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ORIGINAL RESEARCH

Hypermagnesemia and mortality in COPD patients

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Abstract

Background: Magnesium, the second most abundant intracellular cation, is essential for enzymatic reactions, neuromuscular function, and respiratorion. While electrolyte imbalances are common in intensive care units (ICUs), the effect of magnesium at ICU admission in chronic obstructive pulmonary disease (COPD) patients remains understudied. This study investigated serum magnesium levels and mortality among COPD patients admitted to the ICU, including the need for mechanical ventilation, ventilation duration, and ICU length of stay. **Methods**: In this retrospective, single-center study, 264 COPD patients admitted to a level 3 ICU between January 2024 and January 2025 were analyzed. Patients under 18 years or receiving magnesium supplementation were excluded. Demographic data, comorbidities, ventilation parameters, ICU stay, and mortality were collected from electronic records. Serum magnesium was measured at ICU admission and categorized as hypomagnesemia, normomagnesemia, or hypermagnesemia. Receiver operating characteristic (ROC) analysis assessed the predictive value of magnesium for mortality. **Results**: The median age was 72.3 years, and 52.3% were male. Ventilatory support was required in 91.7% of patients, with 40.9% receiving invasive mechanical ventilation (IMV). Hypomagnesemia was present in 43.9%, normomagnesemia in 50.8%, and hypermagnesemia in 5.3% of patients. Mortality occurred in 33.3%. Hypermagnesemia was significantly associated with mortality ($p = 0.001$), whereas hypomagnesemia was not ($p = 0.546$). Magnesium showed poor discriminative ability for mortality (Area Under the Curve (AUC) = 0.543), but a threshold >2.39 mg/dL differentiated mortality rates (70% *vs.* 29.9%, $p < 0.001$). Independent mortality predictors were Acute Physiology and Chronic Health Evaluation II (APACHE II) score (Odds Ratio (OR) = 1.179), malignancy (OR = 4.735), and IMV requirement (OR = 46.887). **Conclusions**: Hypermagnesemia on ICU admission is associated with increased mortality in COPD patients, whereas hypomagnesemia is not. Serum magnesium has limited predictive value, and further studies are warranted to clarify its role in critical care. **Clinical Trial Registration**: ACTRN12625000558426, retrospectively registered.

Keywords

Mg; COPD; Mortality; Ventilatory support; NIV

1. Introduction

Magnesium is the second most abundant intracellular cation and acts as a cofactor in over 600 enzymatic reactions spanning protein synthesis, nucleic acid stability, and neuromuscular excitability [1]. Hypomagnesemia is common in intensive care unit (ICU) patients and is often caused by factors such as poor nutrition, renal and gastrointestinal losses, and medications [2, 3]. Magnesium regulates the contractile state of bronchial smooth muscle, with deficiency promoting constriction and supplementation inducing relaxation mainly through calcium channel blockade, reduced acetylcholine sensitivity, immune cell stabilization, and enhanced nitric oxide and prostacyclin release [1]. Recent evidence suggests that magnesium deficiency is associated with systemic inflammation in chronic obstructive pulmonary disease (COPD), as reflected by higher Magnesium Depletion Scores (MDS) being linked to higher COPD prevalence and inflammatory markers [4]. COPD is characterized by irreversible airflow limitation and chronic inflammation [5, 6]. Despite its high global burden and mortality, COPD research remains underfunded compared with other major chronic diseases [7]. Electrolyte disturbances like hypomagnesemia are linked with worse ICU outcomes [8, 9]. Although some studies suggest a relationship between magnesium levels and poor outcomes in critically ill patients, there is a lack of data specifically on ICU patients with COPD. Therefore, this study investigated the association between serum magnesium levels and mortality in ICU-admitted

COPD patients, along with ventilation needs and ICU length of stay.

