

Prognostic Value of Red Cell Distribution Width in Critically Ill Patients and Comparison with Intensive Care Unit Scoring Systems

Emin Fatih Vişneci¹, Başar Cander², Mehmet Gül², Zerrin Defne Dündar², Ali Dur², Abdullah Sadık Girişgin²

¹Clinic of Emergency Medicine, Konya Training and Research Hospital, Konya, Turkey

²Department of Emergency Medicine, Necmettin Erbakan University Meram School of Medicine, Konya, Turkey

Abstract

Aim: This study aimed to investigate the prognostic value of lactate and red cell distribution width (RDW) parameters of patients admitted to emergency service and critical care unit (CCU).

Materials and Methods: A total of 147 patients hospitalized in the CCU of Necmettin Erbakan University, Meram Faculty of Medicine, Department of Emergency Medicine, were included in the study. Vital signs, laboratory results, lactate, and RDW values of the patients were recorded. Acute Physiology and Chronic Health Evaluation II (APACHE II) and sequential organ failure assessment (SOFA) scores were calculated. Duration of hospitalization and intensive care unit stay and mortalities were recorded. Chi-square, Fisher's exact chi-square, and Student t tests were used for statistical analyzes, and Mann-Whitney U test was used for comparing nonparametric data that were not compatible with a normal distribution. $P < 0.05$ were accepted as statistically significant. Spearman correlation analysis was used to assess whether a linear correlation existed between the parameters.

Results: A statistically significant correlation was found between the duration of stay in the CCU for < 7 days and total duration of hospitalization ($p < 0.001$). Also, statistically significant correlations were observed between mortalities of 28 days and 3 months, APACHE II and SOFA scores, and mean lactate (for 24 h and during hospitalization) and RDW values ($p < 0.001$, $p < 0.001$, $p < 0.001$, and $p < 0.05$, respectively). Moreover, correlations were noted between APACHE II scores, lactate value during the first admission, and SOFA scores ($p < 0.001$). Correlations were also observed between 48-h SOFA scores and RDW and lactate values ($p < 0.001$).

Conclusion: SOFA and APACHE II are the scoring systems used in practice. Efficiencies for mortality assessment of critical patients were confirmed. This study showed that lactate and RDW values, which were compatible with the scoring systems, could be used for assessing prognosis. Wider and more comprehensive studies that can assess scoring systems and lactate and RDW values together for prognostic identification are required to validate the findings.

Keywords: Acute physiology and chronic health evaluation II score, critical patient, intensive care, lactate, red cell distribution width, sequential organ failure assessment score

Introduction

Emergency services and emergency critical care units (CCUs) are the most frequently visited departments for the diagnosis and follow-up of critically ill patients (1). CCUs are the optional units among emergency services in Turkey where intensive care patients are followed up. The CCU of Necmettin Erbakan University, Meram School of Medicine, Department of Emergency Medicine, is also a tertiary intensive care unit (ICU). Longer durations for the diagnosis and transfer of critical patients to the other clinics increase the importance of emer-

gency CCUs. Remarkable knowledge of critical patient follow-ups and close follow-up of prognostic signs are necessary. Blood lactate level is one of the most frequently used parameters (2). Tissue hypoxia during shock and the condition after shock resuscitation are the indicators of prognosis for critical cases in terms of identification of severity and mortality risk of diseases and must be considered a useful indicator for conditions such as etiologic diagnosis (3, 4). Red cell distribution width (RDW) is one such indicator. RDW is an index for the variability of erythrocyte volumes and can be used for detecting the anisotosis grade. The RDW value is known to increase in many types of anemia,

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Correspondence to: Emin Fatih Vişneci e-mail: drfatihvisneci@hotmail.com

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hemoglobinopathies, and conditions such as blood transfusion. Recent studies have shown that RDW increases in cardiopulmonary diseases, such as coronary artery disease, heart failure, and pulmonary hypertension, and is strongly correlated with the prognosis (5, 6).

Acute Physiology and Chronic Health Evaluation II (APACHE II) and sequential organ failure assessment (SOFA) are highly efficient scoring systems for assessing disease severity and mortality of patients in ICUs.

The aim of this study was to detect the prognostic value of RDW and lactate for the patients admitted to emergency services and those in CCUs and to compare them with regard to scoring systems.

