American Journal of Emergency Medicine 86 (2024) 135–140

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

The use of the Roth score in emergency department for patients with acute exacerbation of chronic obstructive pulmonary disease

Fatma Tortum [a,*], Erdal Tekin [a], Bugra Kerget [b], Alperen Aksakal [b], Orhan Enes Tuncez [a]

[a] Department of Emergency Medicine, School of Medicine, Ataturk University, Erzurum, Turkey
[b] Department of Pulmonary Diseases, School of Medicine, Ataturk University, Erzurum, Turkey

ARTICLE INFO

Article history:
Received 8 July 2024
Received in revised form 3 October 2024
Accepted 9 October 2024

Keywords:
Roth score
AECOPD
Breath-holding time
Hospitalization
Emergency department

ABSTRACT

Introduction: This study investigated the feasibility of using the Roth score in the emergency setting to make hospitalization or discharge decisions for patients with acute exacerbations of chronic obstructive pulmonary disease (AECOPD).

Materials and methods: This study was conducted prospectively between March 1, 2023 and January 1, 2024 and included 101 patients with Group E chronic obstructive pulmonary disease who were treated in the emergency department of a tertiary hospital. The patients were categorized into two groups: those who were hospitalized and those who were discharged. The Roth score, determined by measuring patients' breath-holding times after forced inspiration and counting rhythmically, was measured in seconds and counted. Changes in Roth scores, arterial blood gas parameters, and transcutaneous oxygen saturation levels measured during AECOPD presentation and after appropriate treatment were examined.

Results: The study included 101 patients (57 males, 44 females) with a mean age of 61.4 years. After AECOPD treatment, the area under the curve for the Roth score was 0.937 s for the duration and 0.969 for the count. At a cut-off value of 9.5 s, the Roth score in seconds had a sensitivity of 92 % and a specificity of 75 %. At a cut-off value of 10.5, the Roth score had a sensitivity of 97 % and a specificity of 70 %.

Conclusion: The Roth score (only counts) increased in discharged patients after AECOPD treatment. It appears to be a viable method for predicting hospitalization or discharge decisions in patients with AECOPD who present to the emergency department.

1. Introduction

Chronic obstructive pulmonary disease (COPD) is a progressive condition characterized by airflow restriction. It is increasingly recognized as a major cause of mortality and morbidity. Chronic obstructive pulmonary disease (COPD) is the third leading cause of death worldwide, causing 3.23 million deaths in 2019 [1].

Acute exacerbations of COPD (AECOPD) frequently lead to emergency department visits. Patients experiencing frequent AECOPD episodes may experience reduced lung function, diminished quality of life, and increased mortality risk [2]. During these episodes, arterial blood gas (ABG) analysis is commonly employed. Initially, ABG evaluations typically reveal mild to moderate hypoxemia, which worsens and progresses to hypercapnia as the disease progresses [3]. While ABG analysis serves as a guide for emergency physicians, it is painful for patients and can result in complications such as arterial damage, spasm, nerve injury, infection, and thrombosis [4].

For the detection of hypoxemia in patients with COPD, transcutaneous oxygen saturation (SpO_2) measurements with a cut-off value of 88–92 % are recommended [5]. This non-invasive technique is practical in emergency settings but can be influenced by various factors, including cold extremities, poor peripheral perfusion, dark skin pigmentation, the use of nail polish, and contamination of the skin or saturation probe [6,7].

The Roth score, developed in 2016 by Chorin et al., is a scoring system for patients with dyspnea [8]. It involves the patient breathing as rapidly as possible and counting out loud from 1 to 30 breaths in a single breath following forced inspiration. This method is simple to administer and has been found to be effective in assessing hypoxia levels in patients [8].

While hospitalization can reduce mortality rates among patients with AECOPD [9,10], the estimated mortality rate for these patients

* Corresponding author at: Department of Emergency Medicine, School of Medicine, Ataturk University, Erzurum, Turkey.
E-mail addresses: drcitirik@hotmail.com (F. Tortum), erdal.tekin@atauni.edu.tr (E. Tekin), bugra.kerget@atauni.edu.tr (B. Kerget), alperen.aksakal@atauni.edu.tr (A. Aksakal), orhantuncez@atauni.edu.tr (O.E. Tuncez).

https://doi.org/10.1016/j.ajem.2024.10.020

ranges from 23 % to 80 % [10]. Therefore, it is crucial to assess which patients who present to the emergency department with AECOPD should be hospitalized or discharged carefully. Such evaluations typically consider clinical status after treatment, along with SpO_2, oxygen saturation (SaO_2), partial oxygen pressure (PaO_2), and partial carbon dioxide pressure ($PaCO_2$) values obtained from ABG analysis. Given the drawbacks of these methods, this study explored the feasibility of using changes in the Roth score as a simpler alternative for making discharge decisions in Group E COPD patients following AECOPD treatment.