2. Methods

2.1 Study design and participant enrolment

This retrospective, single-center, observational study was retrospectively registered at the Australian New Zealand Clinical Trials Registry (identification number ACTRN12625000558426) and approved by our hospital's ethics committee (decision no E-95531838-050.99-127597 dated 27 February 2025). The reporting of the study adheres to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The study included 264 COPD patients admitted to the intensive care unit between January 2024 and January 2025. Patients who were under the age of 18 years and those who were/had been receiving magnesium supplements were excluded from the study.

Upon ICU admission, patient data were retrospectively extracted from the electronic medical record system, including serum magnesium levels (as part of routine laboratory tests), age, sex, and comorbidities (classified according to International Classification of Disease (ICD)-10). Follow-up data, including ICU length of stay, need for invasive or non-invasive mechanical ventilation (and duration if applicable), and mortality status, were also recorded. Based on available data, the Acute Physiology and Chronic Health Evaluation II (APACHE II) score and the Age-adjusted Charlson Comorbidity Index (ACCI) score were calculated [10, 11].

2.2 Score interpretation and analysis plan

In the Core Curriculum 2024, published on behalf of the National Kidney Foundation, the reference range for serum Mg levels was defined as 1.6 to 2.7 mg/dL [12]. However, the magnesium reference ranges reported in the literature vary between studies. Patil *et al*. [13] reported a reference range of 1.7 to 2.7 mg/dL, whereas Khanum *et al*. [14] defined the reference magnesium range as 1.8 to 2.4 mg/dL. In our study, serum magnesium levels were measured using the Beckman DcX700 Chemistry Analyzer (Clinical chemistry analyzer, Beckman Coulter, Inc., Brea , CA , USA), and the reference range was set at 1.9 to 2.5 mg/dL using a colorimetric quantitative method with a xylidyl blue-containing kit. Patients were categorized according to serum magnesium levels measured upon ICU admission: hypomagnesemia ($<$1.9 mg/dL), normomagnesemia (1.9–2.5 mg/dL), and hypermagnesemia ($>$2.5 mg/dL).

2.3 Study covariates

To minimize bias, diagnoses were based on the International Classification of Diseases, 10th Revision (ICD-10), as recorded in the electronic medical record system [15]. COPD was defined using diagnosis codes J44.9, J44.0, and J44.1. Based on the Framingham criteria, congestive heart failure (CHF) was defined according to ICD code I50.9. Chronic kidney disease (CKD) was defined using codes N18, N18.1-5, N18.9, E08.22, E09.22, E10.22, E11.22, E13.22, I12.-, I13.-, in combination with an estimated glomerular filtration rate (eGFR) of less than 60 mL/min/1.73 m^2 for at least 3 months. Coronary artery disease (CAD) was identified by ICD code I25.10, hypertension (HT) by I10, and diabetes mellitus (DM) by codes E10, E11, E11.65, E11.8, and E11.9.

2.4 Statistical analysis

Study data were entered in the Statistical Package for the Social Sciences (IBM® SPSS Statistics for Windows, Version 23.0, Armonk, NY, USA). Descriptive statistics were used to characterize the data. Quantitative variables were expressed as mean, minimum (min), and maximum (max) values, while qualitative data were presented as percentages. The Kolmogorov-Smirnov test was used to assess the normality of data distribution. Normally distributed variables were reported as means, standard deviations (SD) were calculated, and groups were compared using the Student's *t*-test. Non-parametric continuous variables were recorded as medians and compared using the Mann-Whitney U test. Inter Quartile Ranges (IQRs) were also reported for the variables recorded as medians. Quantitative variables were compared using Pearson's chi-square test, and when the sample size was small ($\leq$5), with Fisher's exact test. A p-value of $<$ 0.05 was considered statistically significant. Multiple logistic regression analysis was performed to investigate independent risk factors indicative of mortality. This multiple regression analysis included variables that were significant in the one-variable analysis.

Receiver operating characteristic (ROC) curves were plotted to evaluate the predictive value of magnesium levels for mortality, and the areas under the curve (AUC) were calculated. Also, a 95% confidence interval (CI) was determined for each AUC value. In this study, an AUC value of 0.599 or lower was generally considered to indicate no predictive ability (*i.e.*, inability to predict mortality based on magnesium levels). An AUC between 0.6 and 0.7 was interpreted as indicating a low level of predictive ability, 0.7 to 0.8 as fair, 0.8 to 0.9 as good, and above 0.9 as excellent predictive ability.

