchnic region, brain, and heart consume lactate.[3,8]

Many researchers investigate patient outcomes and lactate levels. Hyperlactatemia is seen in very high-risk patients and is a predictor of mortality.[9] Intraoperative moderate (2-4 mmol/L) and high (≥4 mmol/L) levels of lactate during cardiac surgery were found to be correlated with prolonged hospital length of stay (LOS).[10] Also, ICU and hospital LOS, in-hospital and long-term mortality are positively associated with increased lactate levels.[3,11]

Albumin, a negative acute–phase protein, plays an important role in numerous physiological functions; thus, its deficiency is associated with unfavorable outcomes. Intravascular albumin level <3.5 g/dL is defined as hypoalbuminemia. Hypoalbuminemia in surgical patients like in the medical patients is a mortality risk factor; increased hospital LOS, wound complications, reoperation, and organ dysfunctions can also be seen.[12]

Several diagnostic indices consisting of several parameters, single measured parameters, or their ratios are being investigated to predict patient outcomes more accurately. Lactate and albumin can be used for this purpose and have a lower cost than multiparameter scores. Cost–effectivity is as crucial as early detection and timely clinical management of critically ill patients. Lactate - albumin ratio (LAR) is investigated to predict mortality in septic patients and be superior to a single measured lactate level.[13]

Lactate albumin difference (LAD) can also be used as a predictor of mortality.[14] We believe the recently defined LAD will be more accurate if different cutoff values for medical and surgical ICU patients are used. The first aim of this study is to determine the cutoff values of in–hospital mortality predictors Sequential Organ Failure Assessment (SOFA), lactate, and LAD for medical and surgical ICUs; the second aim is to compare the predictive values of lactate and LAD on mortality, and the third aim is to evaluate the predictive significance of LAD at admission for 90–day mortality.

MATERIALS AND METHODS

In this retrospective study, data from MIMIC–III (Multiparameter Intelligent Monitoring for Intensive Care III) ver1.4 are evaluated.[15] Institutional Review Boards of Beth Israel Deaconess Medical Center (Boston, MA) and the Massachusetts Institute of Technology (Cambridge, MA) both approved the project, and because the information about the patients is de-identified, patient consent was waived.

Cohort Selection

Data between 2001 and 2012 were extracted from MIMIC–III database by utilizing the Structured Query Language (SQL).

We extracted a total of 5570 patients ≥16 years of age who were admitted to ICU for the first time. Exclusion criteria were being >89 years of age, >1 ICU stay, having unavailable or missing data, having undergone cardiac, vascular, thoracic surgery, and being pregnant.

Statistical Analysis

Descriptive statistical methods (mean, standard deviation, medians with interquartile ranges), frequency, total numbers, and percentages are used to describe the patient characteristics and categorical variables. Wilcoxon rank–sum and chi–square tests are used for continuous and categorical variables, when appropriate. Univariate and multivariate logistic regression tests analyzed the association between in–hospital mortality and the maximum lactate, minimum albumin, and LAD values at admission. The groups' variables were compared with univariate analysis, and cutoff points were based on these results. Area under the receiver operating characteristic curves (AUC) were constructed to assess the ability of SOFA, maximum lactate, minimum albumin, and LAD at admission to predict in–hospital mortality with 95% confidence intervals (CI) and odds ratios (OR) were calculated. The optimal cutoff value was calculated by the Youden method, and sensitivity and specificity were determined at this value. ICU admission to 90 day survival curves was obtained by Kaplan–Meier estimation. *p*<0.05 was considered statistically significant. Statistical analyses are done with RStudio (version 1.2.5033).