2. Materials and methods

2.1. Study design and study population

This study was conducted prospectively. This study was conducted with COPD patients who presented to the emergency department of a tertiary hospital between March 1, 2023, and January 1, 2024. Ethical approval was obtained from the Clinical Research Ethics Committee of the Ataturk University Faculty of Medicine (decision number 2/34). Informed consent was obtained from the patients. Based on the study by Ten Broeke et al. [11], to achieve a significant difference of 5 units between the Roth scores in the groups (9.3 ± 7.2 and 14.2 ± 7.2) with 80 % power and 95 % confidence level, it was calculated using G*Power [12] that at least 35 patients per group, totaling at least 70 patients (two tails, α: 0.05, 1-β: 0.80), were required for the study. In our study, a total of 101 COPD patients who visited our hospital were included. Following a G-power analysis, 101 patients were included in the study. The inclusion criteria were having a diagnosis of Group E COPD (defined as experiencing at least two moderate AECOPD episodes annually or having been hospitalized for AECOPD at least once), being over 18 years of age, being fluent in Turkish and being able to understand Turkish, being able to count from 1 to 30, and providing consent to participate. Patients who refused to participate, those with a COPD diagnosis outside Group E, those who required mechanical ventilation (invasive or non-invasive), and those with a Glasgow Coma score of <15 were excluded from the study. Among the 155 evaluated patients, eight required non-invasive mechanical ventilation during treatment, one required invasive mechanical ventilation, 21 refused ABG testing after treatment, 17 did not comply with the Roth score measurement, and seven had unavailable ABG values at presentation. After these patients were excluded, a total of 101 patients were included in the study.

2.2. Data collection and recording

Patient follow-up, data recording, treatment planning, and Roth score measurements before (the first Roth score was measured during the patient's examination upon arrival at the emergency department) and after AECOPD treatment (after a decision was made regarding hospitalization or discharge of the patient) were performed by only one specialist, an emergency medicine specialist with over five years of experience. Demographic information (age, gender, and patient file number) was noted. Initial SpO_2 values were recorded using a pulse oximeter (Nihon Kohden Vismo PVM-2701. NIHON KOHDEN AMERICA, LLC. 15,353 Barranca Parkway, Irvine, CA 92618) available in our clinic. Initial ABG samples were collected via heparinized syringes, and SaO_2, PaO_2, and $PaCO_2$ values were documented. During these procedures, standard AECOPD treatments and evaluations continued. Patients received a short-acting β_2 agonist-anticholinergic combination inhaler (0.5 mg ipratropium bromide equivalent, 2.5 mg salbutamol equivalent) every 20 min, up to six times, until symptom reduction. In addition, they were administered systemic steroids intravenously at a dose of 1 mg/kg. Post-treatment SpO_2 values were recorded. A second ABG sample was taken to measure and record SaO_2, PaO_2, and $PaCO_2$ values.

2.3. Roth score measurement

Roth scores were measured by an informed emergency medicine specialist before and after AECOPD treatment and recorded as two parameters: duration and count. Patients were briefed about the procedure and given a two-minute rest to ensure calm breathing. They were then instructed to take a deep breath and count out loud as rapidly as possible from 1 to 30 in a single breath, without exhaling [8]. The measurement was terminated if the patient exhaled or inhaled again. The count reached and the time taken were recorded via a Casio HS-80TW-1DF stopwatch (Casio Computer Co., Ltd., Tokyo/Japan).

2.4. Statistical analysis

The data were analyzed using SPSS version 20. The results are presented as percentages and numbers. The normality of the data distribution was assessed via the Shapiro–Wilk and Kolmogorov–Smirnov tests. The independent-sample *t*-test was used for normally distributed data, whereas the Mann–Whitney *U* test was employed for nonnormally distributed data. Categorical variables were compared via the chi-square test and Fisher's exact-test. For the evaluation of dependent groups, a paired t-test was used for normally distributed data, and the Wilcoxon test was used for data that did not have a normal distribution. Spearman correlation analysis was conducted to examine the correlation between laboratory parameters and Roth scores. A p value of <0.05 was considered to indicate statistical significance.

3. Results

The study included 101 patients (57 males, 44 females) with a mean age of 61.4 years. The average number of emergency department visits per patient in the previous year was 4.2 ± 3.9. There was a significant difference in the number of emergency department visits in the last year between hospitalized and discharged patients. This difference was statistically significant ($p < 0.001$). The average length of stay in the emergency department for all patients was 75.8 ± 25.6 min. There was a significant difference in the length of stay in the emergency department between hospitalized and discharged patients. This difference was statistically significant ($p = 0.002$). During the study, 79 patients were diagnosed with only AECOPD, whereas 22 patients were diagnosed with both AECOPD and concomitant pneumonia. Among the patients, 45 had access to home oxygen. The average time for the initial Roth score measurement was 7.2 ± 1.8 min, and the average time for the post-treatment Roth score measurement was 75.8 ± 25.6 min. There was a significant difference in the post-treatment Roth score between hospitalized and discharged patients ($p = 0.002$). This difference was statistically significant. The other descriptive characteristics of the patients are summarized in Table 1. (See Table 2.)