"Optimal" cut-off values (internal thresholds) for serum magnesium levels in predicting mortality were determined using the best sensitivity and specificity percentages identified by ROC analysis. The negative predictive value (NPV) and positive predictive value (PPV) specific to these cut-off values were also calculated. Patients were classified according to whether their serum magnesium levels exceeded or fell below the identified cut-off values. The mortality rate was evaluated within each group, and the odds of mortality for those above the cut-off value were compared to those below the cut-off value, using odds ratios (OR) and 95% confidence intervals.

Spearman correlation analysis was performed to assess the correlation of serum magnesium levels with ICU length of stay and duration of ventilation support, and the correlation coefficient (*rho*) was calculated. A positive rho value indicated a direct association between the variables (*i.e.*, as one variable increased, so did the other). Conversely, a negative rho value reflected an inverse relationship (where an increase in one variable corresponded to a decrease in the other). Correlation strength was interpreted as follows: values less than 0.4 indicated a weak correlation, values between 0.4 and 0.7 a mod-

erate correlation, and values above 0.8 a strong correlation. A p-value of < 0.05 was considered statistically significant for all statistical analyses.

3. Results

A total of 267 patients admitted to ICU, between 01 January 2024, and 01 January 2025, at Agri; Turkiye, 3 of them were excluded; 264 of them were included. Based on routine blood testing performed at admission to the ICU, the median serum magnesium level was 1.9 mg/dL (IQR: 0.3). Of all patients, 43.9% (n = 116) were hypomagnesemic, 50.8% (n = 134) were normomagnesemic, and the remaining 5.3% (n = 14) were hypermagnesemic (Fig. 1).

According to the general demographic and follow-up data, the mean age of the study population was 72.3 years, and most of the patients were male (n = 138, 52.3%). The median ICU length of stay was 6 days (range, 1–51 days). Only 22 patients (8.3%) did not require ventilation support. Overall, 185 patients (70.1%) received non-invasive ventilation (NIV), and 51 (27.6%) of those patients were subsequently switched to invasive mechanical ventilation (IMV). In total, 108 patients (40.9%) required IMV. The median duration of ventilatory support was 56 hours (range, 0–1, 224 hours), with a mean of 103.8 hours.

Mortality occurred in 87 patients (33.3%) during follow-up. According to the comparison of demographic, clinical, and ventilation-related variables affecting mortality, gender, HT, DM, and ICU length of stay were found to have no statistically significant effect on mortality ($p = 0.516$, $p = 0.159$, $p = 0.229$, and $p = 0.950$, respectively). Non-survivors had significantly higher APACHE II ($p < 0.001$) and ACCI scores ($p < 0.001$) compared with survivors. In addition, comorbidities such as CHF ($p = 0.01$), CKD ($p = 0.01$), CAD ($p = 0.008$), and malignancy ($p < 0.001$) were more common in the non-survivor group compared to survivors. All patients who did not survive had received ventilation support. The rate of NIV application was significantly higher in patients who survived than in patients who did not survive ($p < 0.001$). Among deceased patients, the rate of IMV was 92%, whereas it was 81.4% in survivors ($p < 0.001$). The switch rate from NIV to IMV was significantly higher in patients who did not survive ($p < 0.001$). Among patients receiving ventilation support, the duration of ventilation was significantly shorter in survivors compared to those who did not survive ($p < 0.001$).

According to routine blood tests performed at ICU admission, serum magnesium levels did not differ significantly between patients who died and those who survived. There was no statistically significant difference between the mortality and non-mortality groups regarding hypomagnesemia ($p = 0.546$) and normomagnesemia ($p = 0.835$). However, the number of hypomagnesemic patients was significantly higher among patients who did not survive ($p = 0.001$).