Table 1. Patients' baseline demographic characteristics

Characteristic	Overall N=5570	Survivors N=4502 (81%)[1]	Non-survivors N=1068 (19%)[1]	*p*-value[2]
Age, (y)	61 (49, 75)	60 (48, 74)	68 (55, 79)	<0.001
Male, n(%)	3094 (56%)	2462 (55%)	632 (59%)	0.009
BMI, (kg/m²)	27 (24, 33)	27 (24, 33)	27 (23, 32)	0.2
SOFA (1st day)	5 (3, 8)	5 (3, 7)	9 (6, 12)	<0.001
Admission Type, n (%)				<0.001
Elective	209 (3.8%)	189 (4.2%)	20 (1.9%)	
Emergency	5244 (94%)	4223 (94%)	1021 (96%)	
Urgent	117 (2.1%)	90 (2.0%)	27 (2.5%)	
Intensive Care Unit, n (%)				<0.001
Medical	4579 (82%)	3656 (81%)	923 (86%)	
Surgical	991 (18%)	846 (19%)	145 (14%)	
Elixhauser Comorbidity Score	4 (0, 9)	4 (0, 8)	7 (3, 12)	<0.001
Mechanical Ventilation, n (%)	2845 (51%)	2085 (46%)	760 (71%)	<0.001
Suspected of Infection, n (%)	4573 (82%)	3657 (81%)	916 (86%)	<0.001
Metastatic Cancer, n (%)	312 (5.6%)	195 (4.3%)	117 (11%)	<0.001
Length of Hospital stay, (day)	8 (4, 15)	9 (5, 16)	6 (2, 13)	<0.001
Length of ICU stay, (day)	2.8 (1.7, 6.0)	2.8 (1.7, 5.6)	3.6 (1.5, 8.4)	<0.001
Lactate (max)(mmol/L)	2.30 (1.50, 4.20)	2.20 (1.40, 3.70)	3.70 (2.00, 7.70)	<0.001
Albumin (min)(mg/dL)	3.00 (2.50, 3.50)	3.00 (2.60, 3.50)	2.60 (2.10, 3.10)	<0.001
Lactate-Albumin Difference	-0.60 (-1.60, 1.30)	-0.80 (-1.70, 0.70)	1.00 (-0.70, 5.10)	<0.001
ICU Severity Score				
OASIS	34 (28, 41)	33 (26, 39)	42 (36, 48)	<0.001
APSIII	50 (37, 66)	46 (35, 60)	73 (56, 93)	<0.001
SAPSII	39 (30, 51)	36 (27, 46)	55 (45, 67)	<0.001

[1]**Statistics presented:** median (IQR); n (%)
[2]**Statistical tests performed:** Wilcoxon rank-sum test; chi-square test of independence
Values are taken within 24h of admission to ICU.
BMI: Body Mass Index, **LAD:** lactate-albumin difference, **MIMIC–III:** Multiparameter Intelligent Monitoring in Intensive Care III, **AUC:** Area under the receiver operating characteristic curve, **SOFA:** Sequential Organ Failure Assessment, **qSOFA:** quick SOFA, **CI:** Confidence Interval, **ICU:** Intensive Care Unit, **APACHE:** Acute Physiology And Chronic Health Evaluation, **OASIS:** Oxford Acute Severity of Illness Score, **SAPS II:** Simplified Acute Physiology Score II, **APS III:** Acute Physiology Score III, **LAR:** Lactate-albumin ratio, **LOS:** Length of stay, **OR:** Odds ratio, **SIRS:** Systemic inflammatory response syndrome

RESULTS

Of 61532 recorded ICU patients in the MIMIC–III database, 5570 patients who met the selection criteria were enrolled. They are divided into two groups according to the ICU type, Medical (n=4579) and Surgical (n=991) ICU; and as survivors (n=4502) and non–survivors (n=1068). The demographic characteristics of the study cohort are shown in (Table 1).

Table 2. Comparisons of characteristics of surgical and medical intensive care unit patients.

Characteristic	Medical N=4579 (82%)[1]	Surgical N=991 (18%)[1]	*p*-value[2]
Age, (y)	62 (49, 75)	61 (50, 74)	0.60
Male, n (%)	2510 (55%)	584 (59%)	0.020
SOFA (1st day)	5 (3, 8)	5 (3, 8)	0.30
Admission Type, n (%)			<0.001
Elective	11 (0.2%)	198 (20%)	
Emergency	4481 (98%)	763 (77%)	
Urgent	87 (1.9%)	30 (3.0%)	
Elixhauser comorbidity score	5 (0, 9)	4 (0, 8)	0.012
Suspected of Infection, n (%)	3710 (81%)	863 (87%)	<0.001
Metastatic Cancer, n (%)	233 (5.1%)	79 (8.0%)	<0.001
Mechanical Ventilation, n (%)	2181 (48%)	664 (67%)	<0.001
Hospital length-of-stay, (day)	8 (4, 14)	11 (7, 20)	<0.001
ICU length-of-stay, (day)	2.8 (1.6, 5.8)	3.0 (1.8, 7.6)	<0.001
Thirty-day mortality, n (%)	1081 (24%)	134 (14%)	<0.001
Ninety-day mortality, n (%)	1363 (59%)	195 (47%)	<0.001
Lactate[3] (mmol/L)	2.30 (1.50, 3.90)	3.00 (1.60, 5.30)	<0.001
Albumin[4] (mg/dL)	3.00 (2.60, 3.50)	2.70 (2.25, 3.10)	<0.001
Lactate-Albumin Difference	-0.70 (-1.60, 1.00)	0.30 (-1.10, 2.90)	<0.001

