



Kerim ABATAY^{1, a}
Ali HALICI^{2, b}
Uğur KAHVECİ^{3, c}
İzzettin HÜR^{4, d}
Engin Deniz ARSLAN^{5, e}

¹ Social Security Institution
General Directorate of
General Health Insurance,
Department of Emergency
Medicine,
Ankara, TÜRKİYE

² Kütahya University of
Health Sciences,
Department of Emergency
Medicine,
Kütahya, TÜRKİYE

³ Eskişehir City Hospital
Department of Emergency
Medicine,
Eskişehir, TÜRKİYE

⁴ Mehmet Akif İnan Training
and Research Hospital,
Department of Emergency
Medicine,
Şanlıurfa, TÜRKİYE

⁵ Antalya Training and
Research Hospital,
Department of Emergency
Medicine,
Antalya, TÜRKİYE

^a ORCID: 0000-0003-4936-3665

^b ORCID: 0000-0003-1392-4694

^c ORCID: 0000-0003-1219-4079

^d ORCID: 0000-0003-3169-7798

^e ORCID: 0000-0002-0155-6903

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Correspondence

Ali HALICI

Kütahya University of
Health Sciences,
Department of Emergency
Medicine,
Kütahya - TÜRKİYE

ali.halici@ksbu.edu.tr

Examination of the Relationship of Blood Copeptin Levels and Pneumonia Severity Scores on Prognosis in Patients Diagnosed with Community-Acquired Pneumonia in the Emergency Department

Objective: In this study, it was aimed to examine the prognostic significance of copeptin in patients with community-acquired pneumonia (CAP) who were admitted to the emergency department.

Materials and Methods: Vital signs, symptoms, examination findings, background information, pneumonia severity scores, laboratory results, and radiological imaging results of 61 patients diagnosed with CAP who were admitted to the emergency department were recorded. Serum copeptin levels of the patients were measured at the time of admission.

Results: 32 (thirtytwo) (52.5%) of 61 patients in the study were male. The median age of the patients was 73 (31-91). 19 out of 61 patients died during the 30-day follow-up period. The copeptin levels of the patients who died were significantly higher than those who survived ($p<0.05$). When the patients were grouped according to pneumonia severity scores, no significant difference was observed between biomarkers. In the ROC analysis of models that were created with biomarkers and pneumonia severity scores, the strongest indicator was Copeptin + C-reactive protein + procalcitonin (AUC 0.747).

Conclusion: As a result, plasma copeptin level can be used in community-acquired pneumonia to estimate severity and mortality. Multiple use of biomarkers and/or use with pneumonia risk scores is superior to their singular use in determining disease prognosis and mortality.

Key Words: Community-acquired pneumonia, copeptin, mortality, CRP, procalcitonin

Acil Servise Başvuran Toplum Kökenli Pnömoni Tanılı Hastalarda Kan Kopeptin Düzeyi ile Pnömoni Ciddiyet Skorlarının Prognoz Üzerine Etkisinin İncelenmesi

Amaç: Bu çalışmanın amacı, toplum kökenli pnömoni (TKP) tanısı ile acil servise başvuran hastalarda kopeptin düzeyinin prognostik değerini ve pnömoni ciddiyet skorları ile ilişkisini değerlendirmektir.

Gereç ve Yöntem: Acil servise başvuran ve TKP tanısı alan 61 hastanın yaşamsal bulguları, semptomları, fizik muayene bulguları, özgeçmiş bilgileri, pnömoni ciddiyet skorları, laboratuvar ve radyolojik inceleme sonuçları kaydedildi. Hastaların başvuru anında serum kopeptin düzeyleri ölçüldü. İstatistiksel analizler SPSS 20.0 ve E-PICOS yazılımları ile gerçekleştirildi.

