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Original Article

# Pulmonary Embolism Severity Index Predicts Adverse Events in Hospitalized COVID-19 Patients: A Retrospective Observational Study

Süleyman Kalaycı, MD[1,*], Bengü Gülhan Köksal, MD[†], Emre Horuz, MD[‡], Evşen Ertem, MD[§], Füsun Cömert, MD[||], Mustafa Umut Somuncu, MD[¶], Belma Kalaycı, MD[¶]

[*]*Zonguldak Ataturk State Hospital, Department of Cardiology, Zonguldak, Turkey*
[†]*Zonguldak Bülent Ecevit University Faculty of Medicine, Department of Anesthesiology and Reanimation, Zonguldak, Turkey*
[‡]*Zonguldak Bülent Ecevit University Faculty of Medicine, Department of Infectious Diseases and Clinical Microbiology, Zonguldak, Turkey*
[§]*Zonguldak Ataturk State Hospital, Department of Anesthesiology and Reanimation, Zonguldak, Turkey*
[||]*Zonguldak Bülent Ecevit University Faculty of Medicine, Department of Medical Microbiology, Zonguldak, Turkey*
[¶]*Zonguldak Bülent Ecevit University Faculty of Medicine, Associate Professor Department of Cardiology, Zonguldak, Turkey*

*Objectives:* Pulmonary embolism is one of the leading causes of death in patients with COVID-19. Autopsy findings showed that the incidence of thromboembolic events was higher than clinically suspected. In this study, the authors investigated the relationship between pulmonary embolism severity index (PESI) and simplified PESI (sPESI) on admission to the hospital, as well as adverse events in hospitalized COVID-19 patients without clinically documented venous and/or pulmonary embolism. The adverse events investigated were the development of acute respiratory distress syndrome, the need for intensive care unit admission, invasive or noninvasive mechanical ventilation, and in-hospital mortality.
*Design:* A retrospective and observational study.
*Setting:* Two large-volume tertiary hospitals in the same city.
*Participants:* A total of 720 hospitalized COVID-19 patients with a positive polymerase chain reaction were evaluated.
*Interventions:* None.
*Measurements and Main Results:* Of the study population, 48.6% (350) were women, and the median age was 66 years (19-96). The overall in-hospital mortality rate was 20.5%. In the multivariate logistic regression analysis, a significant relationship was found between the whole adverse events considered and PESI, as well as sPESI ($p < 0.001$). According to the results, sPESI $\geq$2 predicts in-hospital mortality with a sensitivity of 61.4% and specificity of 83.3% (area under the curve = 0.817, 95% confidence interval 0.787-0.845, $p < 0.001$). Similarly, PESI classes IV and V also were found as independent risk factors for in-hospital mortality (for PESI class IV, odds ratio = 2.81, $p < 0.017$; for PESI class V, odds ratio = 3.94, $p < 0.001$).
*Conclusions:* PESI and sPESI scoring systems were both found to be associated with adverse events, and they can be used to predict in-hospital mortality in hospitalized COVID-19 patients without documented venous and/or pulmonary embolism.


*Key Words:* COVID-19; pulmonary embolism severity index (PESI); respiratory distress syndrome; simplified PESI (sPESI); pulmonary embolism; venous thromboembolism

*Abbreviation:* ARDS, acute respiratory distress syndrome; PESI, pulmonary embolism severity index; sPESI, simplified PESI; VTE, venous thromboembolism

[1]Address reprint requests to Süleyman Kalaycı, Ankara City Hospital, Department of Cardiology, MD, Üniversiteler Mahallesi 1604. Cadde No: 9 Çankaya/ANKARA/TURKEY (ZIP CODE: 06800)

*E-mail address:* dr_suleyman_kalayci@yahoo.com (S. Kalaycı).