Materials and Methods

This was a prospective and observational study conducted in the CCU of Necmettin Erbakan University, Meram School of Medicine, Department of Emergency Medicine. Ethical approval was obtained. Male and female patients aged >18 years who provided informed consent and filled the study form completely were included in the study. Exclusion criteria were as follows: patients who received erythrocyte suspension during their stay in the CCU and in the last 2 weeks, cases with known hematologic malignancy, patients diagnosed with myelodysplastic syndrome, pregnant patients, and patients with malignancies and bone marrow invasion. A total of 647 patients were hospitalized in the CCU during the study period, and 164 of these, whose examinations were completed and who met the inclusion criteria, were included in the study. Three patients were excluded on their or relatives' request; eight patients due to their transfer to another center and six patients based on their blood transfusion needs were excluded from the study. Thus, 147 patients were included in the study. Demographic data, vital signs, and laboratory examinations of the patients were recorded starting from their stay in the CCU. The mean lactate values at the first admission, during the first 24 h, at 48 h, and during the CCU stay were recorded. In addition, the mean RDW value at the first admission, at 48 h, and during the follow-up in the CCU was recorded. Moreover, APACHE II and SOFA scores at first admission and 48 h were calculated. Total hospitalization durations were identified for the patients who stayed in the CCU for <7 days and >7 days. Mortalities at 28 days and 3 months were recorded.

Statistical analysis

The data were statistically assessed using Statistical Package for Social Sciences version 22.0 (IBM Corp.; Armonk, NY, USA). The chi-square test and when necessary Fisher's exact chi-square test were used for categorical data. The Student *t* test was used for parametric data, and the Mann-Whitney U test was used for comparing non-parametric data that were not compatible with a normal distribution. $p < 0.05$ was accepted as statistically significant. The Spearman correlation analysis was used to assess whether a linear correlation existed between some parameters and if the correlation coefficient (*r*) was 0.00-0.25 accepted as extremely weak, 0.26-0.49 accepted as weak, 0.50-0.69 accepted as moderate, 0.70-0.89 accepted as high, and 0.90-1.00 accepted as extremely high.

Results

The mortality and discharge rates of 147 patients included in the study according to their gender are shown in Table 1; 78 patients (53.1%) were males and 69 (46.9%) were females. The mean $\pm$ standard

Table 1. In-hospital mortality and discharge rates according to patient gender

	Death, n (%)	Discharge, n (%)	Total, n (%)
Male	34 (57.6)	44 (50)	78 (53.1)
Female	25 (42.4)	44 (50)	69 (46.9)
Total	59 (100)	88 (100)	147 (100)

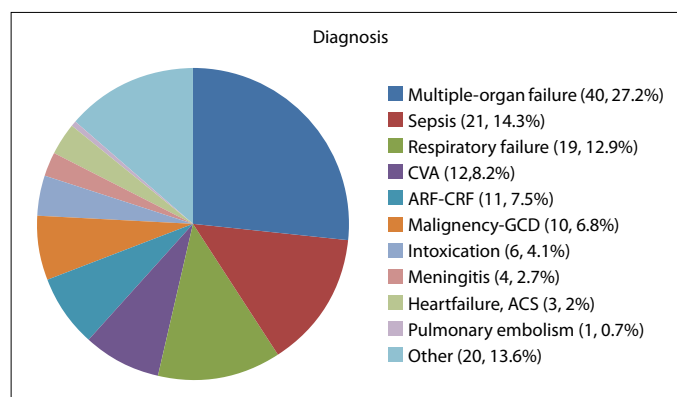


Figure 1. Distribution of patients according to diagnosis

CVA: cerebro vascular accident; ARF: acute renal failure; CRF: chronic renal failure; GCD: general condition disorder

deviation age was 67 ± 15 years; 59 patients (40.1%) died in the hospital, and 88 (59.9%) were discharged.

The distribution of the patients according to their diagnoses is shown in Figure 1. The most frequent diagnoses were sepsis and multiple organ failure.

The mean APACHE II score at the first hospitalization in the CCU was 16 ± 6.5 . The SOFA score at first hospitalization and at 48 h was 5.6 ± 2.8 and 5.9 ± 2.9 , respectively. The mean RDW value at the first hospitalization, at 48 h, and during their stay in the CCU was 13.8 ± 2.5 , 13.8 ± 2.6 , and 13.8 ± 2.5 , respectively. The mean lactate value at first admission in the CCU, at 24 h, mean value at 24 and 48 h was 2.6 ± 2.5 , 1.9 ± 1.6 , 2.2 ± 1.7 , and 1.7 ± 1.3 , respectively. The mean lactate value for the period of stay in the CCU was 1.9 ± 1 .

