Turk Toraks Derg 2013; 14: 134-40 DOI: 10.5152/ttd.2013.26

ORIGINAL INVESTIGATION / ÖZGÜN ARAŞTIRMA

Risk Factors Associated with Mortality of COPD Patients Hospitalised for Exacerbation

Hastaneye Yatış Gerektiren KOAH Alevlenmelerinde Mortalite İlişkili Risk Faktörleri

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Abstract

OBJECTIVE: To investigate factors associated with mortality and assess the changes in arterial blood gas (ABG) in patients hospitalised for exacerbation of chronic obstructive pulmonary disease (COPD).

MATERIAL AND METHODS: This was a retrospective analysis of 49 patients (38 men and 11 women) hospitalised in a tertiary care facility for exacerbation of COPD between January 2004 and December 2005. Data on exposures, ABG, blood chemistry, severity of COPD and treatments were collected from patient charts. Survival status was determined by hospital records and telephone contact with the patients or family members.

RESULTS: The average age of patients in the study was 71.1±10.9 years (mean±SD), and the majority were in stage IV (25 cases, 51%) or stage III (15 cases, 30.6%). Comorbidity was reported in 42 cases (85.7%). The median duration of hospital stay was 14.8 days (range: 4-70) days. Ten patients (20.4%) received mechanical ventilation (MV) support. Six male and three female patients died (18.4%); 2 in the hospital (4.1%) and 7 during the 2 year follow-up (14.9%). Mortality was associated with older age (79.7±12.0 vs. 69.2±9.4 years) and MV support (4/9 deceased vs. 6/40 alive). The change in $PaCO_2$ between the first measurement on admission and during hospitalisation was associated with mortality after discharge (median and range, mmHg, alive: 3 (-29-55.8) and -6 (-10.2-0.1).

CONCLUSION: Prospective studies are required to test the predictive value of changes in $PaCO_2$ for the survival in patients hospitalised for exacerbation of COPD.

KEY WORDS: COPD, exacerbation, mortality

Özet

AMAÇ: Kronik Obstrüktif Akciğer Hastalığı (KOAH) alevlenmesi ile yatan hastalarda mortalite ile ilişkili etkenleri ve arteriyel kan gazı (AKG) değişikliklerini incelemek.

GEREÇ VE YÖNTEMLER: Haziran 2004 ile Aralık 2005 arasında üçüncü basamak bir hastaneye KOAH alevlenmesi için yatırılan 49 (38 erkek, 11 kadın) hastanın retrospektif analizi. Maruziyetler, AKG, kan biyokimyası, KOAH şiddeti ve tedavi bilgileri hasta dosyalarından toplandı. Sağkalım durumu hastane kayıtları ve hasta veya yakınları telefonla aranarak belirlendi.

BULGULAR: Ortalama yaş 71,1 yıldı (SS: 10,9). hastaların çoğu evre IV (25 hasta, %51) ve evre III (15 hasta, %30,6) idi. Komorbidite 42 hastada (%85,7) bildirildi. Hastanede kalış süresi ortancası 14,8 gündü (aralık 4-70). On hasta (%20,4) mekanik ventilasyon (MV) desteği aldı. Altı erkek ve 3 kadın hasta (%18,4), 2'si hastanede (%4,1) ve 7'si (%14,9) 2 yıllık izlemde öldü. İleri yaş (yıl olarak ortalama /SS sırasıyla 79,7/12,0 ve 69,2/9,4) ve MV desteği (sırasıyla 6/40, %15 ve 4/9, %44) mortalite ile ilişkili bulundu. Hastane başvurusundaki $PACO_2$ ile sonrasındaki ilk ölçüm arasındaki fark taburculuk sonrası mortalite ile ilişkili bulundu (ortanca ve aralık, mmHg, sağ: 3 (-29-55,8) ve ölen-6 (-10,2-0,1).

SONUÇ: KOAH alevlenme ile yatan hastalarda $PaCO_2$ değişikliğinin sağkalımdaki prediktif değerini sınamak için prospektif çalışmalara gereksinim vardır.