Bulgular: Çalışmaya dahil edilen 61 hastanın 32'si (%52.5) erkekti ve hastaların medyan yaşı 73 (31-91) olarak saptandı. Otuz günlük takip sürecinde 19 hasta hayatını kaybetti. Mortalite görülen hastalarda kopeptin düzeyleri, sağ kalanlara kıyasla anlamlı düzeyde yüksek bulundu ($p<0.05$). Hastalar pnömoni ciddiyet skorlarına göre gruplandırıldığında, biyobelirteç düzeyleri açısından gruplar arasında anlamlı fark saptanmadı. Biyobelirteçler ve pnömoni ciddiyet skorlarının birlikte değerlendirildiği ROC analizinde en yüksek tanılabilirlik Kopeptin + CRP + Prokalsitonin kombinasyonunda elde edildi (AUC: 0.747).

Sonuç: Plazma kopeptin düzeyinin, toplum kökenli pnömoni tanısı alan hastalarda hastalık şiddetini ve mortalite riskini öngörmeye kullanılabileceği sonucuna varılmıştır. Biyobelirteçlerin çoklu kullanımı ve/veya pnömoni ciddiyet skorlarıyla birlikte değerlendirilmesi, tek başına kullanımına göre hastalık prognozu ve mortalite tahmininde daha etkilidir.

Anahtar Kelimeler: Toplum kökenli pnömoni, kopeptin, mortalite, C-reaktif protein, prokalsitonin

Introduction

Pneumonia is the inflammation of the lung parenchyma. Community-acquired pneumonia (CAP) is pneumonia caused by infectious agents acquired in the community in an individual without known immunodeficiency. While mortality due to pneumonia is 1-5% in outpatients, it reaches 12% in hospitalized patients and 40% in patients who require intensive care support (1).

Prediction of disease severity and prognosis in CAP is necessary for the correct and effective use of health system resources. Standardized scoring systems such as pneumonia severity index (PSI), CURB-65 (confusion-urea nitrogen-respiratory rate-blood pressure-65 years of age), national early warning score (NEWS), and national early warning score-lactate (NEWS-L) have been developed for the decisions of

admission to the service or intensive care unit, early discharge, and antimicrobial therapy (2). While these scoring systems have moderate sensitivity and specificity in determining the treatment method, they have not achieved sufficient success in determining mortality. All these limitations have led clinicians to find reliable, sensitive, and specific prognostic markers.

Materials and Methods

Research and Publication Ethics: The study was conducted in Ankara Diskapı Training and Research Hospital in accordance with the research rules, with the approval of the Ethics Committee Decision dated 02.04.2018 and numbered 48/04.

Adult patients (age > 18 years) who were admitted to the emergency department of the hospital and were diagnosed with CAP based on clinical and laboratory findings were included in the study. CAP diagnosis was made in the presence of at least two symptoms such as fever, cough, sputum, and shortness of breath that suggested an acute lower respiratory tract infection with newly developed pulmonary infiltration on chest X-ray. Patients who were hospitalized in the last 14 days, pregnant women, those with a history of immunosuppression, pulmonary embolism (PE), chronic obstructive pulmonary disease (COPD) attack, decompensated heart failure, pulmonary edema, and acute coronary syndrome were not included in the study. A control group of 25 people with a similar mean age and sex ratio was formed in accordance with the study exclusion criteria.

An informed consent form was obtained from the patients included in the study. The history of the patients was taken from the patients themselves or from their caregivers. They were examined, and imaging and laboratory tests were requested.

Demographic characteristics, history and physical examination, risk factors, vital signs and treatment information of the patients were obtained from the patient follow-up forms. For Copeptin, 5 cc of blood was collected from all patients in standard biochemistry tubes and centrifuged. The plasma was stored at -80 C°. The stored samples were brought to room temperature and thawed one day before the study. Serum copeptin levels were studied in the biochemistry laboratory of our hospital using the *Diasorin Etimax 3000* device and the Human Copeptin ELISA kit.