The mean duration of the stay in the CCU was 10.9 ± 11.8 days (the shortest was 1 d and the longest was 88 d). The mean duration of total hospital stay was 14 ± 13 days (the shortest was 2 d and the longest was 88 d).

Patients who were followed up in the CCU for <7 days and >7 days were compared with the those who survived and those who died in 28 days and 3 months in terms of lactate and RDW values and APACHE II and SOFA scores. Age, gender, and APACHE II and SOFA scores at first admission and at 48 h, mean RDW values at first admission and at 24 h, mean value at 24 and 48 h, and mean lactate value during the whole hospital stay were compared between the groups. Also, the total duration of stay and the duration of stay in the CCU were compared between groups. Patients diagnosed with respiratory failure were excluded while assessing RDW.

The comparison of statistics of the patients followed up in the CCU for <7 days and >7 days is shown in Table 2. The total duration of stay of the patients followed up in the CCU for <7 days was 7.5 ± 6.2 days. The total duration of stay of the patients followed up in the CCU for ≥ 7 days was 20.1 ± 14.4 days ($p < 0.001$).

The comparison of statistics for the patients who survived and those who died in 28 days is shown in Table 3. A statistically signif-

Table 2. Comparison of age, gender, APACHE II score, SOFA score, duration of stay, mean lactate, and RDW values of the patients for the duration of stay in the CCU shorter than 7 days and longer than 7 days

Duration of stay	<7 Days		≥7 Days		P
Age, year (mean±SD)	67±15		67.6±16		0.834
	n	%	n	%	
Gender					
Male	35	50.7	43	55.1	0.593
Female	34	49.3	35	44.9	
APACHE II	15±6.3		17±6.9		0.080
SOFA at first admission	5.3±2.7		5.8±2.9		0.301
SOFA at 48 h	5.5±3.3		6.2±2.7		0.144
RDW at first admission	13.8±2.4		13.9±2.6		0.724
RDW at 48 h	13.9±2.7		13.9±2.6		0.989
Mean RDW (during stay)	13.7±2.5		14±2.6		0.381
Lactate at first admission	2.2±1.4		2.9±3.1		0.749
Lactate at 24 h	2.2±2		1.7±1		0.418
Mean lactate value during 24 h	2.3±1.8		2.2±1.7		0.561
Lactate at 48 h	1.8±1.6		1.7±1		0.256
Mean lactate (during stay)	1.9±1.3		1.8±0.9		0.796
Duration of stay in the CCU	3.8±1.4		17.2±13.5		0.000
Total duration of stay	7.5±6.2		20.1±14.4		0.000
APACHE II: acute physiology and chronic health evaluation II; SOFA: sequential organ failure assessment; RDW: red cell distribution width; CCU: critical care unit					

icant difference was observed between the patients who survived and died in 28 days in terms of APACHE II score ($p=0.001$). A statistically significant difference was found between the SOFA scores at the first admission and at 48 h ($p<0.001$). Moreover, a statistically significant difference in the lactate level at the first admission was observed ($p=0.032$). A statistically significant difference was noted between lactate values at 24 h, mean value at 24 h, and mean value during the hospital stay ($p<0.001$). Also, a statistically significant difference was observed in lactate values at 48 h ($p=0.001$). Moreover, a statistically significant difference was found in the RDW values at first admission and at 48 h and the mean RDW value ($p=0.013$, $p=0.029$, and $p=0.021$, respectively).

The comparison of the statistics for the patients who survived and those who died in 3 months is shown in Table 4. No statistically significant difference was found between the patients who survived and those who died in 3 months in terms of age, gender, and total duration of the stay. The APACHE II score at first admission and the SOFA score at

Table 3. Comparison of age, gender, APACHE II score, SOFA score, duration of stay, mean lactate, and RDW values in terms of 28-day mortality