ANAHTAR SÖZCÜKLER: KOAH, alevlenme, mortalite

Received/Geliş Tarihi: *14.06.2012* ***Accepted/Kabul Tarihi:*** *30.01.2013* ***Available Online Date/Çevrimiçi Yayın Tarihi:*** *17.04.2013*

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality, and it is the only major cause of death that has increased in prevalence over the last decades [1]. The natural course of COPD is characterised by a progressive decline in pulmonary function and exacerbations [2]. Exacerbations are associated with a poor prognosis and an in-hospital mortality rate ranging from 3%-10%, and 1-year and 2-year mortality rates of 43% and 49%, respectively, in severe cases [3-5]. Factors associated with increased risk of mortality in COPD exacerbation included older age, PaO_2 level, baseline $PaCO_2$ level, smoking status, requirement of mechanical ventilation (MV), presence of comorbidities, and hypoproteinemia [3-7].

The aim of this study was to investigate the association between potential risk factors and mortality within 2 years of hospitalisation for exacerbation of COPD. We also investigated how changes in arterial blood gas (ABG) during hospitalisation were correlated with the risk of mortality.

This study was presented as a poster during the 9th Annual Congress of Turkish Thoracic Society, 19-23 April 2006, Antalya, Turkey.
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MATERIAL AND METHODS

This was a retrospective analysis of 49 patients with moderate to severe COPD admitted to a tertiary care facility (Hacettepe University, Medical Faculty Hospital) between January 2004 and December 2005 for exacerbation. Diagnostic information was obtained from hospital records, and included symptoms and exposures (smoking habits and/or biomass smoke exposure), physical examination findings, and pulmonary function testing (PFT) results. Exacerbation of COPD was defined by the presence of an increase in at least two of the following symptoms; dyspnea, sputum volume or sputum purulence [8]. Patients with pneumonia, kyphoscoliosis, acute respiratory distress syndrome, lung cancer or acute pulmonary embolism were excluded from the study. The severity of COPD was classified according to the Global Initiative of Chronic Obstructive Lung Disease (GOLD) criteria, based on the last PFT within one year prior to admission [2]. PFT data was available for 28 patients on admission.

Table 1. Demographic and clinical characteristics of patients with COPD exacerbation upon hospital admission

Patient Characteristics	Entire cohort (n=49)
Age, yr	71.1±10.9, median: 72.8, range: 45-106
Male gender, n (%)	38 (77.6)
Smoker, n (%)	34 (69.4)
Biomass, n (%)	18 (36.7)
FEV_1, L†	0.87±0.34
Admission FEV_1, % predicted†	34±12
Haemoglobin, g/dL	14.0±2.2
Haematocrit, %	43.0±7.2
WBC, $10^3/\mu L$	9575±3035
BUN, mg/dL	28.6±16.4
Creatinine, mg/dL	1.1±0.5
Albumin, g/dL	3.5±0.42
Total protein, g/dL	6.8±0.7
Use of antibiotics, n (%)	40 (81.6)
Systemic corticosteroid treatment	39 (79.6)
GOLD stage‡	
II, n (%)	9 (18.4)
III, n (%)	15 (30.6)
IV, n (%)	25 (51.0)
Duration of follow-up (months)	9.9±6.6, median: 8.2, range: 0-23
Comorbidity	
Any, n (%)	42 (85.7)
Heart disease, n (%)	15 (30.6)
Hypertension, n (%)	13 (26.5)
Diabetes mellitus, n (%)	9 (18.4)
Symptom	
Increased sputum, n (%)	30 (61.2)
Increased purulence, n (%)	21 (42.9)
Increased dyspnea, n (%)	49 (100)
Fever, n (%)	11 (22.4)
MV, n (%)	10 (20.4)
NIMV, n (%)	23 (46.9)

Data are presented as mean ± SD, unless otherwise specified. WBC: White blood cell count, BUN: Blood urea nitrogen, MV: Mechanical ventilation, NIMV: Non-invasive mechanical ventilation, PFT: Pulmonary function testing. †: PFT was available for 28 patients on admission. ‡: According to the PFT data within one year before admission.