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THE COVID-19 PANDEMIC, which started at the end of 2019, continues to affect people all around the world. COVID-19 has a wide clinical spectrum ranging from asymptomatic infection to life-threatening respiratory failure. The overall fatality rate in unvaccinated individuals is estimated to be between 0.15% and 1%.[1]

Pneumonia is the most common manifestation of severe COVID-19. Acute respiratory distress syndrome (ARDS) occurs in symptomatic patients, and can be associated with an exaggerated inflammatory response. Acute respiratory distress syndrome is the leading cause of cardiac complications, need for mechanical ventilation (MV), secondary infections, and death, followed by sepsis.[2] Similar to ARDS, "COVID-19 associated coagulopathy," as a well-defined clinical condition, may lead to morbidity and mortality.[3]

Predicting COVID-19 prognosis is critical to determine the progression of the disease and its treatment protocols. For this purpose, several comorbidity indices or scorings have been used in the previous studies. The pulmonary embolism severity index (PESI) is a score that has been validated most extensively to date, and has been in use for the risk assessment of pulmonary embolism (PE), as well as to determine the severity of disease.[4,5] A simplified PESI (sPESI) was developed and validated to simplify the original version of PESI, by reducing 11 variables to 6 variables.[6,7] According to the authors' literature review, the relationship between PESI or sPESI and the prognosis of the disease has not been investigated before in COVID-19 patients without acute PE. The authors' first aim in this study was to investigate the relationship between PESI/sPESI and adverse events such as in-hospital mortality, the development of ARDS, the need for noninvasive/invasive MV and the intensive care unit (ICU) in hospitalized COVID-19 patients without documented venous thromboembolism (VTE)/PE. The authors' secondary aim was to investigate the relationship between in-hospital mortality and comorbid clinical conditions.

## Materials and Methods

Approval was obtained from the Turkish Republic Ministry of Health, General Directorate of Health Services, COVID-19 Scientific Research Evaluation Commission (No: 2020-11-11T14_36_01) before applying to the ethics committee. Zonguldak Bulent Ecevit University Non-Interventional Clinical Research Ethics Committee approved the study (dated 02/12/2020 and protocol numbered 2020/23).

### *Data Sources*

This retrospective, cross-sectional study involved 762 consecutively hospitalized COVID-19 patients with a positive polymerase chain reaction (PCR), >18 years of age, and applied to 2 hospitals in the same city, Bulent Ecevit University Hospital and Zonguldak Atatürk State Hospital (clinics of infectious diseases and ICUs of anesthesiology and reanimation), between May 2020 and November 2020.

The authors excluded 42 patients totally who had documented PE (n = 19) and those who were treated with hydroxychloroquine (n = 23). Finally, the data of 720 hospitalized patients were analyzed.

The demographic data, risk factors, medications, and clinical and electrocardiographic findings on admission to the hospital were recorded in patients' files. Routine laboratory analysis results also were recorded.

The adverse events that were investigated in this study were the development of ARDS, the need for ICU admission, invasive or noninvasive MV, and in-hospital mortality. The diagnosis of ARDS was made according to the Berlin Definition, and no classification was made according to clinical severity. Both PESI and sPESI were calculated for each study patient to evaluate adverse events.

### *Calculation of PESI and sPESI on Admission to the Hospital*

The original PESI, which includes 11 differently weighted variables, is calculated by scoring the following variables: age, male sex, cancer, chronic heart failure, chronic pulmonary disease, pulse rate ≥110 beats/min, systolic blood pressure <100 mmHg, respiratory rate >30 breaths/min, temperature <36°C, altered mental status, and an arterial oxyhemoglobin saturation <90% (Table 1). According to the PESI, patients with acute PE are divided into 5 categories as follows: class 1: ≤65 points, class II: 6-to- -85 points, class III: 86-to-105 points, class IV: 106-to-125 points, and class V >125 points. The 30-day mortality is low for patients in PESI classes I and II (1.7%-3.5%), and moderate-to-very high for patients in PESI classes III, IV, and V (3.2%-24.5%).[8]

As mentioned before, sPESI is a simplified version of the original PESI. Each variable in the sPESI receives 1 point (Table 1). The variables are age >80 years, cancer, chronic heart failure/chronic pulmonary disease, pulse rate ≥110 beats/min, systolic blood pressure <100 mmHg, and an arterial oxyhemoglobin saturation <90%. If sPESI is 0 points, this indicates a low mortality rate (30-day mortality rate 1%) in patients with acute pulmonary thromboembolism. Also,

Table 1
Original and Simplified Pulmonary Embolism Severity Index.

| Parameter | Original Version | Simplified Version |
|---|---|---|
| Age | Age, y | 1 point (if age >80) |
| Male sex | +10 points | - |
| Cancer | +30 points | 1 point |
| Chronic heart failure | +10 points | - |
| Chronic pulmonary disease | +10 points | 1 point |
| Pulse rate ≥110 beats/min | +20 points | 1 point |
| Systolic BP <100 mmHg | +30 points | 1 point |
| Respiratory rate >30 breaths/min | +20 points | - |
| Temperature <36°C | +20 points | - |
| Altered mental status | +60 points | - |
| Arterial oxyhemoglobin saturation <90% | +20 points | 1 point |

Abbreviation: BP, blood pressure.

sPESI ≥1 point indicates high mortality rate (30-day mortality rate 10.9%) in the same patient group.