Clinical result	Dead		Alive		p
Age, year (mean±SD)	70±13.2		65.8±16.6		0.114
	n	%	n	%	
Gender					
Male	31	59.6	47	49.5	0.239
Female	21	40.4	48	50.5	
APACHE II	18.6±6.7		14.7±6.2		0.001
SOFA at first admission	6.8±3		4.9±2.5		0.000
SOFA at 48 h	7.2±3.3		4.9±2.3		0.000
RDW at first admission	14.±2.6		13.6±2.4		0.013
RDW at 48 h	14.5±2.9		13.4±2.2		0.029
Mean RDW (during stay)	14.5±2.6		13.4±2.3		0.021
Lactate at first admission	3.2±3		2.2±2		0.032
Lactate at 24 h	2.7±2.1		1.4±0.7		0.000
Mean lactate value during 24 h	3±2.2		1.7±1		0.000
Lactate at 48 h	2.1±1.7		1.5±0.9		0.001
Mean lactate (during stay)	2.4±1.4		1.6±0.7		0.000
Duration of stay in the CCU	9.2±6.2		11.9±14		0.704
Total duration of stay	10.2±6.6		16.4±15		0.045
APACHE II: acute physiology and chronic health evaluation II; SOFA: sequential organ failure assessment; RDW: red cell distribution width; CCU: critical care unit					

48 h were higher in the patients who died than in those who survived ($p<0.001$). Lactate values at first admission and at 24 h, mean value at 24 h, and mean value during the hospital stay was different in the patients who died compared to those who survived ($p=0.012$, $p=0.002$, and $p<0.001$, respectively). RDW values at first admission, at 48 h, and during the stay in the CCU were higher in the patients who died than in those who survived ($p=0.016$, $p=0.015$, and $p=0.024$, respectively).

The duration of stay in the CCU was higher in the patients who died than in those who survived. A statistically significant increase in mortality was detected with the increase in the duration of stay in the CCU ($p=0.042$).

Finally, it was assessed whether a correlation existed in terms of age, gender, APACHE II scores, SOFA scores (at first admission and at 48 h), RDW values (at first admission and at 48 h and mean value during the hospital stay), lactate values (at first admission and at 24 h, mean value at 24 h and 48 h, and mean value during the hospital stay), duration of stay in the CCU, and total hospitalization duration. A correlation was found between the SOFA score at first admission and RDW value at

Table 4. Comparison of age, gender, APACHE II score, SOFA score, duration of stay, mean lactate, and meand RDW values of the patients that died and survived in 3 months

Clinical result	Dead		Alive		p
Age, year (mean±SD)	68.4±14.8		66.7±16.2		0.509
	n	%	n	%	
Gender					
Male	34	57.6	44	50	0.364
Female	25	42.4	44	50	
APACHE II	18.5±6.8		14.5±6		0.000
SOFA at first admission	6.7±2.9		4.8±2.5		0.000
SOFA at 48 h	7.5±3		4.8±2.4		0.000
RDW at first admission	14.4±2.6		13.2±2		0.016
RDW at 48 h	14.4±2.8		13.3±2.2		0.015
Mean RDW (during stay)	14.4±2.6		13.4±2.3		0.024
Lactate at first admission	3.1±2.9		2.2±2.1		0.012
Lactate at 24 h	2.4±1.9		1.5±0.9		0.002
Mean lactate value during 24 h	2.8±2.1		1.7±1		0.000
Lactate at 48.hour	2±1.6		1.5±0.9		0.011
Mean lactate (during stay)	2.3±1.3		1.6±0.7		0.000
Duration of stay in the CCU	13.4±15		9.2±8.8		0.042
Total duration of stay	14.9±15.4		13.7±11		0.865
APACHE II: acute physiology and chronic health evaluation II; SOFA: sequential organ failure assessment; RDW: red cell distribution width; CCU: critical care unit					

first admission, mean RDW value during the hospital stay, and lactate value at first admission ($p=0.025$, $p=0.043$, and $p=0.011$, respectively). A correlation was observed between the SOFA score at 48 h and RDW value at 48 h and mean RDW value during the hospital stay ($p=0.04$ and $p<0.001$, respectively). Also, a correlation was observed between the lactate value at 48 h and RDW value at 48 h and mean RDW value during the hospital stay ($p=0.003$ and $p=0.005$, respectively). Moreover, a correlation was noted between the APACHE II score and SOFA score at first admission ($r=0.682$) and the SOFA score at 48 h ($r=0.631$; $p<0.001$ and $p<0.001$, respectively) (Figure 2).

Discussion

Critical patients are those with unstable life functions, who are receiving supportive treatment, with poor general conditions, and generally treated in ICUs (7).