Information on age, gender, smoking status, biomass exposure, PFT, comorbidities and length of hospital stay were collected from patient charts. Baseline findings of complete blood cell (CBC) count, blood chemistry and ABG were recorded. The number of hospital readmissions and survival status were determined by hospital records and by telephone contact after discharge. The name and address of patients and family members were not disclosed, and verbal informed consent was obtained from the family members by telephone contact.

Statistical Analysis

Data are presented as mean±SD, or as median and range when they do not follow a normal distribution as assessed using the Kolmogorov-Smirnov test. The association of survival with patient characteristics, laboratory findings and exposure was analysed. Univariate association of patient characteristics with mortality were reported using crude hazard ratios (HRs) and 95% confidence intervals (CI). Independent predictors of hospital and long-term mortality were identified using Cox regression analysis after adjustment for age and gender. Kaplan-Meier survival curves were drawn and analysed for factors associated with mortality using the log rank test. To assess changes in ABG during hospitalisation, the ABG measurement on admission was subtracted from the first measurement after admission, and the values compared between different patient groups using a Mann-Whitney U test. As an example, change in $PaCO_2$ was calculated as: ($PaCO_{2\ \text{first measurement after admission}}$ - $PaCO_{2\ \text{measurement on admission}}$). For all analyses, a result of $p<0.05$ was considered statistically significant.

RESULTS

Patient Characteristics

Demographic and clinical characteristics of patients followed for a median duration of 8.2 months (range: 0-23 months) are summarised in Table 1. The mean age was 71.1±10.9 years (median: 72.8 years, range: 45-106 years), and the male to female ratio was 38/11. Thirty four (69.4%) patients were current or former smokers. The majority of the patients were classified as COPD stage IV (25 patients, 51%) or stage III (15 patients, 30.6%). Comorbidity was noted in 42 (85.7%) of the patients and included coronary heart disease and congestive heart failure in 15 cases (40.8%), hypertension in 13 cases (34.7%) and diabetes mellitus in 9 cases (18.4%). All patients reported dyspnea, while increased sputum production and purulence were reported by 30 (61.2%) and 21 (42.9%) patients, respectively. Antibiotics and systemic corticosteroid treatment was commenced in 40 (81.2%), and 39 (79.6%) of the patients before hospitalisation, respectively. Ten patients (20.4%) received MV support, and 23 (46.9%) patients received non-invasive mechanical ventilation (NIMV).

Table 2. Hospitalisation data of the patients

	ER (n=31)	IMW (n=41)	ICU (n=15)	Total
ER (n=4)	6.5 (4-27)			6.5 (4-27)
IMW (n=14)		12.7 (6-43)		12.7 (6-43)
ICU (n=2)			(12-14)	(12-14)
ER-IMW (n=16)	2.4 (1-8)	13 (5-27)		17.2 (6-31)
ER-ICU (n=2)	(2-10)		(5-60)	(7-70)
IMW-ICU (n=2)		(2-20)	(4-11)	(13-24)
ER-IMW-ICU (n=9)	2.2 (1-4)	10 (0-18)	8 (3-22)	18 (14-37)
Total	**3 (1-27)**	**12 (2-43)**	**11 (3-60)**	**14.8 (4-70)**

Indicated are the median and range (in brackets) of the duration of stay in days. Only the range is noted when there were two patients. ER: Emergency room, IMW: Internal Medicine Wards, ICU: Intensive care unit

Table 3. Causes of mortality in the COPD patients hospitalised for exacerbation

Age	Gender	Cause of death
61	Male	In hospital, Respiratory failure
73	Male	Acute cardiac event
76	Male	Respiratory related - Congestive heart failure
78	Male	Acute cardiac event
78	Female	Unknown
79	Male	Respiratory related
80	Male	Respiratory related
86	Female	Pneumonia
106	Female	In hospital, Respiratory failure