Hemogram, biochemistry, sedimentation, and ELISA test results were obtained from the hospital database. The CURB-65, PSI, NEWS and NEWS-L scores of the patients included in the study were calculated and recorded. A 30-day follow-up period was conducted after the diagnosis of CAP, and the 30-day mortality rate was recorded.

Statistical Analysis: The SPSS (Statistics Program for Social Scientists) 20 and E-PICOS programs were used for statistical analysis. Continuous data were expressed as mean \pm standard Deviation. Categorical data were presented as a percentage (%).

The Kolmogorov-Smirnov test was performed to check if the data showed normal distribution. Among the groups, the Mann-Whitney U test was performed to compare the data of two groups that did not fit the normal distribution, the Kruskal-Wallis test was performed for the comparison of the data of more than two groups, and Student's t-test was performed to compare normally distributed data. The Chi-Square test was performed to compare frequency data between the two groups. ROC (Receiver-Operating Characteristic) analyzes were performed to determine the correct cut-off point for the independent markers and to calculate the sensitivity and specificity values. Logistic regression analysis was performed to determine the independent marker affecting mortality, whereby $p < 0.05$ was considered statistically significant.

Results

Of the 75 patients initially included in the study, 5 of them were excluded from follow-up due to heart failure, 1 due to acute coronary syndrome (ACS), 2 due to pulmonary thromboembolism (PTE) and 4 due to COPD attacks. Lastly, 2 of the remaining 63 patients were excluded from the study because copeptin values could not be obtained due to device failure while the sera reserved for copeptin were being studied. A total of 32 (52.5%) of the 61 patients with a diagnosis of CAP included in the study were male (Table 1). The median age of the patients was 73 (IQR 31-91) (Table 1). When the complaints of the patients were examined, 23 (37.7%) had fever, 41 had (67.2%) cough, 39 (63.9%) had sputum, and 14 (23.0%) had purulent sputum (Table 1). It was observed that hypertension was determined in 33 (54.1%) of the patients, COPD in 28 (45.9%), CAD in 20 (32.8%), Diabetes Mellitus in 17 (27.9%), chronic heart failure (CHF) in 13 (21.3%), Cerebrovascular Disease in 8 (13.1%), Chronic Liver Disease in 4 (6.6%) and other diseases in 4 (6.6%) accompanied CAP diagnosis. When the deceased and surviving patients were compared, mortality was higher in patients with CAP accompanied by COPD ($p=0.039$) (Table 1). While 22 (36.1%) of the patients were smokers, 39 (63.9%) were non-smokers (Table 1). Distribution of patients in the study group according to demographic characteristics and pneumonia risk scores is presented in Table 1.

When the patients were classified according to PSI, there were 4 (6.6%) patients with a PSI score of 3, 18 (29.5%) patients with a PSI score of 4, and 39 patients (63.9%) with a PSI score of 5. There were 14 (23%) patients with a CURB65 score of 1, 28 (45.9%) with 2, 12 (19.7%) with 3, 6 (9.8%) with 4, and 1 (1.6%) with 5. The mean NEWS score of the patients was 7.1 ± 2.88 and the mean NEWS-L score was 9.6 ± 3.46 . When the deceased and surviving patients were compared, PSI, CURB-65, NEWS and NEWS-L scores were found to be higher in the deceased group. PSI and NEWS-L were statistically significant in predicting mortality ($p=0.045$, $p=0.021$). The number of patients who died during the 30-day follow-up period was 19 (31.1%) (Table 1, Figure 1).