According to the regression analysis conducted with variables which were found to influence mortality, APACHE (OR = 1.179, 95% CI = 1.098–1.265, $p < 0.001$), malignancy (OR = 4.735, 95% CI = 1.154–19.425, $p = 0.03$), and IMV as the type of ventilation support received (OR = 46.887, 95% CI = 4.314–509.627, $p = 0.002$) were identified as independent risk factors affecting mortality (Table 1).

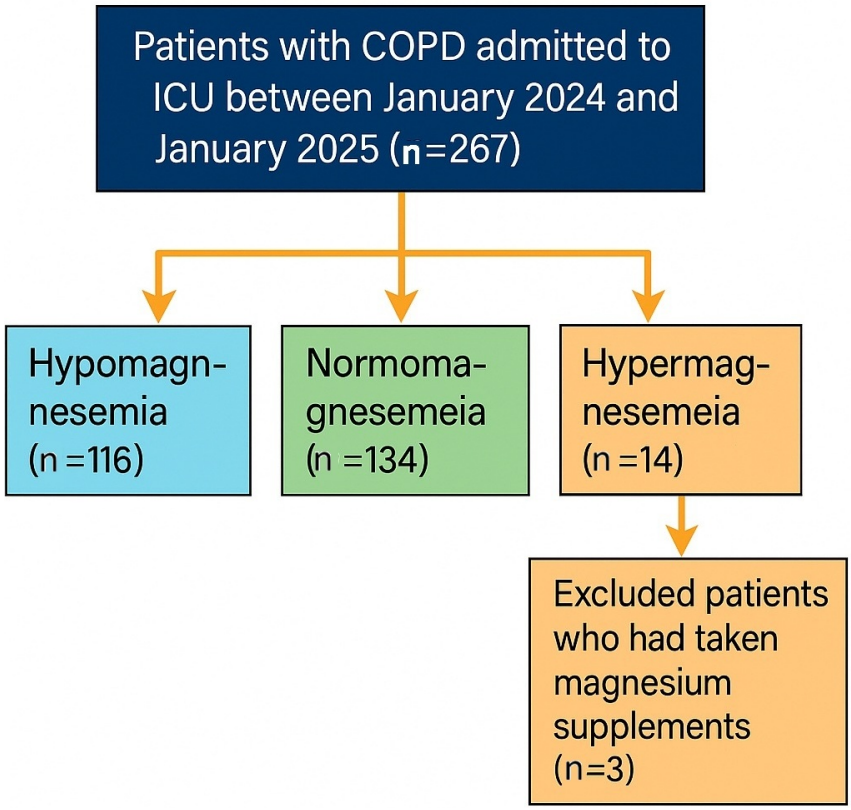

FIGURE 1. Flow chart of included patients with COPD admitted to the intensive care unit at Ağrı Training and Research Hospital, Ağrı, Türkiye, January 2024 to January 2025. COPD: obstructive pulmonary disease; ICU: intensive care unit.

TABLE 1. Regression analysis conducted with variables found to influence mortality*.

Variables	OR	95% CI	*p*-value
APACHE II (for each one-point increase)	1.179	1.098–1.265	**<0.001**
ACCI (for each one-point increase)	0.991	0.711–1.383	0.960
CHF	2.224	0.755–6.549	0.147
CKD	2.646	0.650–10.769	0.174
CAD	2.121	0.541–8.321	0.281
Malignancy	4.735	1.154–19.425	**0.030**
Ventilation support*			**<0.001**
No	1.000		
NIV	1.288	0.112–14.763	0.839
IMV	46.887	4.314–509.627	**0.002**
Length of ventilation support (for each one-hour increase)	1.000	0.998–1.003	0.916
Magnesemia Status			0.555
Hypomagnesemia	1.000		
Normomagnesemia	0.720	0.284–1.828	0.490
Hypermagnesemia	2.240	0.207–24.294	0.507

The analysis did not include age, as it may exert a confounding effect due to its incorporation within the ACCI.
**Patients who were switched from NIV to IMV were also classified under the IMV group in this analysis. p-values shown in bold represent statistically significant results.*
APACHE II: Acute Physiology and Chronic Health Evaluation questionnaire II; ACCI: Age-adjusted Charlson comorbidity index; CHF: Congestive heart failure; CKD: Chronic kidney disease; CAD: Coronary artery disease; NIV: Non-invasive ventilation; IMV: Invasive mechanical ventilation; CI: confidence interval; OR: odds ratios.