The lifespan has been prolonged due to the improvement in life conditions and higher access rates of patients to health services with development in medical sciences.

The available literature shows that 46% of the patients hospitalized in the ICUs are older patients (8). This has led to a significant increase in mortality rates of the older patients hospitalized in the ICUs (9-11). Most of the patients in the present study were older patients. However, a 7-day stay in the CCU, 28-day and 3-month mortality, and age were not found to be significantly correlated. This might be due to the differences between diagnoses of age groups, scores, and the lack of classification according to the age groups. It is necessary to assess the influence of age on mortality rates of different patient groups in terms of diagnosis, gender, APACHE II and SOFA scores, and Glasgow Coma Score.

Mahmood et al. (12) explored the relation between age and clinical course and found no significant difference between female and male patients who were aged 50 years and older, but the mortality at the age of 50 years was lower in female patients than in male patients. Jacobson et al. (13) conducted a prospective observational cohort with the patients internalized in the ICU for a 3-year period; with sepsis in the first 24 h, no correlation was found between mortality, hospitalization duration, and gender. The present study found no statistically significant difference between the genders in terms of the 28-day and 3-month mortalities ($p>0.05$).

Another study by Wang et al. (14) performed in collaboration with medical and surgical ICUs in Canada assessed 1960 patients, and the most frequent reason for hospitalization was found to be multiple trauma and septic shock, followed by respiratory problems (14). Two and three patients had sepsis and respiratory problems, respectively, in the present study, whereas one patient had multiple organ failure due to several reasons. This might be because the current CCU was a general ICU.

Clinical findings in the ICU and laboratory results are used to estimate the prognosis and death risk of the patients in the ICUs. Lactate is one of the most frequent and easily assessed parameters used in shock and other critical diseases (15). Higher lactate values must be considered as a useful indicator in identifying the severity of diseases and mortality rates (16-19). On the contrary, some studies showed the first lactate values as a weak indicator of mortality (20). The present study found a statistically significant difference between lactate values at first admission and at 24 h, mean values at 24 h, 48 h, and during the stay, and 28-day and 3-month mortalities. However, a higher P value was reported for the lactate values at the first admission. Lactate values other than the value at the first admission were more significant.

However, the number of studies on RDW values used in daily practice but not receiving sufficient attention has increased recently. RDW was found to be related to mortality and hospitalization duration. Therefore, RDW is a parameter to be focused on. Physiologic mechanisms (oxidative stress, inflammation, and weak pulmonary function) with higher RDW rates and higher death rates in terms of cardiovascular mortality have been demonstrated but are not completely known (21, 22). Wang et al. (14) found a correlation between higher RDW rates and the APACHE II score. They also found the RDW value to correlate with mortality and duration of stay. Hunziker et al. (23) showed the prognostic value of RDW for ICU mortality, in-hospital mortality, and Simplified Acute Physiology Score (SAPS). The present study found a correlation between RDW value and 28-day and 3-month mortality. Moreover, a correlation was observed between RDW values, SOFA scores at the first admission and at 48 h, and lactate values at 48 h.

