Anatolian Journal of Emergency Medicine 2024;7(4):153-158

ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA MAKALESİ

The Impact of Lactate Clearance, Bilirubin, and Albumin on Mortality in Elderly COPD Patients: Insights from Emergency Department Data

Yaşlı KOAH Hastalarında Laktat Klirensi, Bilirubin ve Albüminin Mortalite Üzerindeki Etkisi: Acil Servis Verilerinden Elde Edilen Bulgular

Mahmut Yaman[1], Abdullah Şen[1], Hasan Mansur Durgun[1], Sema Belek[1], Murat Orak[1], Veysi Tekin[2], Ercan Gündüz[3] Cahfer Güloğlu[1]

ABSTRACT

Aim: Chronic obstructive pulmonary disease (COPD) is a common respiratory condition characterized by symptoms such as cough, dyspnea, and airflow limitation. The prevalence and health risks of COPD increase with age, making emergency interventions crucial for elderly patients. This study investigated the influence of bilirubin, lactate clearance, and albumin levels on mortality rates among elderly COPD patients in emergency settings to inform treatment strategies and improve clinical outcomes.

Material and Methods: Elderly patients diagnosed with COPD were included in this retrospective cohort study. Data on demographics, clinical presentations, laboratory results, comorbidities, and outcomes were collected. Biochemical measurements were performed via biochemical analyses and arterial blood gas analyses.

Results: Among the 139 patients studied, 89 (64%) were male with a mean age of 75 years. The mortality rate was 7.92%. No significant differences were observed in age, sex distribution, or comorbidities between deceased and surviving patients. Lactate clearance and bilirubin levels did not significantly affect mortality. However, albumin levels were notably lower in deceased patients ($p<0.05$). Univariate analysis revealed significant effects of PO_2, neutrophil, and albumin levels on mortality, whereas the multivariate model confirmed that PO_2 and albumin levels were significant predictors.

Conclusion: This study highlights the prognostic value of biochemical markers in predicting mortality among elderly COPD patients in emergency settings. While lactate clearance and bilirubin levels are not reliable predictors of mortality, lower albumin levels are strongly associated with increased mortality risk. These findings underscore the importance of the serum albumin concentration as a critical biomarker in the clinical assessment of elderly COPD patients.

Keywords: Chronic obstructive pulmonary disease, bilirubin, lactate clearance, albumin, elderly

ÖZ

Amaç: Kronik obstrüktif akciğer hastalığı (KOAH), öksürük, nefes darlığı ve hava yolu tıkanıklığı gibi semptomlarla karakterize edilen yaygın bir solunum rahatsızlığıdır. KOAH'ın prevalansı ve sağlık riskleri yaşla birlikte artmakta olup, yaşlı hastalar için acil müdahaleler hayati önem taşımaktadır. Bu çalışma, acil durumlarda yaşlı KOAH hastaları arasında bilirubin, laktat klirensi ve albümin seviyelerinin mortalite oranları üzerindeki etkisini araştırarak tedavi stratejilerini bilgilendirmeyi ve klinik sonuçları iyileştirmeyi amaçlamaktadır.

Gereç ve Yöntemler: KOAH tanısı konan yaşlı hastalar bu retrospektif kohort çalışmasına dahil edilmiştir. Demografik veriler, klinik bulgular, laboratuvar sonuçları, komorbiditeler ve sonuçlar gibi veriler toplanmıştır. Biyokimyasal ölçümler, biyokimyasal analizler ve arteriyel kan gazı analizleri yoluyla gerçekleştirilmiştir. **Bulgular:** İncelenen 139 hasta arasında 89'u (%64) erkek olup, ortalama yaş 75 idi. Mortalite oranı %7,92 olarak belirlenmiştir. Ölen ve yaşayan hastalar arasında yaş, cinsiyet dağılımı veya komorbiditelerde anlamlı farklar gözlenmemiştir. Laktat klirensi ve bilirubin seviyeleri mortaliteyi anlamlı şekilde etkilememiştir. Ancak, ölen hastalarda albümin seviyeleri belirgin şekilde daha düşüktü ($p<0,05$). Tek değişkenli analizde PO_2, nötrofil ve albümin seviyelerinin mortalite üzerinde önemli etkileri olduğu belirlenmiş, çok değişkenli modelde ise PO_2 ve albümin seviyelerinin anlamlı prediktörler olduğu doğrulanmıştır.