*Testing for COVID-19*

Nasopharyngeal specimens were obtained via FLOQSwabs (COPAN Diagnostics Inc, Italy) and were sent to the microbiology laboratory in a viral transport medium (Bioeksen R&D Technologies, Istanbul, Turkey). The detection of SARS-CoV-2 RNA was done with the SARS-CoV-2-Double Gene RT-qPCR amplification kit that targeted the ORF1ab and N genes (Bio-Speedy, Bioeksen R&D Technologies). The lower detection limit reported by the Ministry of Health's General Directorate of Public Health was 200 genom/mL; analytical sensitivity and specificity were 99.4% and 99.0%, respectively. Real-time RT-qPCR was performed using Rotor-Gene 5r Plex Real Time PCR Systems (Qiagen, Venlo, The Netherlands). A cycle threshold value <38 was defined as a positive test result, and a cycle threshold value of ≥38 was defined as a negative test result.

*Statistical Analysis*

The SPSS software version 21.0 for Windows (IBM SPSS Inc., Armonk, NY) was used for statistical analysis. The normal distribution of the data was determined using visual and analytical methods. The study groups were compared using independent sample t-test/one-way analysis of variance for the continuous variables with a normal distribution, and by using Mann-Whitney U/Kruskal-Wallis H test for the continuous variables without normal distribution. The categorical data were compared using the chi-square test. Receiver operating characteristic (ROC) analysis was drawn for the ability of sPESI to predict in-hospital mortality. Logistic regression analysis was performed to determine the independent predictors of adverse events. Traditional risk factors for adverse events were adjusted in all models. To investigate the relationship of PESI with mortality, the PESI was divided into 5 classes as previously validated. Class I was accepted as the baseline value, and the ability of other classes to predict mortality was examined. MedCalc 19.6.4 was used to calculate ROC analyses to determine the cut-off value of sPESI to predict mortality. A p value of < 0.05 was considered as statistically significant.

## Results

*Patients' Characteristics*

A total of 720 consecutive hospitalized COVID-19 patients were enrolled in this study. Of the study population, 48.6% (350) were women, and the median age was 66 [19−96]. The first hospitalization place of 13.8% of study patients was the ICU, and the rest was non-ICU hospitalization. A total of 115 of the non-ICU patients needed intensive care during the follow-up. A total of 148 patients (20.5%) died during their hospitalization period. All of the demographic data and comorbid risk factors of the patients are shown in Table 2.

Table 2
Comparison of Baseline Clinical Parameters According to In-hospital Mortality.

| | Mortality (+) n = 148 | Mortality (−) n = 572 | p Value |
|---|---|---|---|
| Age, y, mean ± SD | 74.5 (35-95) | 64 (19-96) | 0.001 |
| Sex (male), n (%) | 88 (59.5) | 283 (49.4) | 0.029 |
| Diabetes mellitus, n (%) | 59 (39.9) | 186 (32.5) | 0.093 |
| Hypertension, n (%) | 97 (65.5) | 298 (52.1) | 0.003 |
| Chronic pulmonary disease, n (%) | 40 (27.0) | 70 (12.2) | < 0.001 |
| Coronary artery disease, n (%) | 44 (29.7) | 78 (13.6) | < 0.001 |
| Peripheral artery disease, n (%) | 5 (3.4) | 9 (1.6) | 0.156 |
| Chronic heart failure, n (%) | 23 (15.5) | 23 (4.0) | < 0.001 |
| Cerebrovascular disease, n (%) | 20 (13.5) | 19 (3.3) | < 0.001 |
| Cancer, n (%) | 23 (15.5) | 28 (4.9) | < 0.001 |