The ROC curve illustrating the predictive ability of serum magnesium levels for mortality is presented in Fig. 2. The analysis of serum magnesium levels as a predictor of mortality is summarized in Table 2.

Table 2 presents the grouping of patients based on the serum magnesium cut-off value of 2.39 mg/dL, identified using ROC analysis, together with the corresponding mortality rates. The predictive ability of serum magnesium for mortality was below average (AUC = 0.543). Among patients with serum magnesium levels ≤2.39 mg/dL (n = 244), the mortality rate was 29.9%, whereas among those with levels >2.39 mg/dL (n = 20), it was 70.0%. This difference was statistically significant ($p < 0.001$).

Table 3 compares serum magnesium levels based on the need for ventilation support and the requirement for NIV or IMV. There was no statistically significant difference in serum magnesium levels between patients who received ventilation support and those who did not, between those who required IMV and those who did not, or between patients who were switched from NIV to IMV and those who remained on NIV. However, magnesium levels were significantly lower in patients who received NIV compared to those who did not ($p < 0.001$).

Fig. 3 shows the correlation analysis between magnesium levels and ICU length of stay. No correlation was found between these two variables (*rho* = −0.032, $p = 0.601$). Fig. 4 shows the correlation analysis between magnesium levels and duration of ventilation support. No correlation was found between these two variables (*rho* = 0.043, $p = 0.435$).

4. Discussion

In our study, hypomagnesemia, normomagnesemia, and hypermagnesemia were observed in 43.9%, 50.9%, and 5.3% of patients, respectively. Previous studies have reported variable rates: Al-Maqbali *et al.* [16] found hypermagnesemia in 2.1% and hypomagnesemia in 29.6%, whereas Gonuguntla *et al.* [17] reported 13.9% and 40.9%, respectively. In their meta-analysis, Jiang *et al.* [18] suggested that the variability in hypomagnesemia rates among ICU patients may be due to the use of differing diagnostic criteria across studies. These studies, however, reflect the general ICU patient population, whereas our study specifically focused on ICU patients with COPD.

In our study, the overall mortality rate was found to be 33.3%. Among the deceased patients, the APACHE II ($p < 0.001$) and ACCI ($p < 0.001$) scores and the rates of CHF ($p = 0.01$), CKD ($p = 0.01$), CAD ($p = 0.008$), and malignancy ($p < 0.001$) were higher. It should be taken into consideration that CHF, CKD, CAD, and malignancy contribute to the ACCI score. Another study also demonstrated that the mortality rate was significantly higher among patients with elevated APACHE II scores [19]. The reported results are correlated with our results. There are studies in the literature reporting ACCI to be associated with mortality in ICU patients with cardiogenic shock and COVID-19 [20, 21]. However, to our knowledge, no studies have specifically examined ACCI in ICU patients with COPD. Therefore, our study offers an original contribution to the literature.