Sonuç: Bu çalışma, acil durumlarda yaşlı KOAH hastalarında mortaliteyi öngörmede biyokimyasal belirteçlerin prognostik değerini vurgulamaktadır. Laktat klirensi ve bilirubin seviyeleri güvenilir prediktörler olmamakla birlikte, düşük albümin seviyeleri artmış mortalite riski ile güçlü bir şekilde ilişkilidir. Bu bulgular, yaşlı KOAH hastalarının klinik değerlendirilmesinde serum albümin konsantrasyonunun kritik bir biyomarker olarak önemini ortaya koymaktadır.

Anahtar Kelimeler: Kronik obstrüktif akciğer hastalığı, bilirubin, laktat klirensi, albümin, yaşlı

Received: 2 September 2024 Accepted: 27 September 2024

[1]Dicle University Faculty of Medicine, Department of Emergency of Medicine, Diyarbakır, Türkiye
[2]Dicle University Faculty of Medicine, Department of Pulmonary Diseases, Diyarbakır, Türkiye.
[3]Dicle University Faculty of Medicine, Department of Internal Medicine, Diyarbakır, Türkiye.
Corresponding Author: Mahmut Yaman, MD **Adress:** Dicle University Faculty of Medicine, Department of Emergency Medicine, 21280 Diyarbakır, Türkiye. **Telephone:** +90 5412293521 **e-mail**: drmahmutyaman@hotmail.com.
Atıf için/Cited as: Yaman M, Sen A, Durgun HM, et al. The Impact of Lactate Clearance, Bilirubin, and Albumin on Mortality in Elderly COPD Patients: Insights from Emergency Department Data. Anatolian J Emerg Med 2024;7(4):153-158. https://doi.org/10.54996/anatolianjem.1541724.

Introduction

Chronic obstructive pulmonary disease (COPD) is a common respiratory condition characterized by cough, dyspnea, and airflow limitation (1). The global prevalence of COPD continues to rise, with significant variations observed across different regions and age groups (2,3). Although COPD is found in approximately 10% of individuals aged ≥ 40 years, its prevalence varies across countries and increases with age (4). Emergency department visits by elderly COPD patients have become a significant health issue for elderly individuals. COPD, a disease whose frequency increases with age and carries serious health risks, makes emergencies related to COPD in elderly individuals a critical issue requiring medical intervention. Particularly in elderly populations, the management of COPD exacerbations presents unique challenges, necessitating tailored medical approach (5,6). However, the characteristics and responses of patients in this population to treatment may differ from those of younger patients. In this context, the evaluation and management of elderly COPD patients presenting to the emergency department is a complex process that requires the assessment of various parameters (7,8). Biochemical parameters such as lactate clearance, bilirubin, and albumin levels can play a significant role in determining the mortality risk in elderly COPD patients presenting to the emergency department. Lactate clearance is considered an indicator of tissue oxygenation status whereas bilirubin levels can be evaluated as indicators of liver function and the inflammatory response (9,10). Low levels of albumin, a negative acute phase reactant, can be associated with systemic inflammation. Additionally, the level of albumin can be influenced by nutritional status, and low albumin levels may be related to impaired nutritional conditions (11). Determining the effects of these parameters on mortality in elderly patients with COPD can play a crucial role in treatment planning and improving clinical outcomes. In this study, the effects of lactate clearance, and bilirubin and albumin levels on mortality in elderly COPD patients were investigated.