Table 1. Demographic characteristics and pneumonia risk scores

	All Patients	Survivals	Nonsurvivals	p
Age. median (min-max)	73 (31-91)	74.5 (31-91)	72 (48-86)	0.907
Sex				0.592
Male	32 (52.5%)	23 (54.8%)	9 (47.7%)	
Female	29 (47.5%)	19 (45.2%)	10 (52.6)	
Complaint/Symptom				
Fever	23 (37.7%)	15 (35.7%)	8 (42.1%)	0.633
Coughing	41 (67.2%)	27 (64.3%)	14 (73.7%)	0.469
Sputum	39 (63.9%)	26 (61.9%)	13 (68.4)	0.624
Purulent sputum	14 (23.0%)	12 (28.6%)	2 (10.5%)	0.190
Comorbidity				
Hypertension	33 (54.1%)	22 (52.4%)	11 (57.9%)	0.689
COPD	28 (45.9%)	23 (54.8%)	5 (26.3%)	0.039
CAD	20 (32.8%)	13 (31)	7 (36.8%)	0.650
Diabetes Mellitus	17 (27.9%)	12 (28.6)	5 (26.3)	0.856
CHF	13 (21.3%)	7 (16.7%)	6 (31.6%)	0.188
CVA	8 (13.1%)	4 (9.5%)	4 (21.1%)	0.241
CKD	4 (6.6%)	1 (2.4%)	3 (15.8%)	0.085
Chronic Liver Disease	5 (8.2%)	4 (9.5%)	1 (5.3%)	0.500
Other	4 (6.6%)	4 (9.5%)	1 (5.3)	0.500
Smoking	22 (36.1%)	14 (33.3%)	8 (42.1)	0.509
PSI. median(min-max)	141 (61-212)	138.5(61-201)	160(98-212)	0.045
3	4 (6.6%)	4 (9.5%)	-	
4	18 (29.5%)	14 (33.3%)	4 (21.1%)	
5	39 (63.9%)	24 (57.1)	15 (78.9%)	
CURB65. median(min-max)	2 (1-5)	2 (1-4)	2 (1-5)	0.127
1	14 (23%)	12 (28.6%)	2 (10.5%)	
2	28 (45.9%)	19 (45.2%)	9 (47.4%)	
3	12 (19.7%)	6 (14.3%)	6 (31.6%)	
4	6 (9.8%)	5 (11.9%)	1 (5.3%)	
5	1 (1.6%)	-	1(5.3%)	
NEWS median(min-max)	7 (1-14)	6 (1-14)	8 (2-10)	0.112
NEWSL. median(min-max)	9.6 (1.9-21.2)	8.55 (1.9-16)	10.3(6.4-21.2)	0.021