In our study, 70.1% of patients received NIV, 40.9% re-

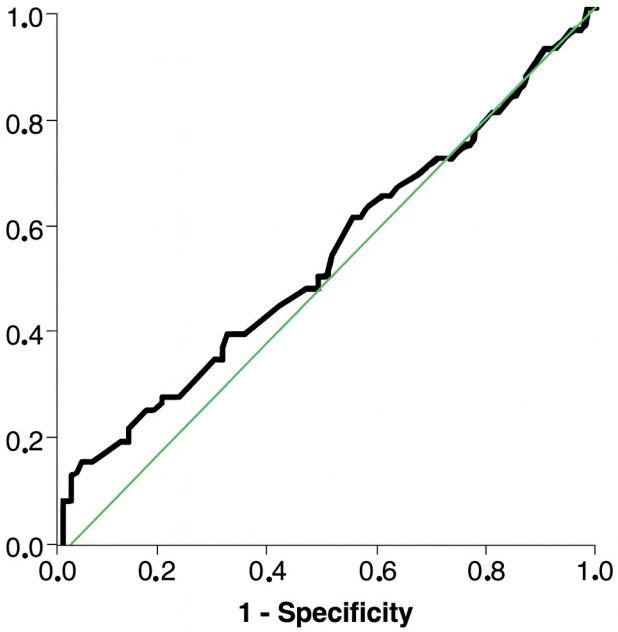

FIGURE 2. ROC curve illustrating the predictive ability of magnesium levels for mortality. (AUC = 0.543, 95% CI = 0.481–0.605).

TABLE 2. Analysis of the predictive ability of serum magnesium levels for mortality, the grouping of patients according to the established cut-off point, and comparison of mortality rates between patients with low and high serum magnesium levels.

Test	AUC	95% CI	Cut-off value	*p*-value	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Mg	0.543	0.481–0.605	2.39	0.27	16	96.6	70	70.1
Cut-off	Total (n = 264)	Without mortality (n = 177)		With mortality (n = 87)		*p*-value	OR	95% CI
≤2.39	244	171/96.6%		73/83.9%		**<0.001**	5.466	2.021–14.781
>2.39	20	6/3.4%		14/16.1%				

AUC: Area under the curve; CI: Confidence interval; Mg: Magnesium; NPV: Negative predictive value; PPV: Positive predictive value; n: Number. The p-value written in bold represents a statistically significant result.

TABLE 3. Comparison of magnesium levels based on the need for ventilation support and the requirement for NIV or IMV.

Variables	Magnesium, median (IQR)	*p*-value
Ventilation support		
No	2.0 (0.3)	0.090
Yes	1.9 (0.3)	
NIV support		
No	2.0 (0.3)	**<0.001**
Yes	1.9 (0.3)	
IMV support		
No	1.9 (0.3)	0.101
Yes	1.9 (0.4)	
Switch from NIV to IMV		
No	1.8 (0.3)	0.481
Yes	1.9 (0.4)	

NIV: Non-invasive ventilation; IMV: Invasive mechanical ventilation; IQR: Interquartile Range.
The p-values written in bold represent statistically significant results.

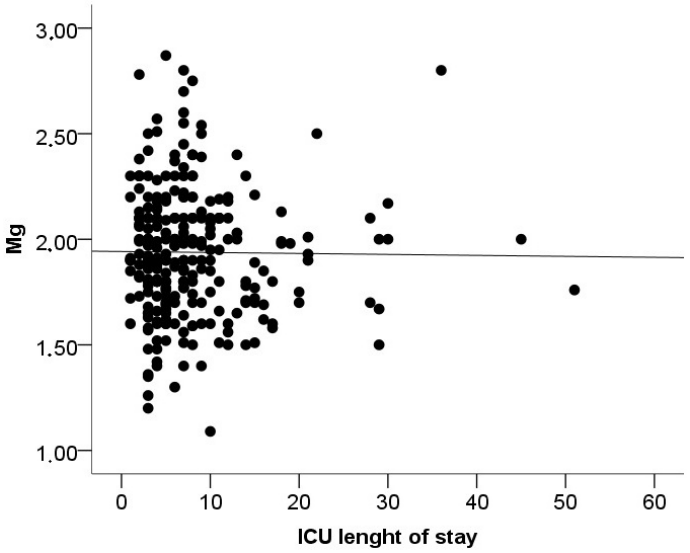

FIGURE 3. Correlation analysis regarding magnesium levels and ICU length of stay (*rho* = −0.032, *p* = 0.601). Mg: Magnesium; ICU: intensive care unit.