Material and Methods

Patient population and study design: The study was conducted in a Medical Faculty Hospital, a tertiary care center with a high patient volume of cases requiring emergency intervention in elderly COPD patients. The study was conducted retrospectively, analyzing elderly patients aged 65 and older diagnosed with chronic obstructive pulmonary disease (COPD) who presented to the emergency department between January 1, 2021, and December 31, 2021. Patient data were accessed through the hospital's information management system. Data were collected on patients' demographic details (age, sex), clinical presentations, laboratory results (including bilirubin levels and lactate clearance), comorbidities, and outcomes. The primary outcome was defined as in-hospital mortality among geriatric COPD patients admitted to the hospital. Secondary outcomes included the prognostic value of biochemical parameters (albumin, bilirubin, and lactate clearance) in predicting mortality. Biochemical parameters were analyzed using blood samples collected at the time of emergency department admission. The bilirubin and albumin levels in the serum samples were measured via biochemical analyzers. These devices operate on a spectrophotometric basis, providing precise measurements of serum bilirubin and albumin concentrations. Lactate clearance was assessed through arterial blood gas analyses, offering insights into tissue oxygenation status in conditions such as sepsis and other critical states. Patients were followed from their admission to the emergency department through their hospital stay, and mortality status was recorded. In-hospital mortality rates were assessed in relation to the biochemical parameters. The study followed only in-hospital mortality. To ensure the methodological integrity of the study and to standardize the reporting processes, this research was conducted in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

This study was approved by Dicle University Medical Faculty Ethics Committee for Noninterventional Studies (Date: June 9, 2022; Number: 189). This study was conducted in accordance with the principles of the Declaration of Helsinki. Of the 165 patients initially evaluated, 26 were excluded by exclusion criteria, leaving a final sample size of 139 patients:

Inclusion criteria:

1. Only patients presenting with acute exacerbation of COPD were included in the study.
2. Complete clinical and laboratory data for all patients included in the study were accessible. This data had to include serum bilirubin, albumin levels, and lactate clearance, as assessed through arterial blood gas analysis.
3. Demographic information, comorbidities, and biochemical parameters of the patients were comprehensively recorded.
4. Patients with available mortality data during their hospital stay were included in the study.

Exclusion criteria:

1. Patients diagnosed with COPD but not presenting with an exacerbation of the disease.
2. Patients with incomplete or insufficient biochemical data, including bilirubin, albumin, or lactate clearance, were excluded from the study.
3. Patients presenting with respiratory diseases other than COPD (e.g., asthma, interstitial lung disease) were excluded.
4. Patients with incomplete records or missing data in hospital records were excluded from the study.
5. Cases where diagnoses or treatment processes could not be tracked based on patient files were not included in the study.

Statistical Analysis

Descriptive statistics were calculated for all variables, and normality was assessed via the Kolmogorov–Smirnov and Shapiro–Wilk tests. The independent samples t test was used for normally distributed variables (e.g., age, albumin), whereas the Mann–Whitney U test was applied for nonnormally distributed variables (e.g., lactate clearance, bilirubin). Categorical variables (e.g., sex and comorbidities) were analyzed via the chi-square test or Fisher’s exact test for small sample sizes. Univariate logistic regression was used to assess the impact of individual biochemical parameters on mortality. Significant variables were included in a multivariate logistic regression model via the forward LR

method. Analyses were conducted with IBM SPSS Statistics, Version 27.0, and a p-value of <0.05 was considered significant.

Results

There were 139 patients that were included in the study. Eighty-nine (64%) of our patients were male. The mean age of the patients in this study was 75.0 years. The number of survivors was 128 (92.08%), and 11 (7.92%) died. Among those who died, eight (72.7%) were male. There was no significant difference (p>0.05) in the age or sex distribution between the deceased and surviving groups. Similarly, there were no significant differences (p>0.05) in the rates of diabetes, hypertension, COPD, heart disease, malignancy, renal failure, or neurological disease between these groups. Additionally, there was no significant difference (p>0.05) in lactate clearance or bilirubin levels; however, albumin levels were significantly lower (p<0.05) in the deceased group, indicating that lower albumin levels could increase mortality risk (Table 1). There was no significant difference (p>0.05) in the WBC, HGB, HCT, RDW, PLT, MPV, lymphocyte, UREA, creatinine, globulin, ALT, AST, ALP, GGT, LDH, amylase, calcium, sodium, potassium, or CRP levels; however, the neutrophil counts were significantly lower (p<0.05) in the deceased group (Table 2). In the univariate model, the significant (p < 0.05) effects of PO_2, neutrophil, and albumin levels were observed in distinguishing between deceased and surviving patients. In the multivariate reduced model, significant and independent (p < 0.05) effects of PO_2 and albumin levels were observed in distinguishing between deceased and surviving patients (Table 3).