Hospital Data

Hospitalisation data is shown in Table 2. Four patients were admitted to and discharged from the Emergency Room (ER) for a median duration of 6.5 days (range: 4-27 days). Fourteen patients were admitted to and discharged from the Internal Medicine Wards (IMW) for a median duration of 12.7 days (range: 6-43 days). Two patients were admitted to and discharged from the Intensive Care Unit (ICU) for a duration of 12 or 14 days. Sixteen patients were admitted to the ER for a median duration of 2.4 days (range: 1-8 days) and then transferred to and discharged from the IMW after a median duration of 13 days (range: 5-27 days). Two patients were admitted to the ER for 2 or 10 days, and then transferred to and discharged from the ICU after 5 or 60 days, respectively. Two patients were admitted to the IMW for 2 or 20 days, and discharged from the ICU after 4 or 11 days, respectively. Nine patients were admitted to the ER for a median duration of 2.2 days (range: 1-4 days) and then transferred to the IMW for a median duration of 10 days (range: 0-18 days) and discharged from the ICU after a median duration of 8 days (range: 3-22 days).

Factors Related to Survival

Nine of the 49 patients in the study died (18.4%), of whom 6 were men and 3 were women. Two deaths occurred in the hospital and 7 after discharge. The mortality rate was 4.1% during hospitalisation and 14.9% within 2 years after discharge. The causes of mortality are presented in Table 3. Two patients died in the hospital due to respiratory failure. Among the causes of death after discharge, 3 were respiratory-related (could not be specified), 1 was pneumonia, 2 were acute cardiac events, 1 was congestive heart failure (in addition to a respiratory-related cause) and 1 was unknown.

Table 4 shows a Cox regression analysis of the association of factors with mortality after adjustment for age and gender. Patients who died were older than those who were alive at follow-up (79.7±12.0 vs. 69.2±9.4 years, respectively). MV support was associated with mortality; 6/40 (15%) of living patients vs. 4/9 (44.4%) of deceased patients had been ventilated (HR: 5.35; 95% CI: 1.36-21.08). Univariate analyses revealed mortality was associated with lower haemoglobin levels (14.4 vs. 12.5 g/dL; living vs. deceased patients, respectively), and higher blood urea nitrogen levels (BUN; 25.5 vs. 42.5 mg/dL; living vs. deceased patients, respectively), but these correlations were not statistically significant after adjustment for age and gender. The severity of COPD within one year of admission, history of hospital readmission, and systemic corticosteroid treatment were not associated with mortality. PFT on admission could not be analysed, as PFT data was only available for one of the deceased patients.

Figure 1 shows the Kaplan Meier survival curve of all patients. Figure 2 shows the Kaplan Meier survival curve of the patients according to the status of MV treatment. Patients who received MV had a higher mortality rate than those who did not (p=0.03).

Arterial Blood Gas Analysis

ABG findings of the patients are shown in Table 5. Measurements at baseline, upon admission, and the first taken after admission were available in 48, 46 and 39 cases, respectively. Eight of the patients who died during the follow-up period had at least 3 measurements. A minimum of 4 final measurements were reported for 33 patients. Patients with complete data had more severe COPD and a higher prevalence of long-term oxygen use at home. Comparisons between patients who were alive or had died during follow-up revealed no significant difference between pH, $PaCO_2$ or HCO_3 measurements. Deceased patients had higher arterial oxygen saturation (SaO_2) upon admission than the living patients (96.0% vs. 88.4%, respectively). Repetitive measurements of ABG did not differ significantly between these two patient populations.