[1]**Statistics presented:** median (IQR); n (%)
[2]**Statistical tests performed:** Wilcoxon rank-sum test; chi-square test of independence
[3]Values are maximum within 24h of admission to ICU
[4]Values are minimum within 24h of admission to ICU
SOFA: Sequential Organ Failure Assessment, **ICU:** Intensive care unit

Table 3. Univariate and multivariate logistic regression analyses of variables potentially associated with in-hospital mortality in intensive care patients

	Univariate binary logistic regression			Multivariate logistic regression		
Predictor	**OR[1]**	**95% CI[1]**	***p*-value**	**OR[1]**	**95% CI[1]**	***p*-value**
Age	1.03	1.02, 1.03	<0.001	1.03	1.02, 1.03	<0.001
Gender (male =1)	1.20	1.05, 1.38	0.008	1.03	0.88, 1.21	0.70
SOFA	1.30	1.27, 1.32	<0.001	1.22	1.19, 1.24	<0.001
Elixhauser Comorbidity score	1.09	1.08, 1.10	<0.001	1.04	1.03, 1.05	<0.001
Suspected of Infection	1.39	1.16, 1.68	<0.001	0.71	0.57, 0.89	0.003
Metastatic Cancer	2.72	2.13, 3.45	<0.001	2.14	1.59, 2.86	<0.001
Mechanical Ventilation	2.86	2.48, 3.31	<0.001	1.43	1.20, 1.70	<0.001
L-A Difference	1.26	1.23, 1.29	<0.001	1.51	1.34, 1.70	<0.001
Lactate (max)	1.23	1.20, 1.26	<0.001	0.74	0.66, 0.84	<0.001
Albumin (min)	0.41	0.36, 0.45	<0.001	--	--	--

[1]**OR:** Odds Ratio, **CI:** Confidence Interval, **SOFA:** Sequential Organ Failure Assessment, **qSOFA:** Quick Sequential Organ Failure Assessment, **ICU:** Intensive care unit, **L:** Lactate, **A:** Albumin
Values are taken within 24h of admission to ICU.
The P-value of the Hosmer-Lemeshow goodness-of-fit test for the multivariate logistic regression model was 0.286. Negelkerke 0.330.

Bivariate analysis revealed a significant difference of age in survivor and non-survivor groups, but there was no difference in medical and surgical ICUs. SOFA score (1st day), Elixhauser comorbidity score, Oxford Acute Severity of Illness Score (OASIS), Acute Physiology Score III (APS III), Simplified Acute Physiology Score II (SAPS II) were higher in non-survivors ($p<0.001$, for all). Survivors' hospital LOS was longer ($p<0.001$), but the ICU LOS was shorter. Admission type and intensive care unit types were also different between the groups. ICU type was potentially associated with in–hospital mortality.

Non-survivors had higher lactate, higher LAD, and lower albumin than survivors ($p<0.001$, for all). In surgical ICUs, lactate, LAD, ICU and hospital LOS were higher, but 30- and 90- day mortalities were lower than medical ICUs. SOFA scores were similar between the ICUs ($p=0.3$) (Table 2).

After adjusting for several confounding factors such as age, gender, maximum SOFA score, Elixhauser comorbidity score, suspected of infection, and mechanical ventilation, we found a significant association between the LAD and in–hospital mortality (adjusted odds ratio [OR] 1.51, 95% CI 1.34 – 1.70; $p<0.001$; Table 3). The goodness–of–fit, assessed with the Hosmer–Lemeshow test for the multivariate logistic regression model, was 0.286, and Negelkerke was 0.330.