		Deceased		Survivor		p	
		Mean. ± SD or n (%)	Median	Mean. ± SD or n (%)	Median		
Age		78.4 ± 10.0	75.0	75.9 ± 7.6	75.0	0.553	m
Sex	Female	3 (27.3)		47 (36.7)		0.531	X^2
	Male	8 (72.7)		81 (63.3)			
Diabetes mellitus	(-)	8 (72.7)		110 (85.9)		0.372	X^2
	(+)	3 (27.3)		18 (14.1)			
Hypertension	(-)	8 (72.7)		76 (59.4)		0.385	X^2
	(+)	3 (27.3)		52 (40.6)			
Chronic obstructive pulmonary disease	(-)	0 (0.0)		2 (1.6)		1.000	X^2
	(+)	11 (100.0)		126 (98.4)			
Heart Disease	(-)	7 (63.6)		77 (60.2)		0.821	X^2
	(+)	4 (36.4)		51 (39.8)			
Malignancy	(-)	11 (100.0)		124 (96.9)		1.000	X^2
	(+)	0 (0.0)		4 (3.1)			
Chronic kidney disease	(-)	11 (100.0)		120 (94.5)		1.000	X^2
	(+)	0 (0.0)		7 (5.5)			
Neurological	(-)	10 (90.9)		124 (96.9)		0.342	X^2
	(+)	1 (9.1)		4 (3.1)			
Lactate clearance (%)		36.7 ± 24.3	35.7	15.2 ± 77.3	27.8	0.285	m
Bilirubin (mg/dL)		0.61 ± 0.35	0.50	0.52 ± 0.31	0.45	0.425	m
Albumin (g/dL)		3.1 ± 0.6	3.2	3.6 ± 0.5	3.6	***0.014***	m
First measurement							
pH		7.3 ± 0.1	7.3	7.3 ± 0.1	7.3	0.648	m
PCO_2 (mmHg)		64.9 ± 24.6	55.0	58.1 ± 16.2	55.5	0.706	m
PO_2 (mmHg)		62.0 ± 33.6	50.4	39.6 ± 17.8	36.0	***0.002***	m
COHb (%)		1.9 ± 0.6	1.9	1.7 ± 0.7	1.6	0.424	m
Lactate (mmol/L)		2.5 ± 1.5	2.2	2.3 ± 2.1	1.8	0.445	m
HCO_3 (mmol/L)		30.4 ± 6.9	29.9	26.2 ± 4.3	26.4	0.081	t
Second measurement							
PH		7.3 ± 0.1	7.3	7.3 ± 0.1	7.3	0.219	t
PCO_2 (mmHg)		69.2 ± 26.0	65.5	57.5 ± 17.8	56.5	0.051	t
PO_2 (mmHg)		62.8 ± 34.6	47.4	55.1 ± 29.6	43.9	0.604	m
COHb (%)		1.7 ± 0.5	1.6	1.8 ± 0.6	1.7	0.607	t
Lactate (mmol/L)		1.6 ± 0.9	1.2	1.6 ± 1.6	1.3	1.000	m
HCO_3 (mmol/L)		30.0 ± 6.8	31.5	27.0 ± 4.6	26.8	0.051	t

Table 1. Comparative analysis of clinical parameters between deceased and survivor patient groups
m: Mann-Whitney U, t: independent sample t test, X^2: Chi-square