*Outcomes*

The authors found that PESI and sPESI scores were independent predictors of all investigated adverse events in patients with COVID-19 PCR (+) and no VTE. Additionally, the authors found that in-hospital mortality was higher in patients with advanced age, male sex, hypertension, chronic lung disease, coronary artery disease, heart failure, cerebrovascular disease, and cancer. Both PESI and sPESI calculated by using the clinical parameters obtained when the patient was admitted to the hospital were compared in terms of in-hospital mortality. Heart rate >100, respiratory rate >30 breaths/min, arterial oxyhemoglobin saturation <90%, and temperature <36°C were found to be elevated statistically significantly in the mortality group (p < 0.001). When the patients were examined according to their first hospitalization place after admission, the mortality rate was increased in the ICU patients (70 [65.5%] *v* 30 [5.4%], p < 0.001). Mortality-related comparison of baseline electrocardiogram parameters, drug usage and clinical manifestations are shown in Table 3. The comparison of each sPESI score and PESI class according to in-hospital mortality is shown in Table 4. The authors also compared the sPESI score among each other's in terms of in-hospital mortality. The difference was found to be statistically significant among sPESI scores (p < 0.001). However, in subgroup analyses, the difference between the sPESI scores was not significant when sPESI was ≥4 (p = 0.343).

Multivariate logistic regression analysis was performed to determine the relationship between PESI/sPESI and adverse events in hospitalized COVID-19 patients. Adverse events, such as the development of ARDS, the need for ICU, invasive or noninvasive MV, and in-hospital mortality, were associated significantly with PESI and sPESI (Table 5). The ROC curve analysis was performed to examine the power and cut-off value of sPESI in predicting in-hospital mortality (Fig 1). The authors concluded that sPESI ≥2 predicted in-hospital mortality, with a sensitivity of 61.4% and a specificity of 83.3% (area

Table 3
Comparison of Baseline Electrocardiogram Parameters, Drug Usage, Clinical Manifestations, and PESI Scores According to In-hospital Mortality.

| | Mortality (+) n = 148 | Mortality (−) n = 572 | p Value |
|---|---|---|---|
| ***Electrocardiogram*** | | | |
| Atrial fibrillation | 29 (19.6) | 28 (4.9) | 0.001 |
| ST segment depression | 17 (12.0) | 27 (6.3) | 0.027 |
| T wave inversion | 18 (12.7) | 50 (11.6) | 0.834 |
| QRS fragmentation | 9 (6.3) | 30 (7.0) | 0.798 |
| LBBB | 11 (7.7) | 10 (2.3) | 0.003 |
| RBBB | 7 (4.9) | 23 (5.3) | 0.850 |
| ***Drug usage*** | | | |
| Antiplatelet | 60 (40.5) | 158 (27.6) | 0.002 |
| Beta-blocker | 45 (30.4) | 145 (25.3) | 0.214 |
| Calcium channel blocker | 34 (23.0) | 136 (23.5) | 0.872 |
| Alfa blocker | 7 (4.7) | 25 (4.4) | 0.850 |
| ACEI | 20 (13.5) | 86 (15.0) | 0.641 |
| ARB | 33 (22.3) | 122 (21.3) | 0.798 |
| Diuretic | 49 (33.1) | 153 (26.7) | 0.125 |
| Oral anticoagulant | 29 (19.6) | 37 (6.5) | < 0.001 |
| ***Clinical manifestations, PESI scoring*** | | | |
| Pulse rate ≥110 beats/min | 32 (22) | 52 (9) | < 0.001 |
| Respiratory rate >30 breaths/min | 35 (24) | 28 (5) | < 0.001 |
| Arterial oxyhemoglobin saturation <90% | 22 (15) | 18 (3) | < 0.001 |
| Temperature <36°C | 43 (29) | 65 (11) | < 0.001 |
| ICU hospitalization at admission | 70 (65.4) | 30 (5.4) | < 0.001 |
| PESI, point | 231 (136-303) | 94 (35-246) | < 0.001 |
| sPESI, point | 3 (1-6) | 1 (0-4) | < 0.001 |

NOTE. Variables are expressed as n (%) and median [minimum-maximum].
Abbreviations: ACEI, angiotensin-converting enzyme inhibitors; ARB, angiotensin-receptor blockers; ICU, intensive care unit; LBBB, left bundle-branch block; PESI, pulmonary embolism severity index; sPESI, simplified pulmonary embolism severity index; RBBB, right bundle-branch block.

under the curve = 0.817, 95% CI 0.787-0.845, p < 0.001). The patients were divided into 5 classes according to their PESI scores. Patients in PESI class I were accepted as baseline.