Table 1 summarizes the SpO_2 values, ABG parameters (SaO_2, PaO_2, and $PaCO_2$), and Roth scores (in seconds and count) at the initial evaluation and after treatment. Compared with hospitalized patients, discharged patients had significantly greater initial SpO_2, ABG SaO_2, and Roth scores (seconds and counts) ($p < 0.001$). These patients also had significantly lower initial ABG $PaCO_2$ levels ($p < 0.001$). The post-treatment SpO_2 and ABG SaO_2 values and Roth scores (seconds and counts) at discharge were significantly greater, and the post-treatment ABG $PaCO_2$ values were significantly lower in the discharged group ($p < 0.001$). The Roth score only increased in discharged patients treated for AECOPD in the emergency department (Fig. 1). (See Fig. 2.)

The receiver operating characteristic analysis indicated that the area under the curve (AUC) value was 0.978 s for the Roth score measured in seconds and 0.970 for the Roth score measured in the count. To identify patients suitable for discharge, a Roth score delta (the Roth score delta value represents the difference between the initial and second measured Roth scores) of >2.5 in count had a sensitivity of 94 % and a

Table 1
Sociodemographic characteristics and initial and post-treatment SpO_2 values, ABG parameters, and Roth scores for patients presenting with AECOPD.

	Total ($n = 101$)	Discharged patients ($n = 66$)	Hospitalized patients ($n = 35$)	p
Age, years	61.8 ± 14.9	59.8 ± 15.1	65.8 ± 13.8	0.085
Gender, male	57 (56.4 %)	34 (51.5 %)	23(65.7 %)	0.171
Number of admissions to the emergency department in the last year	4.2 ± 3.9	3.5 ± 4.0	5.4 ± 3.4	**<0.001**
Initial Roth score time(minute)	7.2 ± 1.8	7.0 ± 1.7	7.5 ± 2.1	0.184
Post-treatment score time(minute)	75.8 ± 25.6	71.9 ± 27.6	83.1 ± 19.7	**0.002**
Length of emergency department visit	75.8 ± 25.6	71.9 ± 27.6	83.1 ± 19.7	**0.002**
Number of times SABA/SAMA was performed in the emergency department	3.7 ± 1.3	3.6 ± 1.3	3.9 ± 1.4	0.288
Emergency department Pneumonia diagnoses				
With pneumonia	22 (21.8 %)	12 (18.2 %)	10 (28.6 %)	0.231
Without pneumonia	79 (78.2 %)	54 (81.8 %)	25 (71.4 %)	
Coronary artery disease	29 (28.7 %)	20 (30.3 %)	9 (25.7 %)	0.628
Hypertension	53 (52.5 %)	27 (40.9 %)	26 (74.3 %)	0.800
Diabetes mellitus	35 (34.7 %)	19 (28.8 %)	16 (45.7 %)	0.626
Total number of drugs used (at home)	2.9 ± 2.1	2.2 ± 2.1	4.2 ± 1.5	**<0.001**
Number of home inhalers:				**<0.001**
ICS+ LABA	59 (58.4 %)	48 (72.7 %)	11 (31.4 %)	
LABA+ LAMA	8 (7.9 %)	1 (1.5 %)	7 (20.0 %)	
ICS+ LABA+ LAMA	34 (33.7 %)	17 (25.8 %)	17 (48.6 %)	
Availability of oxygen at home	45 (44.6 %)	21 (31.8 %)	24 (68.6 %)	**<0.001**
Number of prior hospitalizations in the last year	1.0 ± 1.4	0.5 ± 1.0	2.0 ± 1.4	**<0.001**
Initial SpO_2	84 ± 9.4	87 ± 7.4	78.5 ± 10.2	**<0.001**
SaO_2 on initial ABG	85.4 ± 9.1	88 ± 7.6	80 ± 10	**<0.001**
$PaCO_2$ on initial ABG	44.7 ± 11.4	39.7 ± 8.4	54.1 ± 10.4	**<0.001**
Initial Roth score (seconds)	10 ± 4.7	11.4 ± 5	7.8 ± 2.8	**<0.001**
Initial Roth score (count)	15 ± 7.6	18 ± 7.9	10 ± 3.4	**<0.001**
Post-treatment SpO_2	89 ± 5.7	91.4 ± 4.1	84.8 ± 6	**<0.001**
SaO_2 on post-treatment ABG	89.4 ± 5.8	91.5 ± 4.5	85.4 ± 5.8	**<0.001**
$PaCO_2$ on post-treatment ABG	41.6 ± 10.2	36.3 ± 6.4	51.5 ± 8.4	**<0.001**
Post-treatment Roth score (seconds)	14.8 ± 7.2	18.3 ± 6.2	8.2 ± 3	**<0.001**
Post-treatment Roth score (count)	21.8 ± 11.3	28 ± 8.8	10.2 ± 4	**<0.001**