	Survivor		Deceased		p	
	Mean ± SD	Median	Mean ± SD	Median		
WBC (x10³/µL)	15.8 ± 7.9	14.2	11.7 ± 6.0	10.2	0.062	m
HGB (g/dL)	12.3 ± 2.6	12.9	13.0 ± 2.8	13.7	0.163	m
HCT (%)	39.2 ± 7.9	39.5	41.8 ± 8.5	43.0	0.080	m
RDW (%)	14.9 ± 2.0	13.9	16.0 ± 3.0	15.3	0.236	m
PLT (x10³/µL)	328.7 ± 125.4	270.0	251.6 ± 82.4	249.0	0.071	t
MPV (fL)	9.9 ± 0.7	9.9	10.2 ± 0.9	10.1	0.229	m
Lymphocyte (x10³/µL)	1.1 ± 0.9	0.8	1.3 ± 1.0	1.1	0.316	m
Neutrophil (x10³/µL)	13.5 ± 7.5	11.5	9.2 ± 5.3	7.4	***0.025***	m
Ürea (mg/dL)	57.1 ± 38.7	45.1	61.5 ± 63.8	47.1	0.740	m
Creatine (mg/dL)	0.8 ± 0.5	0.8	1.0 ± 0.4	1.0	0.077	m
Albumin (g/dL)	3.1 ± 0.6	3.2	3.6 ± 0.5	3.6	***0.014***	m
Globulin (g/dL)	3.2 ± 0.5	3.3	3.2 ± 0.5	3.2	0.767	m
ALT (U/L)	27.1 ± 23.4	18.4	22.4 ± 34.9	17.1	0.553	m
AST (U/L)	33.0 ± 21.0	26.6	36.8 ± 93.3	24.4	0.757	m
ALP (U/L)	87.7 ± 38.3	75.0	82.4 ± 26.7	80.0	0.740	m
GGT (U/L)	71.9 ± 95.4	45.3	33.2 ± 33.2	22.6	0.449	m
LDH (U/L)	306.9 ± 114.4	328.7	350.4 ± 243.8	287.1	0.899	m
Amylase (U/L)	56.6 ± 34.6	51.0	73.7 ± 41.7	64.9	0.149	m
Calcium (mg/dL)	8.6 ± 0.7	8.6	9.0 ± 0.9	8.9	0.133	m
Sodium (mEq/L)	132.1 ± 9.6	134.5	135.0 ± 5.7	136.5	0.134	m
Potassium (mEq/L)	4.6 ± 0.9	4.6	4.8 ± 0.8	4.8	0.491	m
CRP (mg/dL)	8.9 ± 7.8	7.0	6.8 ± 8.3	2.4	0.268	m

Table 2. Comparative Analysis of Laboratory Parameters Between Survivor and Deceased Patient Groups
m: Mann-Whitney U, t: independent sample t test.

	Univariate Model					Multivariate Model				
	OR	95% CI			p	OR	95% CI			p
PO_2 (mmHg)	0.97	0.95	-	0.99	***0.007***	0.97	0.94	-	0.99	***0.013***
Neutrophil (x10³/µL)	0.90	0.82	-	0.98	***0.021***					
Albumin (g/dL)	3.99	1.31	-	12.17	***0.015***	3.65	1.12	-	11.87	***0.031***

Table 3. Univariate and Multivariate Logistic Regression Analysis for Predicting Mortality in Patients
Logistic Regression (Forward LR)

Discussion

Our study investigated the relationships between lactate clearance, bilirubin levels, and albumin levels and mortality among elderly COPD patients who presented to the emergency department. COPD is a major health concern among elderly individuals and is characterized by frequent exacerbations that can lead to acute respiratory failure and increased mortality (2,3). As the population ages, the incidence and impact of COPD continue to rise, emphasizing the need for effective management strategies in emergency settings (12). Our results indicate that lactate clearance and bilirubin levels do not significantly influence mortality rates in elderly COPD patients. Our finding aligns with those of previous studies such as Durmuş et al., which also reported no significant effect of lactate clearance on mortality in COPD exacerbations (13). Similarly, recent research underscores the limited prognostic value of lactate levels in predicting mortality among COPD patients (14,15). In contrast to some studies suggesting a protective role of higher serum bilirubin levels in COPD outcomes, our analysis did not find a significant association between bilirubin levels and mortality (16). This discrepancy may be attributed to differences in the study populations, methodologies, and specific clinical settings in which bilirubin levels were evaluated. In contrast, the serum albumin concentration has emerged as a robust predictor of mortality. Low albumin levels are significantly associated with increased mortality risk, reflecting the multifaceted role of albumin as a marker of inflammation, nutritional status, and overall health. The importance of albumin as a prognostic marker is supported by the literature, including a nationwide cohort study demonstrating that severe hypoalbuminemia is a strong independent risk factor for acute respiratory failure in COPD patients (17). The prognostic utility of albumin in COPD may be attributed to its ability to reflect systemic inflammation and nutritional deficits, both of which are prevalent in the elderly COPD population. In the literature, it has been suggested that lactate clearance and bilirubin levels reflect the levels of inflammation and oxidative stress in circulation, and therefore could be used to predict mortality risk. However, this study demonstrated that these markers are ineffective at predicting mortality in elderly COPD patients. COPD exacerbation is an emergent respiratory condition, and biomarkers play a very limited role in the decision-making process (18). Therefore, albumin levels provide an important guide for understanding and managing the clinical