The optimal cutoff values, AUC, Youden's index, sensitivity, and specificity for SOFA score, LAD, and maximum lactate according to the ICU type are shown in (Table 4).

The AUC of overall LAD (AUC=0.713, 95% CI:0.695–0.731) was larger than overall maximum lactate (AUC=0.680, 95% CI:0.662–0.699) on the first day (Table 4). In the surgical ICU, both the maximum lactate and LAD cutoff values were higher. The AUC of SOFA score (AUC=0.776, 95% CI:0.735–0.817) and the cutoff value were greater in surgical ICU than medical ICU (AUC=0.762, 95% CI:0.745–0.780). (Table 4) (Figure 1).

When different cutoff values for SOFA and LAD are used, survival probability significantly changes, as shown in Kaplan-Meier 90 day survival curves ($p<0.0001$, for all). (Figure 2,3)

DISCUSSION

In this study, we used the MIMIC–III database to evaluate the LAD calculated on the first day as a prognostic factor of mortality in medical and surgical ICU patients. It is revealed that as compared to single lactate and albumin measurement for predicting mortality among ICU patients, LAD's diagnostic performance was better, and another main finding of this study was that cutoff values vary among medical and surgical ICUs. Oxygen delivery depends on both micro–and macro–circulation, oxygen content in blood and, hemoglobin levels; patients admitted to ICUs have derangements considering these parameters, which lead to hyperlactatemia. Garcia *et al*. state that the adrenergic response's activation leads to hyperlactatemia in sepsis–associated hyperlactatemia.[8] Lactate is investigated as a prominent prognostic factor in studies. Shin *et al*. study revealed AUC values of lactate levels and LAR in predicting 28 day mortality as <0.70 (0.65, 0.69, respectively).[13] Our data showed AUC values of lactate level and LAD in predicting in-hospital mortality as 0.68 and 0.71, respectively. LAD demonstrated significantly greater discrimination for in–hospital mortality than lactate. The predictive performance of LAD is superior to LAR for mortality in critically ill patients.[14] Patient specific factors may contribute erroneous results if we accept a single cutoff value for prognostic factors like albumin or lactate. ICU specific predictors and cutoff values should be implemented to improve patient care and reduce mortality. The common mortality predictor in medical, surgical, and cardiovascular ICUs was organ system failure index (OSFI), and no other predictor was shared among them.[2] The surgical ICU group had statistically significant higher initial lactate levels and LAD than the medical ICU group ($p<0.001$). Elective admissions to surgical ICUs were higher than medical ones, length of hospital, and ICU stay was also longer in this group. In non–survivors, initial lactate was more elevated, and albumin was lower; the LAD was significantly higher than the survivors. As expected non–survivors had higher SOFA, Elixhauser Comorbidity Scores, and ICU severity scores (OASIS, APS III, SAPS II) ($p<0.001$, all).

In severe sepsis, cytokines release, capillary leakage, hypoxia, oxidative stress, and several factors affect albumin metabolism and action; thus, serum hypoalbuminemia is a risk factor for mortality.[16] Even in well–nourished patients, an acute situation like trauma or diseases causes hypoalbuminemia because it is associated with inflammation.[17] Surgery is a major

Table 4. Cutoff value, Youden index, sensitivity, specificity of predictors associated with in-hospital mortality

Predictors	Cutoff value	AUC	Youden's Index	Sensitivity (%)	Specificity (%)
SOFA score					
Overall	7	0.763	0.3348	69.19	70.50
Medical ICU	7	0.762	0.3975	68.58	71.17
Surgical ICU	8	0.776	0.4294	65.51	77.42
L-A Difference					
Overall	0	0.713	0.2999	64.60	65.39
Medical ICU	0	0.719	0.3166	62.41	69.25
Surgical ICU	2.1	0.735	0.3482	60.00	74.82
Lactate (max)					
Overall	4.3	0.680	0.2503	44.66	80.36
Medical ICU	3.6	0.681	0.2563	48.97	76.66
Surgical ICU	5.5	0.710	0.3153	51.03	80.49

SOFA: Sequential Organ Failure Assessment, **L:** Lactate, **A:** Albumin, **ICU:** intensive care unit, **AUC:** Area under the receiver operating characteristic curves