Table 4. Association of factors with mortality in COPD patients hospitalised for exacerbation

	Alive (n=40)	Deceased (n=9)	HR crude (95% CI)	HR adjusted# (95% CI)
Male gender, n (%)	32 (80.0)	6 (66.7)	0.41 (0.09-1.73)	
Age, yr	69.2±9.4	79.7±12.0	1.16 (1.05-1.29)	
Hospital stay, days	17±9.2	22.4±19.2	1.04 (0.99-1.08)	
Follow-up, months	11.0±6.2	4.7±5.7		
Smoker, n (%)	29 (72.5)	5 (55.6)	0.39 (0.09-1.55)	
Biomass exposure, n (%)	14 (35.0)	4 (44.4)	1.65 (0.44-6.20)	
Comorbidity, n (%)	35 (87.5)	7 (77.8)	0.60 (0.12-2.91)	
Antibiotic use, n (%)	35 (87.5)	8 (88.9)	0.72 (0.09-5.91)	
Systemic steroid treatment, n (%)	33 (82.5)	6 (66.7)	1.98 (0.49-7.97)	
Emphysema, n (%)	22 (55.0)	3 (33.3)	0.37 (0.09-1.51)	
MV, n (%)	6 (15)	4 (44.4)	3.78 (1.01-14.20)	5.35 (1.36-21.08)
NIMV, n (%)	17 (42.5)	6 (66.7)	2.34 (0.58-9.38)	
LTOT, n (%)	20 (50.0)	5 (55.6)	1.38 (0.37-5.18)	
COPD Stage 4, n (%)	19 (47.5)	6 (67.7)	2.08 (0.52-8.35)	
Characteristics upon admission				
Increased sputum, n (%)	25 (62.5)	5 (55.6)	0.72 (0.19-2.70)	
Increased purulence, n (%)	17 (42.5)	4 (44.4)	1.03 (0.28-3.84)	
Fever, n (%)	9 (22.5)	2 (22.2)	0.91 (0.19-4.41)	
Hospital readmission, n (%)	24 (60.0)	8 (88.9)	3.70 (0.46-29.88)	
Haemoglobin, g/dL	14.4±2.0	12.5±2.5	0.74 (0.55-0.98)	0.79 (0.56-1.12)
WBC, 103/µL	9.8±3.1	8.5±2.7	0.23 (0.02-2.21)	
BUN, mg/dL	25.5±13.4	42.5±21.9	1.04 (1.01-1.08)	1.03 (0.99-1.06)
Creatinine, mg/dL	1.1±0.5	1.3±0.6	2.17 (0.81-5.82)	
Total protein, g/dL	6.8±0.7	6.9±0.8	1.01 (0.38-2.65)	
Serum albumin, g/dL	3.5±0.4	3.5±0.3	0.79 (0.16-4.05)	

Data are presented as mean ± SD unless otherwise specified. MV: Mechanical ventilation, NIMV: Non-invasive mechanical ventilation, LTOT: Long-term oxygen therapy, BUN: Blood urea nitrogen. HR: Hazard ratio, 95% CI: Confidence interval. Adjusted HR: HR adjusted for age and gender in the Cox regression analysis.

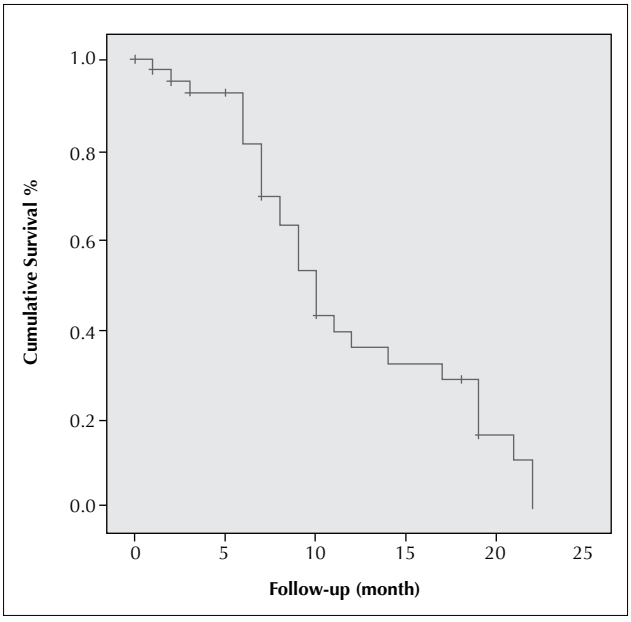

Figure 1. Kaplan Meier survival curve of all patients

The difference between the first $PaCO_2$ measurement taken after admission and that recorded upon admission was significantly lower in the patients who died within the two year follow-up period after discharge compared to those who were still alive (median and range in mmHg, alive: 3, ((-29)-55.8), deceased: -6, ((-10.2)-0.1), p=0.04). Figure 3 shows the scatter plot of the difference between $PaCO_2$ measurements of the living patients and those who died after discharge. There was no significant association between mortality and the differences in pH, SaO_2 or HCO_3.