course of COPD in elderly patients in emergency situations. These findings suggest that when assessing the complex health conditions of elderly COPD patients, relying on a single biochemical marker may not be sufficient. Therefore, the use of multiple markers and their integration into clinical assessment is important for evaluating mortality risk in elderly COPD patients. Moreover, the finding that albumin levels are useful in predicting mortality is significant and can potentially impact clinical practice. In addition to being associated with inflammation, the serum albumin concentration is also a marker reflecting overall nutritional status. Therefore, it is important to evaluate albumin levels in elderly COPD patients during emergency situations and consider low albumin levels when determining appropriate treatment strategies. In this context, for clinicians providing healthcare to elderly COPD patients, routine monitoring of albumin levels and taking necessary measures to correct low levels are important.

Limitations

Considering the limitations of the study, the generalizability of these findings may be constrained by certain factors. For example, the sample of the study being selected from a specific geographical region and conducted within a certain time frame could impact the generalizability of the results. However, the findings of this study, by emphasizing the clinical importance of biochemical markers used in emergency situations in elderly COPD patients, may contribute to the direction of future research towards expanding the knowledge in this area.

Conclusion

Our study underscores the importance of albumin levels in predicting mortality among elderly COPD patients in the emergency department. Unlike lactate clearance and bilirubin levels, albumin levels are strongly associated with increased mortality risk, highlighting its role as a marker of inflammation, nutrition, and overall health. These findings support the routine assessment of the serum albumin concentration in the clinical management of elderly COPD patients. Clinicians should prioritize albumin levels when formulating treatment plans to improve survival outcomes. Future research should investigate other biochemical markers to enhance emergency care strategies for this vulnerable population.

Conflict of Interest: The authors declare that there is no conflict of interest.

Financial Support: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Authors' Contribution: MY: Content planning, literature search and review, data collection or management, data analysis, writing - original draft. **AŞ:** Content planning, literature search, editing - original Draft. **HMD:** Data collection or management, data analysis, editing - original draft. **SB:** Data collection or management, data analysis, editing - original draft. **MO:** Data collection or management, data analysis, editing - original draft. **VT:** Content planning, data analysis, editing - original Draft. **EG:** Content planning, data analysis, editing - original Draft. **CG:** Data collection or management, data analysis, editing - original draft. All authors reviewed and approved the final version of the manuscript for submission.

Ethical Approval: This study was approved by Dicle University Medical Faculty Ethics Committee for Noninterventional Studies (Date: June 9, 2022; Number: 189). This study was conducted in accordance with the principles of the Declaration of Helsinki.