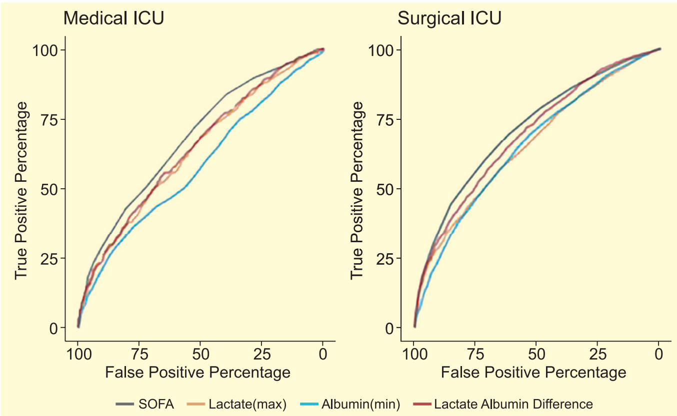

Figure 1. Area under the receiver operating characteristic curves (AUC) of in-hospital mortality
SOFA: Sequential Organ Failure Assessment, **ICU:** Intensive care unit

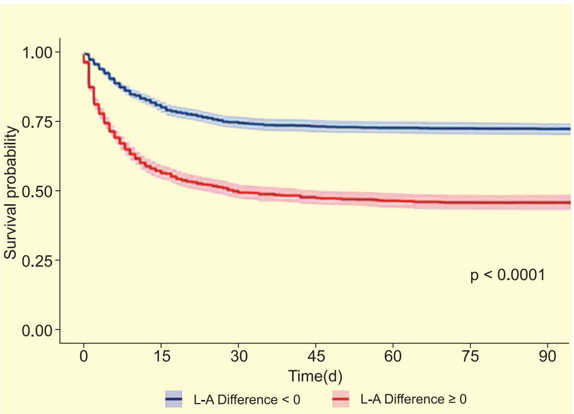

Figure 2. Kaplan-Meier 90-day survival curves for Lactate - Albumin Difference
L: Lactate, **A:** Albumin

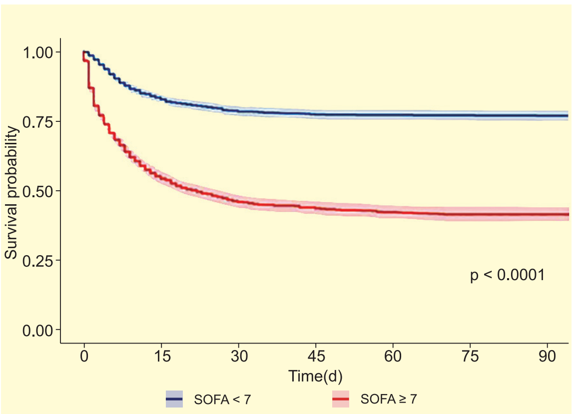

Figure 3. Kaplan-Meier 90-day survival curves for SOFA score

cause of trauma and inflammation. Patients who have hypoalbuminemia tend to have higher lactate levels, which may be the result of severe infection and microcirculatory disorder.[18] The albumin level was <3gm/L in the non–survivors in the surgical ICU, and it was not a predictor of mortality in medical and cardiovascular ICUs.[2] In surgical patients, the reason for hypoalbuminemia is not decreased synthesis but rather catabolism and the disturbance of its regulation by the stress endocrine response, liver function, and inflammatory markers.[19] Mechanical ventilation, metastatic cancer, and suspected infection rates were higher in surgical than medical ICUs; these factors may contribute to the difference in albumin and lactate levels between the ICUs. In our study, albumin levels also vary among medical and surgical ICUs.

Novel predictive markers derived from lactate and albumin measurements were proposed as studies revealed the significance of lactate and albumin in predicting mortality.[13,16,20]

Kong *et al*. evaluated the LAR's prognostic significance to maximize the initial values of lactate and albumin on admission.[16] In severe conditions, lactate levels increase, and albumin levels decrease, and the gap between lactate and albumin difference widens. Therefore, we evaluated LAD's significance rather than LAR in predicting mortality in different ICU admissions.