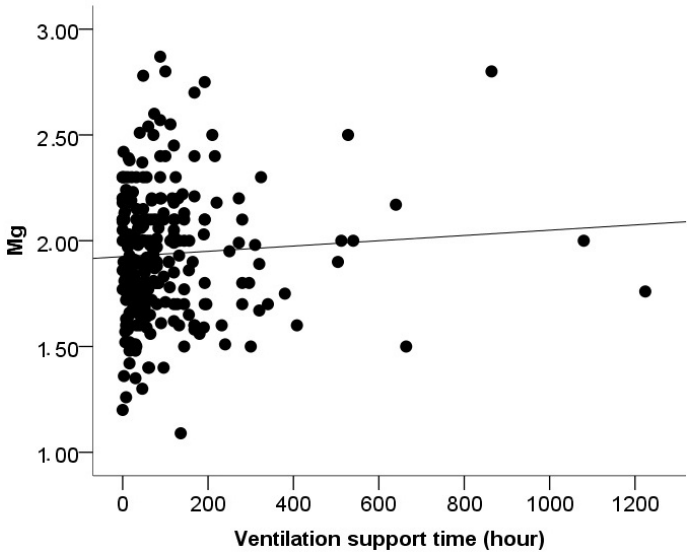

FIGURE 4. Correlation analysis regarding magnesium levels and duration of ventilation support (*rho* = 0.043, *p* = 0.435). Mg: Magnesium.

ceived IMV, and 27.6% required transition from NIV to IMV. The rate of IMV varies across studies. For example, Li *et al*. [22] reported an IMV rate of 40.6% in patients who presented to the clinic with acute exacerbation of COPD, and their result is consistent with our findings. However, Pierre *et al*. [23] reported an IMV rate of 20.5%, while Diop *et al*. [24] found it to be 16.7%. These results are not consistent with our study. These conflicting results may be attributed to variations in comorbidities that affect the need for IMV.

Among the deceased patients, the rates of IMV and switch from NIV to IMV were statistically higher ($p < 0.001$). Ongel *et al*. [25] found that the need for IMV increased mortality by 28 times. Another study conducted in a respiratory intensive care unit also reported significantly higher mortality rates in patients who received IMV or were switched from NIV to IMV [26]. The results of these two studies comply with our results.

When examining the relationship between mortality and serum magnesium levels in our study, no statistically significant differences were found between the patients who survived and those who did not survive regarding hypomagnesemia ($p = 0.546$) and normomagnesemia ($p = 0.835$). However, the prevalence of hypermagnesemia was significantly higher among patients who did not survive ($p = 0.001$). Al-Maqbali *et al*. [16] reported higher mortality rates in patients with hypermagnesemia compared to those with hypomagnesemia, which is consistent with the findings of our study. Nevertheless, their study also demonstrated increased mortality in hypomagnesemic patients relative to those with normal magnesium levels, which differs from the findings of our study. However, it is worth noting that our study was conducted exclusively in patients with COPD, whereas the above-mentioned study did not provide specific diagnostic information regarding the underlying respiratory diseases. Menteş *et al*. [27] conducted an intensive care study that also included patients with COPD

and found no association between magnesium levels and mortality. In their meta-analyses of critically ill patients, Jiang *et al*. [18] and Upala *et al*. [28] reported an association between hypomagnesemia and increased mortality rate. Other studies in the literature have also demonstrated that patients with hypomagnesemia have higher mortality rates compared to those with normomagnesemia [3, 29–31]. Additionally, Gonuguntla *et al*. [17] showed that hypomagnesemia was associated with a higher mortality rate compared to both normomagnesemia and hypermagnesemia [18]. The relationship between magnesium levels and mortality remains controversial in the literature and is marked by conflicting findings. Many studies in the literature include heterogeneous patient populations (*e.g.*, general ICU patients), with the distribution of respiratory diseases often not clearly specified. Besides, variations in sample size and diagnostic cut-off values may have also contributed to discrepancies between studies [32]. The differences observed in our study can be likely attributed to the fact that our patient population exclusively consisted of individuals with COPD. Specific pathophysiological mechanisms affecting magnesium balance in patients with COPD may suppress or alter the impact of hypomagnesemia on mortality. For this reason, a ROC analysis was conducted to assess the predictive value of magnesium for mortality in our study. While hypermagnesemia was found to be significantly associated with increased mortality, its predictive ability was found to be below average. Our study adds value to the existing literature by evaluating magnesium not only through a cut-off value but also by incorporating ROC analysis.