Note: SpO_2: transcutaneous saturation value, ABG: arterial blood gas, SaO_2: oxygen saturation in ABG, $PaCO_2$: partial carbon dioxide pressure in ABG, AECOPD: acute exacerbation of chronic obstructive pulmonary disease, ICS: inhaled corticosteroids, SABA: short-acting $beta_2$- agonist, SAMA: short-acting muscarinic antagonists, LABA: long-acting $beta_2$- agonist, LAMA: long-acting muscarinic antagonists.

specificity of 83 %, whereas a Roth score delta of >2.5 in seconds had a sensitivity of 93 % and a specificity of 99 %.

Following AECOPD treatment, the Roth score in seconds had an AUC value of 0.937, whereas the Roth score in count had an AUC of 0.969. At a cut-off value of 9.5 s, the sensitivity of the Roth score in seconds was 92 %, and the specificity was 75 %. For the Roth score obtained in the count, at a cut-off value of 10.5, the sensitivity was 97 %, and the specificity was 70 %.

Table 3 shows the correlations between hospitalization duration and initial SpO_2 values, ABG SaO_2 and $PaCO_2$ parameters, Roth scores, and annual hospital visit frequency for the included patients. Accordingly, SpO_2 values, the Roth score in seconds, and the Roth score in the count were inversely correlated with hospitalization rates ($R = -0.464$, $p = 0.01$, $R = -0.267$, p = 0.01, and $R = -0.354$, p = 0.01, respectively). A positive correlation was observed between ABG $PaCO_2$ levels and hospitalization ($R = 0.44$, p = 0.01).

Table 2
ROC analysis of post-treatment SpO_2, ABG parameters, Roth scores (seconds and count), and delta values for the hospitalization decision in patients presenting with AECOPD.

	Area	Std error	p	Asymptotic 95 % confidence interval	
				Lower Bound	Upper Bound
Post-treatment SpO_2	0.816	0.45	<0.01	0.728	0.905
Post-treatment SaO_2	0.805	0.43	<0.01	0.721	0.890
Post-treatment $PaCO_2$	0.82	0.029	<0.01	0.026	0.138
Post-treatment Roth score (seconds)	0.937	0.024	<0.01	0.889	0.985
Roth score delta (seconds)	0.978	0.011	<0.01	0.957	0.999
Post-treatment Roth score (count)	0.969	0.015	<0.01	0.941	0.998
Roth score delta (count)	0.970	0.015	<0.01	0.942	0.999

Note: SpO_2: transcutaneous saturation value, ABG: arterial blood gas, SaO_2: oxygen saturation in ABG, $PaCO_2$: partial carbon dioxide pressure in ABG, AECOPD: acute exacerbation of chronic obstructive pulmonary disease.

4. Discussion

Upon evaluating transcutaneous SpO_2, ABG parameters, Roth scores (seconds and counts), and Roth score delta values (seconds and counts) in patients with AECOPD who presented to the emergency department, these parameters may help decide whether a patient should be hospitalized or discharged. The most sensitive parameter was the difference between the Roth score (second and count) at the initial presentation and after treatment. For patients with AECOPD, the ability to hold their breath for 9.5 s and count to at least 10 in a single breath after treatment or the ability to count to a number 2.5 higher than the initial Roth score or hold their breath for 2.5 s longer than the initial Roth score was highly specific and sensitive for predicting discharge. Thus, the Roth score may be used as a practical method for making hospitalization or discharge decisions for patients with AECOPDs in an emergency setting. This study is also the first to link patient outcomes (discharge or hospitalization) with the Roth score in the AECOPD patient population.

Chorin et al. introduced the Roth score and conducted a study on hospitalized, hypoxic patients with varying causes of hypoxia (pneumonia, heart failure, ischemic heart disease, COPD, etc.) to determine the degree of hypoxia [8]. They reported maximum Roth scores of 15 counts and 8 s in patients with a SpO_2 value of <95 % [8]. Our study focused solely on Group E COPD patients and assessed the relationships between SpO_2, SaO_2, $PaCO_2$, and the Roth score at the time of presentation and after AECOPD treatment. In our study, the initial $SpO_2 < 95$ % value and Roth score were consistent with the findings reported by Chorin et al. in terms of count, but our patients had longer Roth scores in seconds. This could be attributed to our exclusive focus on patients with COPD. Similar findings were reported by Hedhli et al., who also evaluated patients with COPD and reported a maximum breath-holding time of 25 ± 8 s. [13]. Chronic hypoxic adaptation in Group E COPD patients may have contributed to prolonged breath-holding times.