Univariate and multivariate logistics regression tests were conducted to explore the variables potentially associated with hospital mortality in intensive care patients. Using multivariate analysis, we found that factors including LAD, lactate, albumin, SOFA score other than gender all were risk factors independently associated with mortality. The combination of lactate and albumin, i.e., LAD (OR: 1.51, 95%CI 1.34, 1.70), may predict mortality better than maximum lactate level (OR: 0.74, 95%CI 0.66, 0.84) in ICUs.

SOFA score predicts mortality by using the worst parameters measured; and analyzing the six-organ system dysfunction. LAD predicts mortality by using only two parameters and can be used as an alternative to the SOFA score.[14] Unlike Acute Physiology And Chronic Health Evaluation III (APACHE III), both SOFA and LAD require less data collection and can be calculated without computer technology; therefore, they are less costly. The AUC of the LAD and SOFA were >0.70 for predicting in–hospital mortality. Yin *et al*., for better estimating the prognosis of septic patients, proposed combining albumin levels with sepsis outcome scoring systems.[18] Prediction of mortality in different ICUs was studied, AUC of SOFA score were 0.82 in medical ICU, 0.70 in postoperative surgical ICU, and 0,87 in trauma ICU.[21] In our study, different AUC values were identified in different ICUs, as well.

In this study different cutoff values of SOFA, LAD and lactate are evaluated in medical and surgical ICUs. Patient groups were identified as postoperative intensive care admissions and medical indications for ICU treatment. As expected, patients with high SOFA scores, urgent–emergent admissions, and elderly patients had higher mortality. The medical group had higher mortality than the surgery group (20.2%, 14.6%, respectively); this may be because postoperative surgical patients are sometimes admitted to ICU just for close monitoring and follow–up postoperatively. An increase in SOFA score ≥2 has more predictive value for hospital mortality than quick SOFA (qSOFA) and SIRS criteria.[22] In the non–survivors' group, SOFA and other ICU severity scores were higher, but we only evaluated the initial scores. Patients' admission types, comorbidities, and infection presence, ventilatory support vary among medical and surgical ICUs. (Table 2) In our study, although they have similar Elixhauser comorbidity scores, the surgical group had longer ICU and hospital LOS but less 30–day and 90–day mortality. In medical obese patients, the mortality rate was higher than surgical obese patients, and this significant difference persisted in the first-year post ICU admission.[23] Both in non–survivors and surgical ICU groups, lactate levels were high, and albumin levels were lower than the other group, which led to a higher LAD value.

Mortality factors should be identified according to the ICU–admission types and patients' comorbidities. The severity scores SAPS II and corrected APACHE IV are designed for ICU patients. Patients characteristics and admission types play an important role in mortality; therefore, new predictive values are needed, and severity scores could be tailored according to the unit they will be used.

There are several limitations to this study. First, as this is a retrospective cohort study, we are subject to selection and information bias; therefore, prospective investigations for further validation of this prediction algorithm is required. Second, it uses a single institution's database, and due to missing lactate and albumin data, it may not reflect the entire cohort. Technological improvements, digitalization of ICU data, and web-based calculators enable such algorithms to be automatically calculated and promptly given real–time mortality prediction scores.

To get the best results from these outcome prediction algorithms, they should be tailored according to the population they will use.

CONCLUSION

In our retrospective cohort study, LAD's predictor value of mortality was superior to initial minimum albumin and maximum lactate values. Different cutoff values of the SOFA score, LAD, and maximum lactate should be used in medical and surgical ICUs.

Further prospective multicenter studies should be conducted to reveal LAD's importance and different cutoff values of scores and parameters that are predictors of in-hospital mortality in medical and surgical ICUs patients.

Author Contributions

Gülbin Töre Altun (GTA), Mustafa Kemal Arslantaş (MKA), Pelin Corman Dinçer (PCD), Reyhan Arslantaş (RA), and Alper Kararmaz (AK) conceived and planned the study. They were mainly responsible for the design of the study. MKA and GTA collected the data. MKA and AK were primarily responsible for analyzing the data. GTA, MKA, PCD, and RA wrote the first draft of the manuscript. All authors contributed to the interpretation of findings and reviewed the manuscript. GTA, MKA, and AK reviewed the statistical analyses and made changes to the manuscript's content. All authors have also provided an intellectual contribution to the manuscript.

*The authors declare that there are no conflicts of interest.

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