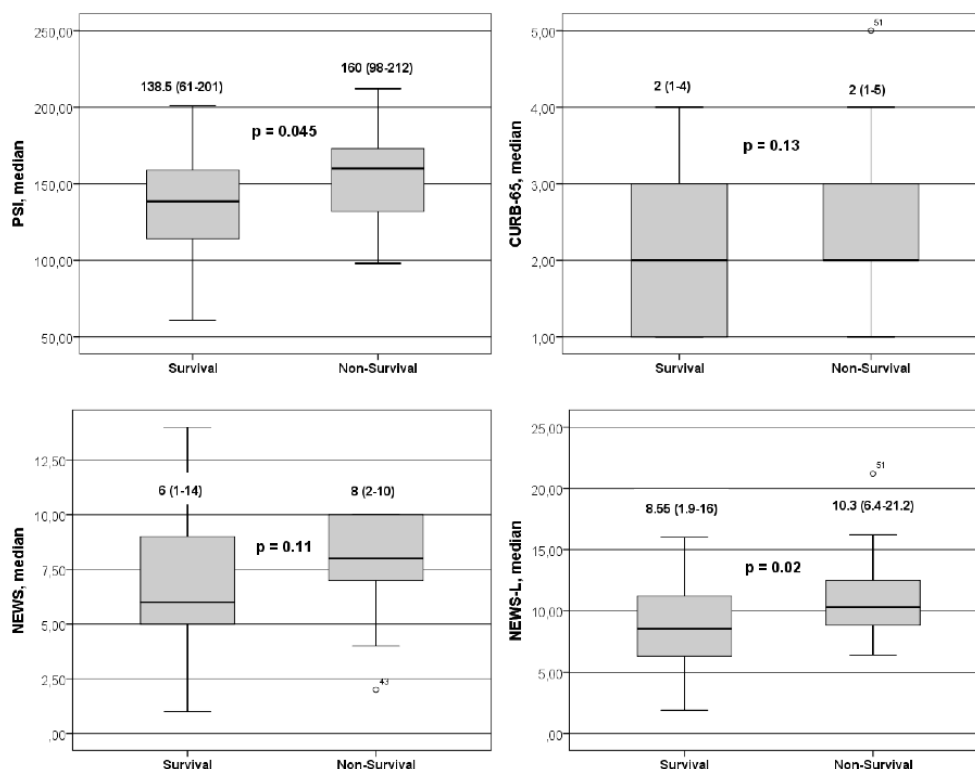


Figure 1. Comparison of Pneumonia Risk Scores in patients who died due to CAP and those who survived

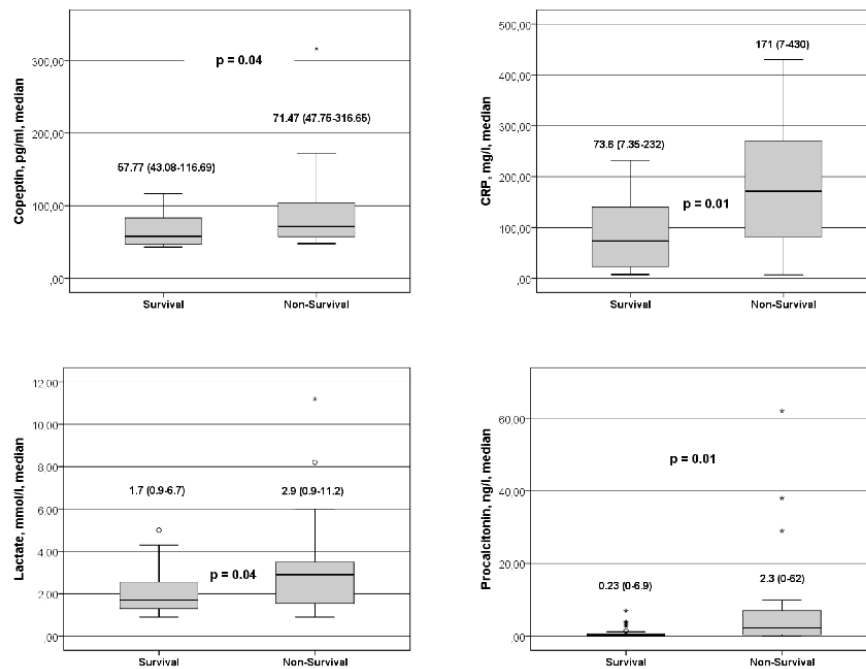


Figure 2. Comparison of biomarkers in patients who died due to CAP and those who survived

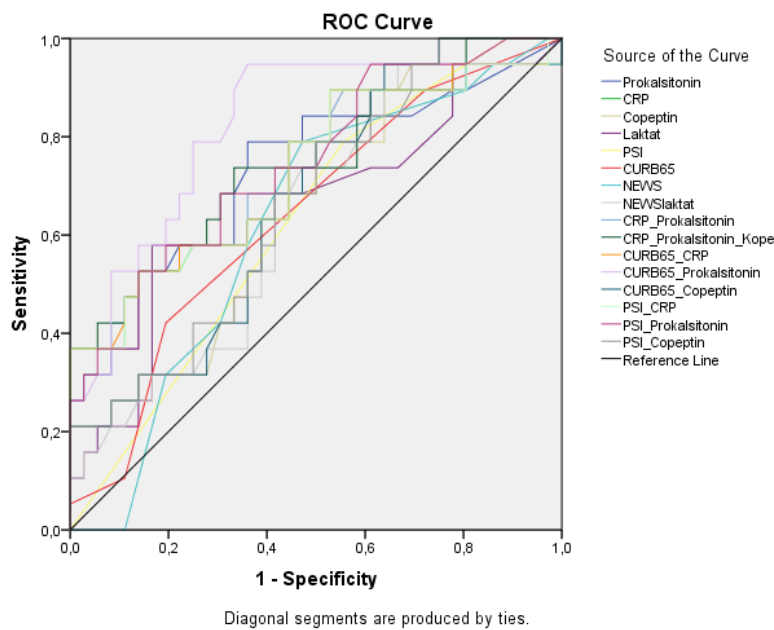


Figure 3. The cut-off values obtained from the ROC analysis for mortality prediction of CAP patients, and their specificity and sensitivity