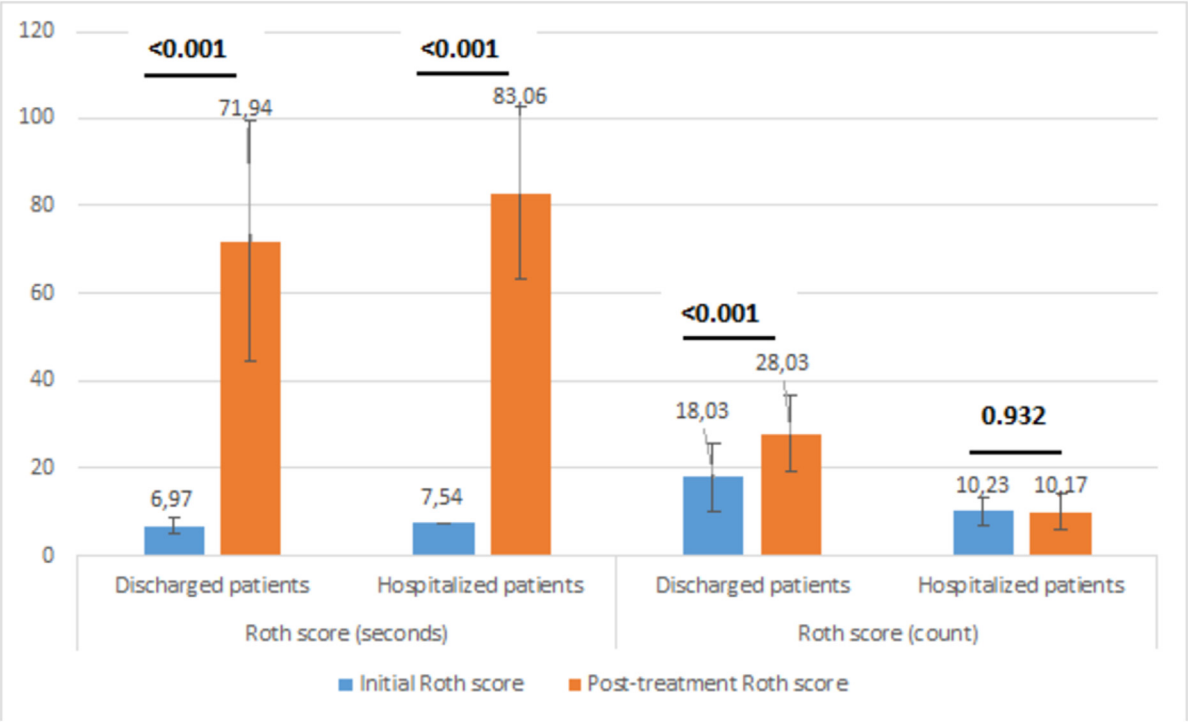

Fig. 1. Comparison of Roth scores of discharged and hospitalized patients before and after treatment.