References

1. Agusti A, Vogelmeier CF. GOLD 2024: a brief overview of key changes. J Bras Pneumol. 2023;49(6):e20230369. doi:10.36416/1806-3756/e20230369.
2. Mannino DM, Buist AS. Global burden of COPD: risk factors, prevalence, and future trends. Lancet. 2007;370(9589):765-773. doi:10.1016/S0140-6736(07)61380-4.
3. López-Campos JL, Tan W, Soriano JB. Global burden of COPD. Respirology. 2016;21(1):14-23. doi:10.1111/resp.12660.
4. QuickStats: Percentage of adults aged ≥18 years with diagnosed chronic obstructive pulmonary disease, by urbanization level and age group—National Health Interview Survey, United States, 2019. MMWR Morb Mortal Wkly Rep. 2021;70(26):959. doi:10.15585/mmwr.mm7026a3.
5. Schrijver J, Lenferink A, Brusse-Keizer M, et al. Self-management interventions for people with chronic obstructive pulmonary disease. Cochrane Database Syst Rev. 2022;1(1):CD002990. doi:10.1002/14651858.CD002990.pub4.
6. Cross AJ, Thomas D, Liang J, et al. Educational interventions for health professionals managing chronic obstructive pulmonary disease in primary care. Cochrane Database Syst Rev. 2022;5(5):CD012652. doi:10.1002/14651858.CD012652.pub2.
7. Sullivan J, Pravosud V, Mannino DM, et al. National and state estimates of COPD morbidity and mortality—United States, 2014-2015. Chronic Obstr Pulm Dis. 2018;5(4):324-333. doi:10.15326/jcopdf.5.4.2018.0157.
8. Liu Y, Carlson SA, Watson KB, et al. Trends in the prevalence of chronic obstructive pulmonary disease among adults aged ≥18 years—United States, 2011-2021. MMWR Morb Mortal Wkly Rep. 2023;72(46):1250-1256. doi:10.15585/mmwr.mm7246a1.
9. Tian HH, Han SS, Lv CJ, et al. The effect of early goal lactate clearance rate on the outcome of septic shock patients with severe pneumonia. Chin J Crit Care Med. 2012;24:42-45.
10. Sullivan JI, Rockey DC. Diagnosis and evaluation of hyperbilirubinemia. Curr Opin Gastroenterol. 2017;33(3):164-170. doi:10.1097/MOG.0000000000000354.
11. Li X, Qin S, Sun X, et al. Prognostic significance of albumin-globulin score in patients with operable non-small-cell lung cancer. Ann Surg Oncol. 2018;25(12):3647-3659. doi:10.1245/s10434-018-6715-z.
12. Vogelmeier CF, Criner GJ, Martínez FJ, et al. Global strategy for the diagnosis, management, and prevention of chronic obstructive lung disease 2017 report: GOLD executive summary. Arch Bronconeumol. 2017;53(3):128-149. doi:10.1016/j.arbres.2017.02.001.
13. Durmuş U, Doğan NÖ, Pekdemir M, et al. The value of lactate clearance in admission decisions of patients with acute exacerbation of COPD. Am J Emerg Med. 2018;36(6):972-976. doi:10.1016/j.ajem.2017.11.002.
14. Vincent JL, Quintairos E Silva A, Couto L Jr, et al. The value of blood lactate kinetics in critically ill patients: a systematic review. Crit Care. 2016;20(1):257. doi:10.1186/s13054-016-1403-5.
15. Ramirez-Ramos CF, Saldarriaga-Giraldo CI, Yepes-Calderón M, et al. Arterial lactate levels and their prognostic value in patients undergoing pulmonary thromboendarterectomy. Arch Peru Cardiol Cir Cardiovasc. 2021;2(2):96-102. doi:10.47487/apcyccv.v2i2.131.

16. MacDonald DM, Kunisaki KM, Wilt TJ, et al. Serum bilirubin and chronic obstructive pulmonary disease (COPD): a systematic review. BMC Pulm Med. 2021;21(1):33. doi:10.1186/s12890-021-01395-9.
17. Chen CW, Chen YY, Lu CL, et al. Severe hypoalbuminemia is a strong independent risk factor for acute respiratory failure in COPD: a nationwide cohort study. Int J Chron Obstruct Pulmon Dis. 2015;10:1147-1154. doi:10.2147/COPD.S85831.
18. Nowak M, Brożek GM, Zejda JE, et al. Impact of changing GOLD guidelines (2007-2011-2017) on assignment of a COPD patient to disease severity category. Postepy Dermatol Alergol. 2020;37(2):221-228. doi:10.5114/ada.2018.79143.