Table 4
Comparison of Each sPESI and PESI Score Group According to In-hospital Mortality.

| | Mortality (+) | Mortality (−) | p Value |
|---|---|---|---|
| sPESI | | | < 0.001 |
| 0 | (0) 0 | 259 (45.4) | |
| 1 | 6 (4.1) | 172 (29.6) | |
| 2 | 36 (24.3) | 95 (16.6) | |
| 3 | 41 (27.7) | 41 (7.2) | |
| 4 | 55 (37.2) | 5 (0.9) | |
| 5 | 8 (5.4) | 0 (0) | |
| 6 | 2 (1.4) | 0 (0) | |
| PESI | | | < 0.001 |
| 0-65 | 0 (0) | 61 (10.7) | |
| 66-85 | 0 (0) | 141 (24.7) | |
| 86-105 | 5 (3.4) | 184 (32.2) | |
| >105 | 143 (96.6) | 186 (32.5) | |

NOTE. Variables are expressed as n (%).
Abbreviations: PESI; pulmonary embolism severity index, sPESI; simplified pulmonary embolism severity index.

Table 5
Multivariate Logistic Regression Analysis to Determine the Relation of PESI and sPESI With Adverse Events in Hospitalized COVID-19 Patients.

| | OR | p Value |
|---|---|---|
| sPESI | | |
| Noninvasive MV need | 2.304 (1.925 ± 2.733) | < 0.001 |
| ICU need | 3.214 (2.625 ± 3.927) | < 0.001 |
| ARDS | 3.183 (2.570-3.944) | < 0.001 |
| Invasive MV need | 3.104 (2.520-3.823) | < 0.001 |
| Mortality | 3.323 (2.666-4.141) | < 0.001 |
| PESI | | |
| Noninvasive MV need | 1.031 (1.027 ± 1.036) | < 0.001 |
| ICU need | 1.066 (1.054 ± 1.078) | < 0.001 |
| ARDS | 1.085 (1.066-1.105) | < 0.001 |
| Invasive MV need | 1.086 (1.067-1.106) | < 0.001 |
| Mortality | 1.080 (1.062-1.098) | < 0.001 |

Abbreviations: ARDS, acute respiratory distress syndrome; ICU, intensive care unit; OR, odds ratio; MV, mechanical ventilation; PESI, pulmonary embolism severity index; sPESI, simplified pulmonary embolism severity index.

Regression analysis was used to detect whether the other 4 PESI classes were independent risk factors for in-hospital mortality or not. It was concluded that PESI classes IV and V were independent risk factors for in-hospital mortality (for PESI class IV, odds ratio [OR] = 2.81, 95% CI 1.53-5.84, p < 0.017; for PESI class V, OR= 3.94, 95% CI 2.13-11.18, p < 0.001) (Fig 2).

When the electrocardiograms of all patients were evaluated, the frequencies of atrial fibrillation (AF), left bundle-branch block (LBBB), and ST-segment depression were found to be significantly high in the mortality group. The frequency of antiplatelet and anticoagulant drug usage was also high in the mortality group. There were no significant differences between the 2 groups in terms of the frequency of the usage of other medications.

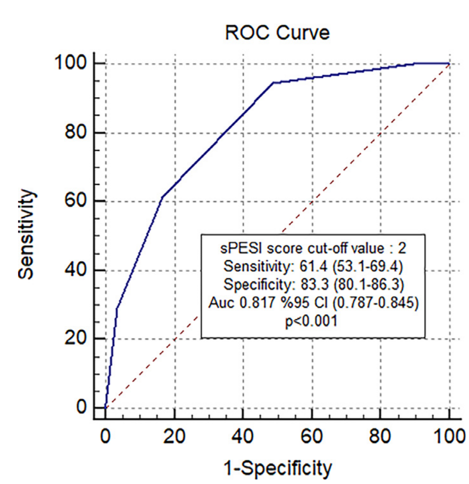


Fig 1. Receiver operating characteristics curve showing the distinguishing ability of simplified pulmonary embolism severity index for mortality. AUC, area under the ROC curve; ROC, receiver operating characteristics; sPESI, simplified pulmonary embolism severity index.