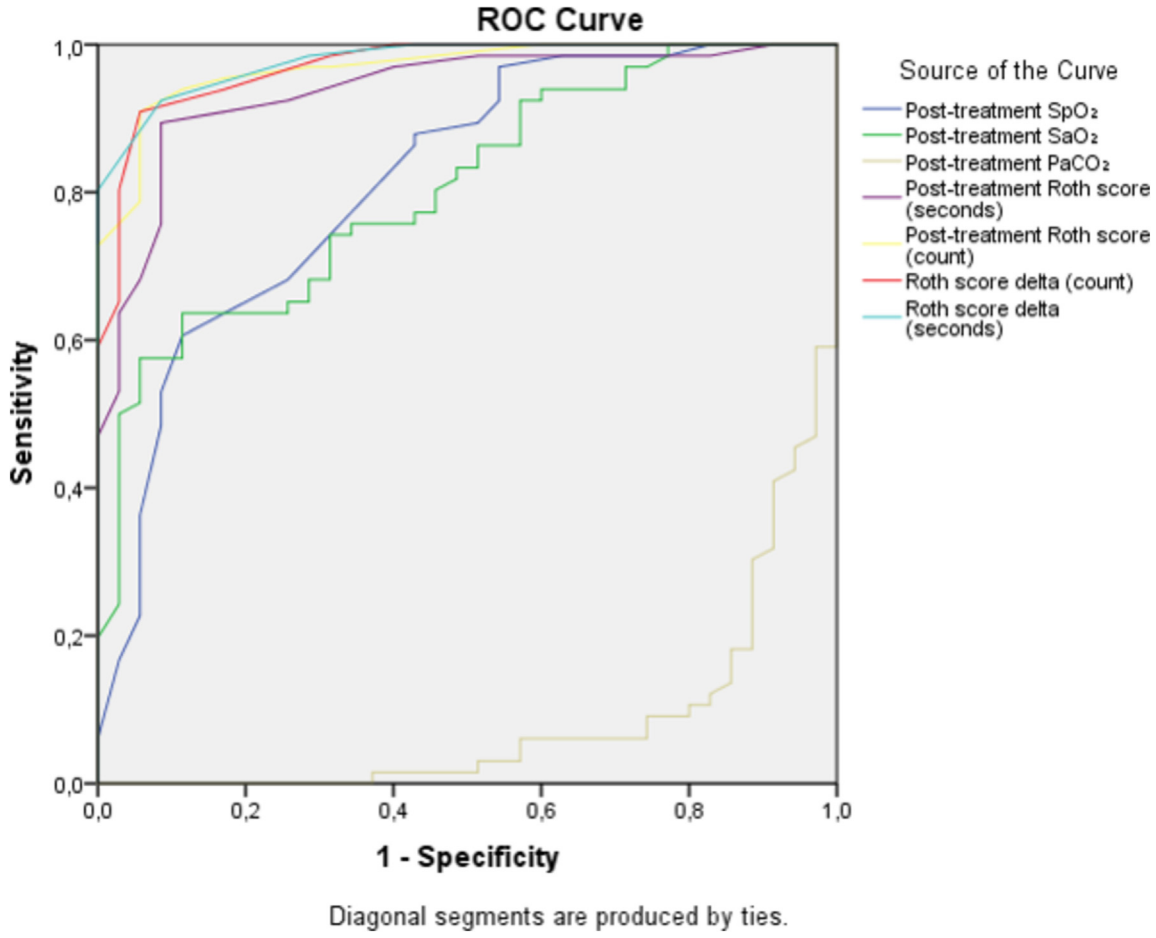

Fig. 2. ROC analysis showing sensitivity and specificity for discharge, post-treatment SpO_2, ABG parameters, Roth scores (seconds and counts), and delta values (seconds and counts) for patients presenting to the emergency department with AECOPD.

Table 3
Correlations between hospitalization duration and initial SpO_2 values, ABG SaO_2 and $PaCO_2$ parameters, Roth scores, and annual hospital visit frequency for the included patients.

		Initial SpO_2	Initial ABG SaO_2	Initial ABG $PaCO_2$	Initial Roth score (sec)	Initial Roth score (count)	Number of ED visits/year	Number of hospitalizations/year
Initial SpO2	R	1.000						
	p	.						
Initial ABG SaO_2	R	0.842**	1.000					
	p	<0.001	.					
Initial ABG $PaCO_2$	R	−0.472**	−0.468**	1.000				
	p	<0.001	<0.001	.				
Initial Roth Score (sec.)	R	0.331**	0.313**	−0.333**	1.000			
	p	0.001	0.001	0.001	.			
Initial Roth score (count)	R	0.277**	0.268**	−0.420**	0.807**	1.000		
	p	0.005	0.007	<0.001	<0.001	.		
Number of ED visits/year	R	−0.175	−0.080	0.134	−0.128	−0.135	1.000	
	p	0.080	0.429	0.180	0.201	0.177	.	
Number of hospitalizations/year	R	−0.464**	−0.342**	0.440**	−0.267**	−0.354**	0.663**	1.000
	p	<0.001	<0.001	<0.001	0.007	<0.001	<0.001	.

Note: **Correlation is significant at the 0.01 level (2-tailed). SpO_2: transcutaneous saturation value, ABG: arterial blood gas, SaO_2: oxygen saturation in ABG, $PaCO_2$: partial carbon dioxide pressure in ABG, AECOPD: acute exacerbation of chronic obstructive pulmonary disease, ED: emergency department.

To our knowledge, only two other studies have evaluated the Roth score in relation to dyspnea without distinguishing the cause and exploring its association with hypoxia [11,14]. In one of these studies, De La Hoz et al. reported that the Roth score was not significantly associated with the degree of hypoxia in patients with dyspnea of various origins [14]. The presence of individuals in their cohort with dyspnea for various reasons (active COVID-19 infection, asthma exacerbation, COPD exacerbation, and unidentified causes) may have contributed to their conclusion that there was no association between the Roth score and the severity of hypoxia. In another study, Ten Broeke et al. reported that the Roth score was associated with hypoxia in patients with dyspnea caused by COVID-19 [11].

In our study, although the Roth scores measured at the time of the discharged patient's initial examination in the emergency department were low in both counts and seconds, a significant increase in Roth scores was observed after AECOPD treatment. However, while an increase in Roth scores measured in seconds was observed in hospitalized patients, no significant change was observed in the count measurements. This may be because, prior to treatment, patients were under stress due to hypoxia and tended to count more quickly, whereas after treatment, despite an increase in breath-holding time, the patient's counting rate might have slowed down as they became more relaxed than at baseline. Additionally, although increased oxygenation during treatment may have extended the breath-holding time, it might not have been sufficient to increase the patient's counting effort. We specifically evaluated Group E COPD patients during AECOPD, possibly explaining the significant association between the Roth score and hypoxia. It is anticipated that hypoxic patients will have a low Roth score because of the challenges they have in breath holding and counting following forced inspiration. Consequently, as SpO_2 and SaO_2 values decrease at the initial presentation, the Roth score decreases in terms of both seconds and count. Moreover, as $PaCO_2$ levels rise, the Roth score may decrease in both seconds and count.