Table 2. Demographic characteristics and copeptin levels of control and patient groups

	Control	Patient	p
Age (min-max)	68 (32-88)	73 (31-91)	0.841
Sex			0.822
Male	13 (52%)	32 (52.5%)	
Female	12 (48%)	29 (47.5%)	
Copeptin Median (min-max)	27.73 (3.26-94.57)	64.32 (43.08-316.65)	<0.001

Table 3. Creatinine, lactate, ESH, CRP, PCT and copeptin correlation analysis

		Lactate	ESH	CRP	PCT	Copeptin
Creatinine	r	0.123	0.085	0.268	0.424	0.089
	<i>p</i>	0.346	0.547	0.044	0.001	0.495
Lactate	r		0.167	0.005	0.325	0.080
	<i>p</i>		0.233	0.972	0.014	0.540
ESH	r			0.314	0.279	0.077
	<i>p</i>			0.023	0.043	0.583
C-reactive protein	r				0.576	0.235
	<i>p</i>				<0.001	0.078
Procalcitonin	r					0.152
	<i>p</i>					0.265

Table 4. Univariate and multivariate logistic regression analysis for mortality

	<i>p</i>	OR	95% CI	
			Lower	Upper
Univariate				
Procalcitonin	0.044	1.001	1.367	1.853
CRP	0.003	1.011	1.004	1.018
Copeptin	0.044	1.001	1.000	1.033
Lactate	0.036	1.458	1.025	2.075
PSI	0.055	1.016	1.000	1.023
NEWS-L	0.031	1.217	1.018	1.454
Multivariate				
Procalcitonin	0.166	1.247	0.912	1.705
CRP	0.022	1.010	1.001	1.018
Copeptin	0.635	1.007	0.979	1035
Lactate	0.695	1.093	0.700	1707
NEWS-L	0.131	1216	0.943	1567

Table 5. The cut-off values obtained from the ROC analysis for mortality prediction of CAP patients, and their specificity and sensitivity

	Cut-off value	AUC	95% CI	<i>p</i>	Sensitivity (%)	Specificity (%)
PCT (ng/mL)	0.39	0.730	0.58-0.88	0.005	68	67
CRP (mg/L)	119	0.730	0.58-0.87	0.006	63	64
Copeptin (pg/mL)	63.61	0.663	0.52-0.81	0.048	68	58
Lactate (mmol/L)	2.75	0.657	0.49-0.82	0.052	58	83
PSI	3.5	0.629	0.48-0.77	0.119	78	44
CURB-65	2.5	0.641	0.49-0.79	0.088	42	81
NEWS	6.5	0.625	0.47-0.78	0.130	78	53
NEWS-L	9	0.647	0.50-0.79	0.075	73	53
CRP+PCT	77.84	0.735	0.59-0.89	0.004	78	56
CRP+PCT+Copeptin	178,93	0.747	0.61-0.89	0.003	74	67
CURB-65+CRP	80.15	0.733	0.59-0.88	0.005	79	56
CURB-65+PCT	3.23	0.821	0.70-0.94	<0.001	79	75
CURB-65+Copeptin	58.78	0.670	0.53-0.81	0.040	79	50
PSI+CRP	81.65	0.730	0.58-0.88	0.005	79	56
PSI+PCT	5.34	0.746	0.61-0.88	0.003	68	70
PSI+Copeptin	68.61	0.664	0.52-0.81	0.046	68	58

Demographic characteristics and copeptin levels of the control and patient groups are shown in Table 2. While there was no difference in age and sex between the groups ($p>0.05$), the mean copeptin level (77.4 pg/mL) of the patient group was significantly higher than the mean copeptin value (36.3 pg/mL) of the control group ($p<0.001$).