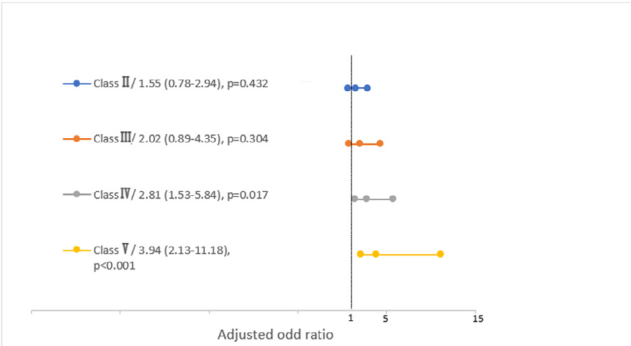


Fig 2. Logistic regression analysis to determine the relation of the pulmonary embolism severity index class with in-hospital mortality in COVID-19 patients.

## Discussion

This study hypothesized that there may be a relationship between PESI/sPESI scores and poor outcomes, as well as survival, in hospitalized COVID-19 patients. The major implications of a high PESI/sPESI score from this study were found to be (1) worsening of the clinical outcomes, (2) ICU requirement, and (3) in-hospital death.

The COVID-19 pandemic still affects many people all around the world. The overall mortality rate from COVID-19 in hospitalized patients ranges from 15%-to-20%, but it may be ≤40% for patients requiring admission to the ICU.[9] Various laboratory markers, clinical factors, and risk scores can be used to determine the need for ICU and in-hospital mortality rate in patients with COVID-19.[10] Among them, advanced age is the most important predictor of mortality.[11]

COVID-19 infection has been associated with a hypercoagulable state that may lead to increased risk of VTE and pulmonary thrombosis/thromboembolism.[12] Although the actual rate of VTE in patients hospitalized with COVID-19 is elusive, it varies from 4.8%-to-85% according to recent studies.[13-15] Jiménez et al. evaluated a meta-analysis of 36 studies with >11,000 patients, and found that the rate of VTE in patients with COVID-19 was 17% (12% for deep venous thrombosis (DVT), 7.1% PE).[14] However, postmortem studies reported a high rate of VTE.[16,17]

The PESI is a proven risk scoring system used in acute thromboembolism risk classification. According to the study of Xu et al., 101 hospitalized COVID-19 patients with PE confirmed by pulmonary computed tomograpy angiography were evaluated, and found that the patients with intermediate-to-high-risk PESI (classes III, IV, and V) had worse outcomes than the patients with low-risk PESI (classes I and II), resulting in a high percentage of ICU admission (29% *v* 11%; p = 0.038) and a high mortality rate (27% *v* 6%; p = 0.007).[18] In this study, most patients (65%) had intermediate-to-high-risk PESI (>85), which portended a worse prognosis, with high mortality rate and prolonged length of stay. However, unlike this study, the hospitalized COVID-19 patients with PE also were enrolled into this study.

In another study, a new score (modified-sPESI) was developed in patients with COVID-19 by changing the age limit from >80 to >65. In this study, the relationship between ICU requirement and modified sPESI was detected.[19] Patients who had a history of DVT/PE were not included. However, it was not investigated if the patients were diagnosed with PE during their hospitalization. As a result of this study, it was found that the modified-sPESI predicted the need for intensive care with high specificity and sensitivity (area under the curve = 0.948; 84.6% sensitivity and 94.6% specificity, p < 0.001).

To the authors' knowledge, there has been no published study on the prognostic effects of PESI or sPESI in hospitalized COVID-19 patients without documented VTE/PE. As a result of this study, the authors concluded that the PESI and sPESI measured at diagnosis are independent risk factors for in-hospital adverse events in hospitalized COVID-19 patients without documented VTE/PE. The authors also found that a PESI class of IV and V at the time of diagnosis and sPESI ≥2 can be used as a strong predictor of in-hospital mortality in this patient population. As mentioned before, predicting COVID-19 prognosis is critical to determining the progression of the disease and treatment protocols. According to the authors' findings, PESI and sPESI on admission to the hospital are useful in determining adverse events in hospitalized COVID-19 patients. In other words, clinicians can determine the risk status of hospitalized COVID-19 patients according to PESI and sPESI values on admission to the hospital, and may be more aggressive in applying anticoagulant and specific treatments.