Given the pathophysiology of COPD, patients experience severe attacks due to severe bronchospasm and obstruction, and both hypoxia and hypercapnia occur along with respiratory fatigue [15]. Therefore, new or worsening hypercapnia ($PaCO_2 > 45$ mmHg) is a criterion for severe AECOPD [16]. Therefore, increased $PaCO_2$ levels, indicating severe AECOPD, are correlated with lower Roth scores. As the severity of AECOPD increases, the likelihood of hospitalization also increases [17,18]. In our study, the Roth score was closely related to patients' $PaCO_2$ levels and the need for hospitalization. The literature also suggests that high $PaCO_2$ levels in patients with COPD are associated with increased mortality and hospitalization rates [19,20]. However, our study focused only on hospitalization requirements, not mortality rates.

Our study has certain limitations. First, the Roth score has not yet been validated in the Turkish population, and the study was conducted at a single center with a limited number of patients. Second, we evaluated hospitalization or discharge decisions but did not consider mortality rates or the need for mechanical ventilation after hospitalization. Lastly, the Roth score is a scoring system that depends on the patient and the language used. Consequently, the accuracy of the scoring is influenced by the patient's emotional state, cognitive capacity, and willingness to perform. Despite adequately informing and obtaining consent from the patients included in our study, it is possible that their scoring efforts may have affected our results.

5. Conclusion

To our knowledge, this is the first study to examine the relationship between the Roth score and hospitalization or discharge decisions, specifically in patients with AECOPD. The Roth score appears to be a viable method for assisting such decisions in patients with AECOPD who present to the emergency department. Higher Roth scores (not seconds but counts) after treatment indicate a greater likelihood of discharge.

Ethical issue

Ethical approval was obtained from the Clinical Research Ethics Committee of the Ataturk University Faculty of Medicine (decision number 2/34). Informed consent was obtained from the patients.

Funding

None.

CRediT authorship contribution statement

Fatma Tortum: Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Data curation, Conceptualization. **Erdal Tekin:** Supervision, Software, Methodology, Formal analysis, Conceptualization. **Bugra Kerget:** Writing – review & editing, Software, Resources, Formal analysis, Data curation. **Alperen Aksakal:** Visualization, Software, Investigation, Formal analysis. **Orhan Enes Tuncez:** Visualization, Resources, Funding acquisition, Data curation.

Declaration of generative AI and AI-assisted technologies in the writing process

Artificial intelligence programs were not used during the writing of the article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajem.2024.10.020.

References

[1] World Health Organization (WHO). Chronic respiratory diseases. https://www.who.int/news-room/fact-sheets/detail/chronic-obstructive-pulmonary-disease-(copd); 2024. Date last accessed: July 25.

[2] Meeraus WH, DeBarmore BM, Mullerova H, Fahy WA, Benson VS. Terms and definitions used to describe recurrence, treatment failure and recovery of acute exacerbations of COPD: a systematic review of observational studies. Int J Chron Obstruct Pulmon Dis. 2021 Dec;24(16):3487–502. https://doi.org/10.2147/COPD.S335742. PMID: 34992357; PMCID: PMC8713707.

[3] Sheng F, Chen L, Lin H, Wu H. Systematic review and meta-analysis: value of venous blood gas in the diagnosis of acute exacerbation of chronic obstructive pulmonary disease in emergency department. Ann Palliat Med. 2022 Apr;11(4):1473–81. https://doi.org/10.21037/apm-22-336. [PMID: 35523755].

[4] Wong EKC, Lee PCS, Ansary S, Asha S, Wong KKH, Yee BJ, et al. Role of venous blood gases in hypercapnic respiratory failure chronic obstructive pulmonary disease patients presenting to the emergency department. Intern Med J. 2019 Jul;49(7):834–7. https://doi.org/10.1111/imj.14186. [PMID: 30515940].

[5] Buekers J, Theunis J, De Boever P, Vaes AW, Koopman M, Janssen EV, et al. Wearable finger pulse oximetry for continuous oxygen saturation measurements during daily home routines of patients with chronic obstructive pulmonary disease (COPD) over one week: observational study. JMIR Mhealth Uhealth. 2019 Jun 6;7(6):e12866. https://doi.org/10.2196/12866. [PMID: 31199331; PMCID: PMC6594211].

[6] Lee H, Ko H, Lee J. Reflectance pulse oximetry: practical issues and limitations. Ict Express. 2016 December;2(4):195–8. https://doi.org/10.1016/j.icte.2016.10.004.