According to the regression analysis performed with variables found to be associated with mortality, APACHE II score, presence of malignancy, and the use of invasive mechanical ventilation were identified as independent risk factors for mortality. In parallel with our study, Cao *et al*. [33] identified the need for IMV as an independent risk factor for mortality. Likewise, Ongel *et al*. [25] identified both IMV requirement and APACHE II score as independent risk factors for mortality. In contrast, Jain *et al*. [34] reported only the APACHE II score as an independent risk factor, supporting the findings of our study.

When the relationship between ventilation support type and serum magnesium levels was examined in our study, only patients receiving NIV had a significantly higher rate of hypomagnesemia compared to those who did not receive NIV. In their studies, both Limaye *et al*. [35] and Safavi *et al*. [3] reported an association between hypomagnesemia and the need for mechanical ventilation. However, the type of mechanical ventilation was not specified in these studies. In contrast, another study found that hypomagnesemia was significantly associated with the need for both IMV and NIV [36]. These discrepancies may be attributed to several underlying factors. Our study focused exclusively on patients with COPD. The need for IMV may be more closely related to disease progression or underlying comorbidities rather than initial serum magnesium levels in this population.

Our study indicated no correlation between serum magnesium levels and ICU length of stay or duration of mechanical ventilation. In the meta-analysis by Jiang *et al*. [18] and the study by Laddhad *et al*. [36], the researchers reported longer ICU stays in hypomagnesemic patients, although no difference was observed in terms of ventilation duration [29]. In their meta-analysis, Upala *et al*. [28] also found longer ICU stays in hypomagnesemic patients, but mechanical ventilation duration was not assessed in that study. As we noted above, these discrepancies may stem from differences in patient populations (*e.g.*, our study focused solely on COPD patients), the measurement of serum magnesium levels upon admission, and sample size.

5. Limitations

This study has several limitations that need to be acknowledged. First, its retrospective and single-center design may limit generalizability. Second, serum magnesium levels were measured only at ICU admission, and dynamic changes during ICU stay, which might better reflect the clinical course, were not assessed. Additionally, only total serum magnesium measurement was available; ionized magnesium, which is considered more physiologically relevant [37], was not measured in our cohort. Notably, all studies we cited in this study also reported total levels rather than ionized magnesium levels, which allows for direct comparison but does not address the potential contribution of the biologically active fraction. Furthermore, due to the retrospective design and ICU workflow, spirometry parameters and stable-phase treatment details (such as home NIV use and recent glucocorticoid therapy) were not comprehensively available in the medical records. Although these data were present for a very small subset of patients from prior outpatient visits, they were incomplete and inconsistent and thus excluded from the statistical analysis to avoid bias. This limitation restricts the ability to correlate our findings with pulmonary function measures and stable-phase treatment regimens.

6. Conclusions

Our findings suggest that serum magnesium level alone is not a reliable predictor of mortality among COPD patients admitted to the ICU. Although hypermagnesemia on admission was more frequent among non-survivors, the multivariate analysis did not confirm an independent association between serum magnesium and mortality. Therefore, serum magnesium levels should be interpreted alongside comorbidities and severity scores such as APACHE II. Routine assessment of serum magnesium upon ICU admission may still provide supportive information for risk evaluation. Further prospective and interventional studies are needed to clarify whether modulation of magnesium levels can improve outcomes in critically ill COPD patients.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

CÖ—designed and performed the research, analyzed the data and wrote the manuscript. KKÖ, AK and YŞ—collected the data and help for writing manuscript. GA—supervised and provided help for writing the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This retrospective observational study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Human Investigation Committee (IRB) of Agri Ibrahim Cecen University approved this study (decision no E-95531838-050.99-127597 dated 27 February 2025). The requirement for obtaining informed consent was waived by the ethics committee because of the retrospective design of the study.

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Not applicable.

FUNDING

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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