There was a significant difference between the laboratory parameters of the deceased and surviving patients. Copeptin, CRP, PCT, and lactate values were found to be significantly higher in the deceased group [Copeptin ($p=0.04$), CRP ($p=0.01$), PCT ($p=0.01$), lactate ($p=0.04$)] (Figure 2). No correlation was found between Copeptin and other laboratory values in the correlation analysis (Table 3). A significant difference was found between the PRC, CRP, Copeptin, Lactate, PSI and NEWS-L values of the deceased and surviving patients. In the multivariate analysis, only CRP was found to be significant as an independent risk factor for mortality (Odds Ratio: 1.009, 95%CI: 1.001-1.018, $p=0.025$) (Table 4).

AUC data and confidence intervals obtained from ROC analysis generated by biomarkers and pneumonia severity scores are shown in Table 5. As a result of the analysis, the highest AUC (0.730) values were obtained for CRP and procalcitonin. This was followed by copeptin (AUC: 0.663) and lactate (AUC: 0.657) (Figure 3).

AUC data and confidence intervals obtained from ROC analysis of models created with biomarkers and pneumonia severity scores are shown in Table 5. As a result of multiple analyzes, the highest AUC (0.747) value was obtained by adding procalcitonin and copeptin to CRP (Figure 3).

Discussion

Community-acquired pneumonia is associated with significant morbidity and mortality, especially in older adult patients and patient groups with comorbidities (6). Current scoring systems such as CURB-65 and PSI are used to decide whether to treat patients as outpatients or inpatients. Among these pneumonia severity scores, PSI, CURB-65, NEWS and NEWS-L have an important role in predicting the 30-day mortality of patients with CAP in the mild and moderate risk groups. Nevertheless, PSI is a less useful scoring system than CURB-65 since it is harder to calculate PSI than CURB-65 and requires the measurement of several variables. While these scoring systems have moderate sensitivity and specificity in determining the treatment method, they have not achieved sufficient success in determining mortality. All these limitations have led clinicians to seek reliable, sensitive, and specific prognostic markers. In this regard, biomarkers such as Copeptin, CRP, PCT have been examined in many studies (2, 7).

In this study, the median serum copeptin level of 64.32 (43.08-316.65) pg/mL in patients with CAP was significantly higher than 27.73 (3.26-94.57) pg/mL in the control group. In addition, serum copeptin levels were

found to be significantly higher in direct proportion to the severity of CAP in patients. In the study by Mohamed et al. aiming to determine the predictive value of copeptin as a severity indicator of community-acquired pneumonia, mean serum copeptin level was found to be significantly higher in pneumonic patients compared to the control group. A significant positive correlation was found between serum copeptin levels and the degree of respiratory distress (3). In the present study, copeptin levels were found to be high in the patient group with CAP, similar to what has been reported in the literature. Since pneumonia damages the parenchymal areas in the lungs where gas exchange takes place, the ventilation/perfusion balance is disturbed. This causes the release of AVP. Along with AVP, copeptin is also synthesized and the concentration of copeptin increases in the circulation.

In this study, the average copeptin value of the deceased patient group was found to be significantly higher than the average copeptin value of the surviving patients. The sensitivity was 68% and the specificity was 59% for copeptin. In the study by Stolz et al. on the relationship between COPD exacerbation and pneumonia, it was shown that copeptin levels increased as the severity of pneumonia increased when patients were classified according to PSI (8). In severe COPD, vasoconstriction caused by hypoxia leads to an increase in copeptin levels along with AVP on V1 receptors. Kolditz et al. studied 51 patients diagnosed with CAP and found that the 7-day survival rate was significantly lower in patients with high copeptin levels (9). In the study by Krüger et al., in which they examined the importance of copeptin regarding the severity and prognosis of pneumonia in patients with CAP, copeptin was found to be the strongest parameter in predicting 28-day mortality (10). In the present study, copeptin was found to be associated with pneumonia severity and mortality, similar to the literature. As the severity of pneumonia increases, conditions such as sepsis that adversely affect circulation occur. Circulatory system damage activates baroreceptors in the aortic arch and carotid sinus, and the decrease in arterial blood pressure causes an increase in serum copeptin levels.