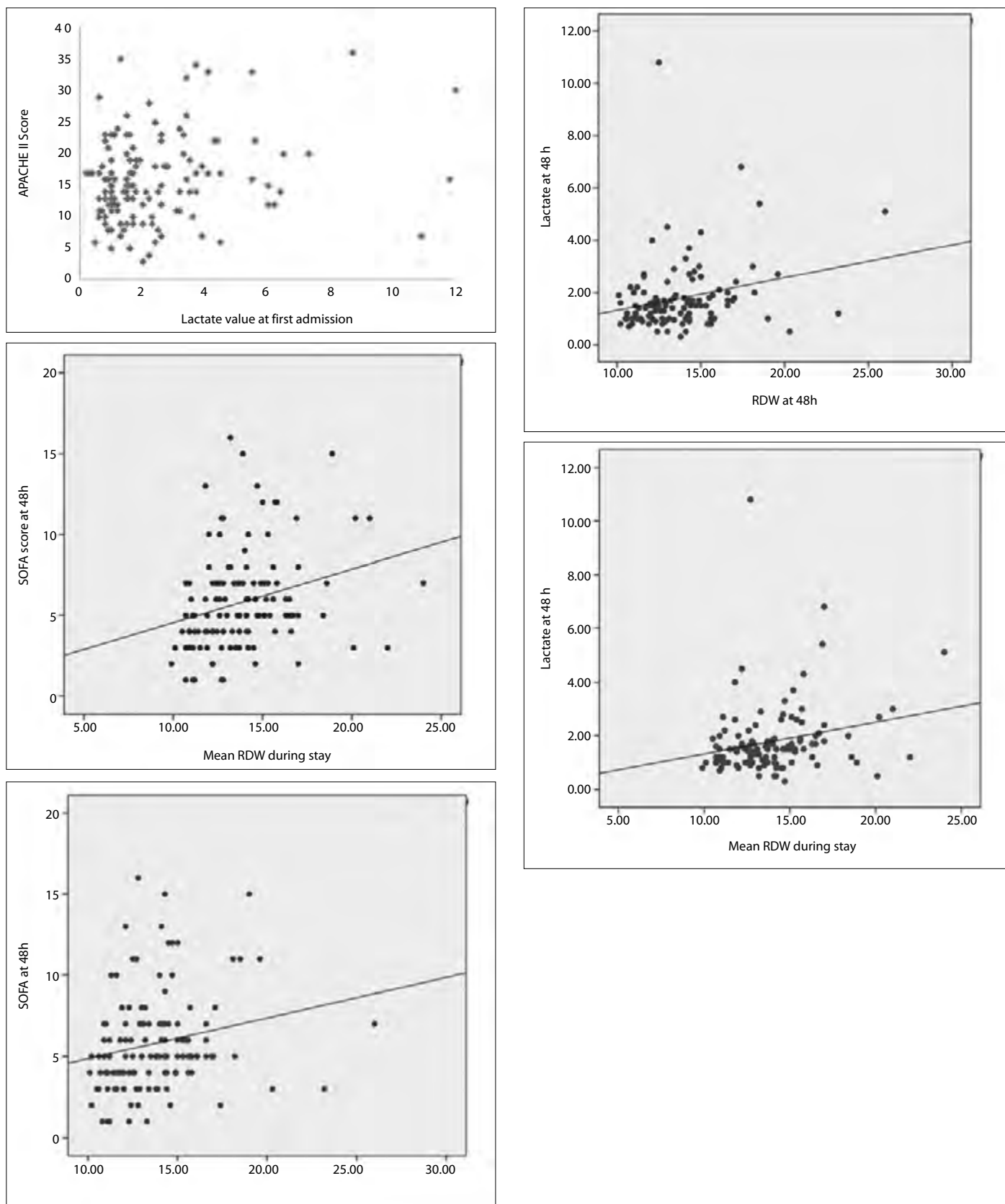


Figure 2. a-e. (a) Correlation between the lactate value at first admission and APACHE II score, (b) Correlation between the mean RDW value during stay and SOFA score at 48 h, (c) Correlation between the RDW value and SOFA score at 48 h, (d) Correlation between the RDW value and lactate value at 48 h, (e) Correlation between the mean RDW value during stay and lactate value at 48 h
APACHE II: acute physiology and chronic health evaluation II; SOFA: sequential organ failure assessment; RDW: red cell distribution width

The present study found a correlation between one of the most commonly used parameters APACHE II and SOFA scores with 28-day and 3-month mortalities. Hantke et al. (24) assessed SOFA and APACHE II scores in 874 surgical intensive care patients and found the values below the line identified for mortality (0.73 for APACHE II and 0.71 for SOFA). Timsit et al. (25) calculated SOFA scores for each day in a 1-week period for 1685 intensive care patients. For the first week in the ICU, the SOFA score was used to estimate mortality, and was suggested for use to estimate contributions of background diseases to death risk. The estimation of mortality for the patients in the CCU by using APACHE II and SOFA scores in the present study was compatible with the literature. APACHE II and SOFA scores were found to correlate with mortality. Higher statistically significant APACHE II and SOFA scores were observed in the patients who died while assessing the 28-day and 3-month mortalities.

Conclusion

Therefore, APACHE II and SOFA scores continue to be an important guide for estimating mortality. Lactate and RDW values, which are compatible with scoring systems, are considered prognostic indicators. Also, more comprehensive studies will help in assessing the parameters that can be used for the prognosis of critical patients.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Necmettin Erbakan University School of Medicine (18.01.2013, Decision No: 2013-332).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Conflict of Interest: No conflict of interest was declared by the authors.

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