DISCUSSION

In this study we identified an association between mortality and both older age and MV support in COPD patients hospitalised for exacerbation. There was no significant correlation between mortality and findings of ABG, CBC, blood chemistry or severity of COPD. Risk of mortality after discharge was associated with decrease in $PaCO_2$ in the two measurements performed during hospital stay.

Age was an independent predictor of mortality. Almost half of the patients in our study were older than 70 years of age,

Table 5. Arterial blood gas data

	Living		Deceased		
	Median	(Range)	Median	(Range)	p
pH					
Baseline	7.37	(7.23-7.45)	7.30	(7.23-7.44)	0.36
Admission	7.36	(7.16-7.55)	7.30	(7.21-7.43)	0.12
1st assessment	7.35	(7.05-7.72)	7.32	(7.22-7.44)	0.48
Last assessment	7.38	(7.28-7.43)	7.37	(7.32-7.42)	0.71
$PaCO_2$					
Baseline	51.7	(26.1-83.6)	61.9	(29.5-84.2)	0.48
Admission	55.1	(24.4-90.8)	61.4	(20.9-86.2)	0.37
1st assessment	59.3	(12.4-146.6)	67.4	(21.0-79.8)	0.51
Last assessment	51.2	(37.6-77.0)	53.7	(27.3-71.0)	0.85
SaO_2					
Baseline	89.5	(44.9-99.5)	91.3	(62.6-99.3)	0.70
Admission	88.4	(45.4-99.6)	96.0	(76.2-99.4)	0.01
1st assessment	89.2	(54.2-99.4)	89.2	(76.8-99.4)	0.83
Last assessment	88.8	(70.0-97.5)	90.5	(87.0-98.5)	0.14
HCO_3					
Baseline	30.0	(17.2-42.5)	31.4	(16.5-41.4)	0.74
Admission	31.1	(20.2-43.6)	29.6	(13.6-40.2)	0.66
1st assessment	32.7	(15.8-44.3)	32.1	(12.8-41.2)	0.75
Last assessment	30.2	(24.0-46.0)	29.3	(13.8-46.0)	0.62

ABG measurements were available for 39 living and 9 deceased patients for the baseline, 38 living and 8 deceased patients for the admission, 31 living and 8 deceased patients for the 1st assessment after admission, and 26 living and 7 deceased patients for the last assessment after admission.
SaO_2: Arterial oxygen saturation

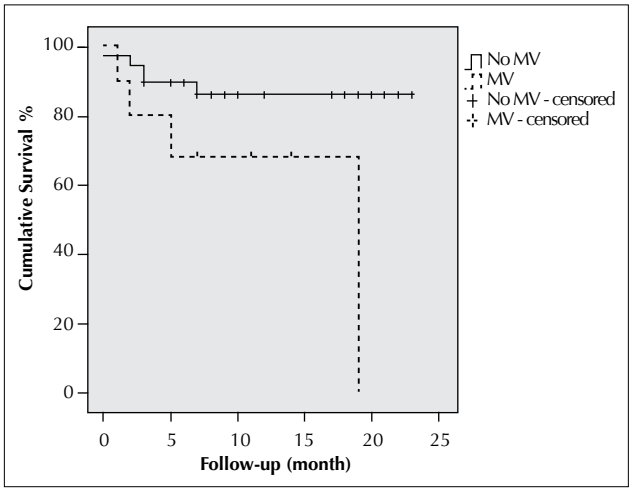

Figure 2. Kaplan Meier survival curve of the patients according to the status of MV treatment (p: 0.003, log rank test)