The reason why the PESI/sPESI are related to adverse events may be the presence of undiagnosed VTE/PE in hospitalized COVID-19 patients. It is difficult to diagnose PE in patients with COVID-19 by virtue of the similarity of symptoms and laboratory findings for both conditions. Additionally, the fact that the histopathologically diagnosed VTE diagnosis rates were much higher than the clinical rates may have caused these results.

As in previous COVID-19 studies, mortality was found to be elevated in patients with hypertension, diabetes mellitus, cerebrovascular disease, heart failure, chronic obstructive pulmonary disease, and coronary artery disease, as well as in male sex and older age groups.[20,21] In this study, patients with diabetes mellitus were also significantly high in the mortality group, consistent with previous studies. However, this difference was not statistically significant (39.9% *v* 32.5%, p = 0.093). Cancer patients have an increased risk of COVID-19 infection due to their immunosuppressive state and cancer treatment, and their prognosis is poorer than the general population.[22] COVID-19 is more fatal, especially in cancer patients >70 years old.[23,24] In this study, 7% of the patients hospitalized with COVID-19 were diagnosed with cancer. The incidence of cancer was significantly high in the mortality group (15.5% *v* 4.9%, p < 0.001).

The frequency of peripheral artery disease was found to be 1.9% in this study, and no significant correlation was found with in-hospital mortality. Smolderen et al. found a significant relationship among peripheral artery disease and overall mortality and major cardiac events in their study.[25] This difference may have been related to the retrospective design of this study, as well as the presence of undiagnosed patients with peripheral artery disease. Additionally, whereas in-hospital mortality was evaluated in this study, overall mortality was evaluated in the study by Smolderen et al.

In this study, electrocardiogram features of the patients also were examined. The electrocardiogram abnormalities in COVID-19 may be due to cytokine storm, electrolyte abnormalities, hypoxic injury, plaque rupture, microthrombi, coronary spasm, and/or myocardial injury.[26] The frequency of AF was found to be higher in the mortality group (19.6% *v* 4.9%, p = 0.001). According to the meta-analysis by Romiti et al., the prevalence of AF was found as 8% in patients with COVID-19, and the risk of all-cause mortality was higher in patients with AF than non-AF patients, with a high degree of heterogeneity (OR: 3.97, 95% CI 2.76-5.71).[27] The LBBB previously has been associated with mortality in COVID-19 patients. In this study, the frequency of LBBB was found to be higher in the mortality group (7.7% *v* 2.3% p = 0.003). However, the authors did not find a relationship between ST-segment depression and T- wave inversion and mortality. In the study by Lanza et al., AF, LBBB, and ST-segment depression were associated with mortality.[28] They also concluded that LBBB is an independent risk factor for mortality (hazard ratio = 9.48, 95% CI 3.37-26.6, p < 0.001). In the same study, no relationship was found between right BBB and mortality. Also, in this study, no significant relationship was found between the presence of right bundle-branch block and mortality (4.9% *v* 5.3, p = 0.850).

### *Limitations*

The major limitations of this study were its retrospective design and a short time participation period. Another limitation of this study was that all patients did not routinely undergo any imaging method to rule out VTE and PE. Only patients with clinical suspicion were screened for VTE and/or PE by imaging methods. As a result, the authors excluded patients with confirmed PE and/or VTE. However, among the included patients, there may have been many patients who had undiagnosed VTE and/ or PE. This imparted bias to the findings.

In addition to these limitations, the patient population included in this study reflected the prevaccination era of the COVID-19 pandemic. The management of hospitalized COVID-19 patients has changed over time with the invention of the COVID-19 vaccines, changes in treatment protocols, and prophylactic anticoagulant therapies. New studies may be planned in the future to examine how the PESI and sPESI scoring systems predict the risk of adverse events in vaccinated patients or different variants. Nevertheless, this study provided precious prognostic information regarding the COVID-19 clinical course, and it will shed light on future studies.

## Conclusion

This study demonstrated that PESI and sPESI scores successfully can determine clinical deterioration, need for ICU admission, and in-hospital mortality of hospitalized COVID-19 patients without clinically documented venous or pulmonary thromboembolism.

## Declaration of Competing Interest

None.

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