[7] DeMeulenaere S. Pulse oximetry: uses and limitations. J Nurse Pract. 2007 May;3(5):312–7. https://doi.org/10.1016/j.nurpra.2007.02.021.

[8] Chorin E, Padegimas A, Havakuk O, Birati EY, Shacham Y, Milman A, et al. Assessment of respiratory distress by the Roth score. Clin Cardiol. 2016 Nov;39(11):636–9. https://doi.org/10.1002/clc.22586. [Epub 2016 Oct 4. PMID: 27701750; PMCID: PMC6490799].

[9] Liang L, Li C, Shen Y, Rong H, Jing H, Tong Z. Long-term trends in hospitalization and outcomes in adult patients with exacerbation of chronic obstructive pulmonary disease in Beijing, China, from 2008 to 2017. Int J Chron Obstruct Pulmon Dis. 2020 May;21(15):1155–64. https://doi.org/10.2147/COPD.S238006. PMID: 32547003; PMCID: PMC7247605.

[10] Global Initiative for Chronic Obstructive Lung Disease 2024 Report. https://goldcopd.org/2024-gold-report/; 2024. Date last accessed: 6 Augst.

[11] Ten Broeke CEM, Himmelreich JCL, Cals JWL, Lucassen WAM, Harskamp RE. The Roth score as a triage tool for detecting hypoxaemia in general practice: a diagnostic validation study in patients with possible COVID-19. Prim Health Care Res Dev. 2021 Oct;18(22):e56. https://doi.org/10.1017/S1463423621000347. PMID: 34658321; PMCID: PMC8527530.

[12] Kang H. Sample size determination and power analysis using the G*Power software. J Educ Eval Health Prof. 2021;18:17. https://doi.org/10.3352/jeehp.2021.18.17. Epub 2021 Jul 30. PMID: 34325496; PMCID: PMC8441096.

[13] Hedhli A, Slim A, Ouahchi Y, Mjid M, Koumenji J, Cheikh Rouhou S, et al. Maximal voluntary breath-holding tele-inspiratory test in patients with chronic obstructive pulmonary disease. Am J Mens Health. 2021 May-Jun;15(3). https://doi.org/10.1177/15579883211015857. 15579883211015857. [PMID: 33993797; PMCID: PMC8127757].

[14] la Hoz GV, Fernández-Aedo I, Berasaluze-Sanz L, Ubierna-Prieto JA, EngD JC. Ballesteros-Peña S; SCuORE working group. Validity of the "Roth score" for hypoxemia screening. Am J Emerg Med. 2023 Apr;66:129–34. https://doi.org/10.1016/j.ajem.2023.01.034. Epub 2023 Jan 24. PMID: 36753928.

[15] Long B, Rezaie SR. Evaluation and Management of Asthma and Chronic Obstructive Pulmonary Disease Exacerbation in the emergency department. Emerg Med Clin North Am. 2022 Aug;40(3):539–63. https://doi.org/10.1016/j.emc.2022.05.007. Epub 2022 Jul 9. PMID: 35953216.

[16] Sharma M, Joshi S, Banjade P, Ghamande SA, Surani S. Global initiative for chronic obstructive lung disease (GOLD) 2023 guidelines reviewed. Open Respir Med J. 2024 Jan;10(18). https://doi.org/10.2174/0118743064279064231227070344. e18743064279064. PMID: 38660684; PMCID: PMC11037508.

[17] Rothnie KJ, Müllerová H, Smeeth L, Quint JK. Natural history of chronic obstructive pulmonary disease exacerbations in a general practice-based population with chronic obstructive pulmonary disease. Am J Respir Crit Care Med. 2018 Aug 15;198(4):464–71. https://doi.org/10.1164/rccm.201710-2029OC. PMID: 29474094; PMCID: PMC6118021.

[18] Zhang Y, Zheng SP, Hou YF, Jie XY, Wang D, Da HJ et all. A predictive model for frequent exacerbator phenotype of acute exacerbations of chronic obstructive pulmonary disease. J Thorac Dis 2023 Dec 30;15(12):6502–6514. https://doi.org/10.21037/jtd-23-931. Epub 2023 Dec 21. PMID: 38249857; PMCID: PMC10797373.

[19] Dreher M, Neuzeret PC, Windisch W, Martens D, Hoheisel G, Gröschel A, et al. Prevalence of chronic hypercapnia in severe chronic obstructive pulmonary disease: data from the HOmeVent registry. Int J Chron Obstruct Pulmon Dis. 2019 Oct;18(14):2377–84. https://doi.org/10.2147/COPD.S222803. [PMID: 31695357; PMCID: PMC6805244].

[20] Wei X, Yu N, Ding Q, Ren J, Mi J, Bai L. The features of AECOPD with carbon dioxide retention. BMC Pulm Med. 2018 Jul 31;18(1):124. https://doi.org/10.1186/s12890-018-0691-8. PMID: 30064410; PMCID: PMC6066936.