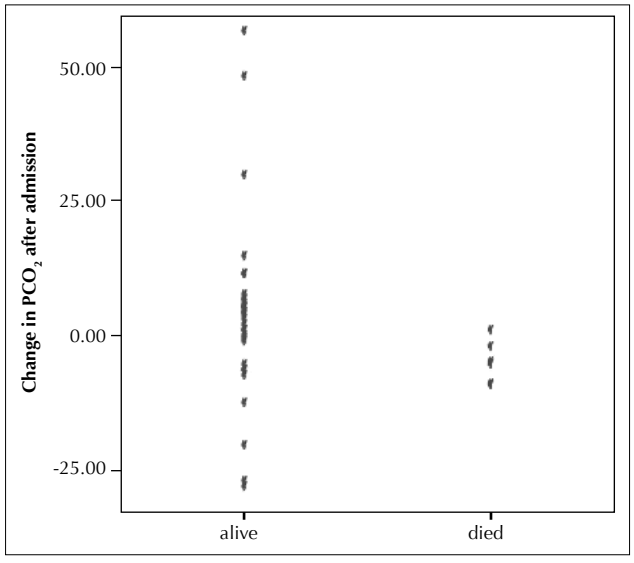

Figure 3. The scatterplot of the difference between PaCO2 measurements in the alive patients and patients died after discharge (p: 0.04, Mann-Whitney U test

which could add to the strength of the association. Age was also reported as an important determinant of survival in COPD patients in previous studies [3, 4, 7, 9]. This could be due to the physiological changes (e.g. higher degree of airway obstruction) or other factors associated with aging that may influence mortality. However, the severity of COPD was not associated with mortality. Similarly, Chung et al., [10] did not find a correlation between severity of respiratory failure and mortality. We do not have information on factors related to social support and quality of life for our cohort that could help explain the correlation between aging and mortality.

The average mortality rate of patients with COPD exacerbation in this study was 4.1% during hospital stay, 14.9% after discharge and 18.4% overall within 2 years. Connors et al., [3]

reported a mortality rate during hospital stay of 11%, that increased to 43% after 1 year of follow-up. Groenewegen et al., [4] reported a 1-year mortality rate of 23%, while a Turkish study by Gunen et al., [5] reported 6-month and 1-year mortality rates of 24% and 33%, respectively. Another study showed that mortality of patients with COPD in need of MV was 52.9% [11]. These findings may reflect the different study populations and follow-up periods. The mortality rate after COPD exacerbation in our study was similar to the lower range of previous studies.

The major causes of death in patients with COPD and chronic respiratory failure were acute or chronic respiratory failure, heart failure, pulmonary infection or embolism, cardiac arrhythmia and lung cancer [12]. A recent study reported that pulmonary embolism was detected in 13.7% of patients hospitalised with COPD exacerbation [13]. Hansell et al., [14] reported ischaemic heart disease as the major underlying cause of death in COPD. In our study, the majority of deaths were respiratory-related or due to heart disease. Pulmonary thromboembolism may also have contributed to mortality in our patients, since it has been reported at frequencies of 28% and 51% in post-mortem studies [15,16]. Whether this was a contributing factor is unclear, however, since autopsies were not performed in the present study.

Although previous studies have demonstrated $PaCO_2$ is a predictor of survival [5,17], $PaCO_2$ level upon admission was not associated with mortality in our patients. Permissive hypercapnia may be a physiologic adaptation that can lead to better survival rates [18,19]. In our study, lower $PaCO_2$ in the first assessment after admission was associated with mortality during follow-up. Rapid correction of $PaCO_2$ could have a negative influence on respiratory control and increase mortality. Other parameters of ABG were not associated with mortality, and most of our patients received MV support, suggesting the possible role of interaction between these factors on mortality. As this was not a prospective study, ABG assessments were not standardised. Some patients were tested while receiving oxygen and/or MV support. Therefore, these findings should be confirmed in a larger cohort of COPD patients hospitalised for exacerbation. If not due to chance, changes in $PaCO_2$ after admission could be useful for the assessment of prognosis and preventive strategies in COPD patients hospitalised for exacerbation.