In this study, as a result of multiple analyzes with other biomarkers, the highest value was obtained by adding PCT and copeptin to CRP. In line with these findings, copeptin was shown to be an important biomarker for predicting mortality in patients with CAP. However, in the multivariate logistic regression analysis performed to determine the factors that independently determine mortality in patients with CAP, it was seen that the only independent parameter was CRP. It was shown that one unit increase in CRP increases the risk of mortality by 0.9%. In the study by Masia et al. conducted with 173 patients with CAP, in the multivariate survival analysis including procalcitonin, CRP and PSI, the copeptin level was shown to be the only variable that was statistically significant in predicting mortality independently (11). These results were likely due to an insufficient number of patients and a high number of comorbid diseases.

The mean PCT and CRP values of patients who died in the present study were significantly higher than those of patients who survived. Sensitivity for procalcitonin was 68%, specificity was 67%, whereas sensitivity for C-reactive Protein was 63%, and specificity was 61%. The result of multiple analyses showed that adding procalcitonin to PSI, and adding procalcitonin to CURB-65 significantly increased AUROC. Similarly, the addition of CRP to PSI and the addition of CRP to CURB-65 significantly increased AUROC. In previous studies, CRP and PCT were found to be predictors of mortality (12-14, 18). Min Woo Kim et al. evaluated the relationship between the serum biomarker and pneumonia risk scoring and mortality in a total of 115 patients, and created the best model of mortality prediction by adding CRP and PCT to PSI (12). In the study by Menendez et al. on the use of biomarkers together with pneumonia risk scoring to predict mortality in patients with CAP, a total of 453 patients were included, and after multiple regression analysis that included PSI and CURB-65 from pneumonia risk scoring systems, only CRP was found to be an independent predictive biomarker (13). Studies investigating the effect of procalcitonin on prognosis in patients with diagnosis of CAP have shown that increased procalcitonin is associated with mortality (14-17). In the present study, PCT and CRP were also shown to be important prognostic biomarkers for mortality.

In this study, it was also shown that lactate is an important biomarker in terms of prognosis in patients with CAP. Sensitivity was found to be 58% and

specificity was found to be 83% for lactate. In the study by Sion et al., in which they examined the importance of adding a lactate measurement to NEWS scoring in determining the prognosis, PSI, CURB-65 and NEWS were compared with NEWS-L and the importance of lactate level in terms of prognosis was revealed (3). Gwak et al. investigated the relationship between lactate and mortality in patients hospitalized with the diagnosis of CAP, and the lactate levels of patients who died were found to be significantly higher. In the multivariate logistic regression analysis for hospitalization mortality using lactate, CRP and PSI laboratory variables, only lactate and CRP were found to be significant (18). In the study by Kaya AE et al., which compared the pneumonia severity scores in pneumonia cases, the NEWS-L score, including the lactate level, was found to be the most successful score in predicting mortality and the need for intensive care and hospitalization (19). In the present study, similar to the literature, the lactate level of the patients who died was found to be significantly higher than the patients who survived. In relation to this, the NEWS-L score was also found to be statistically significantly higher in patients who died.

As a result, according to the findings we obtained, plasma copeptin is a molecule that can be used in the diagnosis of community-acquired pneumonia and in estimating its severity and mortality. Multiple use of biomarkers and/or use with pneumonia risk scores is superior to their singular use in determining disease prognosis and mortality.

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