The total length of hospital stay in this series (14.8 days) was similar to that of previous studies, whereas the median length of stay in the ICU (11 days) was longer [20,21]. Anon et al., [22] reported a longer duration of stay in both the ICU and hospital (41 days and 65 days, respectively) in COPD patients who were receiving long-term oxygen treatment at home.

Tessa et al., [23] found that the presence of comorbidities was a predictive factor for mortality. Incalzi et al., [5] demonstrated that survival was inversely correlation with chronic renal failure, myocardial infarction or ischaemia in COPD patients who were consequently discharged after hospital admission for an acute exacerbation. In contrast, comorbidity and mortality were not found to be correlated in two earlier studies [4, 24] nor did we find evidence of such an association in the present study, a finding that may reflect the high prevalence of comorbidities in our series of patients.

Lower values of 'forced expiratory volume in 1 second' (FEV_1) are associated with mortality in most, but not all, studies [3,6,22,24-26]. As a tertiary care hospital, some of the patients were transferred to the study center from other health care facilities. Therefore, PFT data on admission was not available for all patients, which made it difficult to investigate the association between FEV_1 on admission and mortality.

The National Emphysema Treatment Trial found an independent association between increased mortality and lower haemoglobin level [27]. Anaemia was associated with poor survival in COPD patients [28]. Renal dysfunction was associated with mortality in patients with exacerbation of COPD treated with MV [29]. The lack of significant association between mortality and haemoglobin as well as BUN (as a marker of renal function) in our study could be due to the small number of patients.

The limitations of the present study include the retrospective design, lack of statistical power for testing independent associations (due to the sample size), and lack of data on follow-up PFT and ABG. We also did not have complete data on body mass index that is a strong predictor of mortality in COPD patients [30]. Hence, prospective investigation of a larger group of patients with COPD and exacerbation would help to confirm the association between survival and the change in $PaCO_2$ during hospitalisation.

In conclusion, older age and MV support were associated with mortality in COPD patients hospitalised for exacerbation within two years of discharge. Decreased $PaCO_2$ after admission was identified as an independent risk factor for mortality after discharge. Further research is required to test the predictive role of change in $PaCO_2$ for survival in COPD patients.

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

Peer-review: Externally peer-reviewed.

Author Contributions
Conception - E.Y.N., B.E.A., A.U.D., A.T.İ., L.Ç.; Design - E.Y.N., B.E.A., A.U.D., A.T.İ., L.Ç.; Supervision - E.Y.N., B.E.A., A.U.D., A.T.İ., L.Ç.; Fundings - A.T.İ., L.Ç.; Materials - A.T.İ., B.E.A.; Data Collection and/or Processing - E.Y.N., A.U.D.; Analysis and/or Interpretation - A.U.D., E.Y.N., B.E.A.; Literature Review - E.Y.N., B.E.A.; Writer - E.Y.N., A.U.D., L.Ç.; Critical Review - L.Ç., A.T.İ., A.U.D., E.Y.N.

Çıkar Çatışması
Yazarlar herhangi bir çıkar çatışması bildirmemişlerdir.

Hakem değerlendirmesi: Dış bağımsız.

Yazar Katkıları
Fikir - E.Y.N., B.E.A., A.U.D., A.T.İ., L.Ç.; Tasarım - E.Y.N., B.E.A., A.U.D., A.T.İ., L.Ç.; Denetleme - E.Y.N., B.E.A., A.U.D., A.T.İ., L.Ç.; Kaynaklar - A.T.İ., L.Ç.; Malzemeler - A.T.İ., B.E.A.; Veri toplanması ve/veya işlemesi - E.Y.N., A.U.D.; Analiz ve/veya yorum - A.U.D., E.Y.N., B.E.A.; Literatür taraması - E.Y.N., B.E.A.; Yazı yazan - E.Y.N., A.U.D., L.Ç.; Eleştirel İnceleme - L.Ç., A.T.İ., A.U.D., E.Y.N.

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